La Société Tunisienne de l'Electricité et du Gaz (STEG)

Preparatory Survey on Rades Combined Cycle Power Plant Construction Project in Tunisia

Final Report

March, 2014

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., LTD

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Abbreviations

Abbreviations	Words
AIS	Air Insulated Substation
B/C	Benefit/Cost
CB	Circuit Breaker
CCPP	Combined Cycle Power Plant
C&I	Control and Instrumentation
C/P	Counter Part
CT	Current Transformer
DS	Disconnecting Switch
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Enviromental Management Plan
ESIA	Environmental and Social Impact Assessment
ETAP	Tunisian Petroleum Activities Company
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
Ghannouch CCPP	Existing Ghannouch Combined Cycle Power Plant
GIS	Gas Insulated System (or Substations)
GT	Gas Turbine Power Plant
HRSG	Heat Recovery Steam Generator
IEC	International Electrotechnical Commission
IMF	International Monetary Fund
IPP	Independent Power Producer
ISO	International Standard Organization
JICA	Japan International Cooperation Agency
LCB	Local Competitive Bid
L/A	Loan Agreement
LTSA	Long Term Service Agreement
MDCI	Ministry of Development and International Cooperation
MOI	Ministry of Industry
NPV	Net Present Value

Abbreviations	Words
O&M	Operation and Maintenance
PRS	Pressure Reduction Station
PT	Potential Transformer
P/S	Thermal power stations
PQ	Pre-Qualification
Rades A TPP	Existing Rades A Thermal Power Plant
Rades A&B TPPs	Existing Rades A&B Thermal Power Plants
Rades B TPP	Existing Rades B Thermal Power Plant
Rades C CCPP	Rades C Combined Cycle Power Plant (The Project)
Rades II CCPP	Existing Rades II Combined Cycle Power Plant (IPP by Carthage Power)
Rades I S/S	Rades I Substation
Rades II S/S	Rades II Substation
Rades III S/Y	Rades III Switch Yard
SNDP	Tunisian Oil distribution Company
Sousse A TPP	Existing Sousse A Thermal Power Plant
Sousse B CCPP	Existing Sousse B Combined Cycle Power Plant
Sousse C CCPP	Sousse C Combined Cycle Power Plant (Under construction)
Sousse D CCPP	Sousse D Combined Cycle Power Plant (Under construction)
S/S	Substation
ST	Steam Turbine
STEG	Tunisian Electricity and Gas Company
STIR	Tunisian Refining Industries Company
S/Y	Switch Yard
T/L	Transmission lines
TOR	Terms of Reference
TPP	Thermal Power Plant
WTP	Willing to Pay

Units

Prefixes

μ	:	micro- $= 10^{-6}$
m	:	milli- $= 10^{-3}$
c	:	centi- $= 10^{-2}$
d	:	deci- $= 10^{-1}$
da	:	deca- = 10
h	:	hecto- $= 10^{2}$
k	:	kilo- $= 10^{3}$
M	:	mega- $= 10^{6}$
G	:	giga- $= 10^{9}$

Units of Length

m	:	meter
mm	:	millimeter
cm	:	centimeter
km	:	kilometer
in	:	inch
ft	:	feet
yd	:	yard

Units of Area

cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ft^2	:	square feet (foot)
yd^2	:	square yard
ha	:	hectare

Units of Volume

m^3	:	cubic meter
l	:	liter
kl	:	kiloliter

Units of Mass

g	:	gram
kg	:	kilogram
t	:	ton (metric)
lb	:	pound

Units of Density

kg/m^3	:	kilogram per cubic meter
t/m^3	:	ton per cubic meter
mg/m^3N	:	milligram per normal cubic meter
g/m^3N	:	gram per normal cubic meter
ppm	:	parts per million
μg/scm	:	microgram per standard cubic meter

Units of Pressure

kg/cm^2	:	kilogram per square centimeter (gauge)
lb/in^2	:	pound per square inch
mmHg	:	millimeter of mercury
mmHg abs	:	millimeter of mercury absolute
mAq	:	meter of aqueous
lb/in^2, psi	:	pounds per square inches
atm	:	atmosphere
Pa	:	Pascal
bara	:	bar absolute

Units of Energy

kcal	:	kilocalorie
Mcal	:	megacalorie
MJ	:	mega joule
TJ	:	tera joule
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
Btu	:	British thermal unit

Units of Heating Value

kcal/kg	:	kilocalorie per kilogram
kJ/kg	:	kilojoule per kilogram
Btu/lb	:	British thermal unit per pound

Units of Heat Flux

$kcal/m^2h$	:	kilocalorie per square meter hour
Btu/ft^2H	:	British thermal unit per square feet hour

Units of Temperature

deg	:	degree
°	:	degree

C	:	Celsius or Centigrade
°C	:	degree Celsius or Centigrade
F	:	Fahrenheit
°F	:	degree Fahrenheit

Units of Electricity

W	:	watt
kW	:	kilowatt
A	:	ampere
kA	:	kiloampere
V	:	volt
kV	:	kilovolt
kVA	:	kilovolt ampere
MVA	:	megavolt ampere
Mvar	:	megavar (mega volt-ampere-reactive)
kHz	:	kilohertz

Units of Time

s	:	second
min	:	minute
h	:	hour
d	:	day
y	:	year

Units of Flow Rate

t/h	:	ton per hour
t/d	:	ton per day
t/y	:	ton per year
m^3/s	:	cubic meter per second
m^3/min	:	cubic meter per minute
m^3/h	:	cubic meter per hour
m^3/d	:	cubic meter per day
lb/h	:	pound per hour
m^3N/s	:	cubic meter per second at normal condition
m^3N/h	:	cubic meter per hour at normal condition

Units of Conductivity

μS/cm	:	microSiemens per centimeter

Units of Sound Power Level

dB	:	deci-bell

Units of Currency

US$	:	US Dollar
¥	:	Japanese Yen

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1. Background and Objectives of the Preparatory Survey

Background and Objectives of the Preparatory Survey

Necessity to Construct 430 to 500MW of New Combined Cycle Power Plant to cope with increasing power demand in Tunisia

- To carry out Preparatory Survey on Rades CCPP (Combined Cycle Power Plant) Construction Project
- To formulate the Project suitable for JICA ODA LOAN

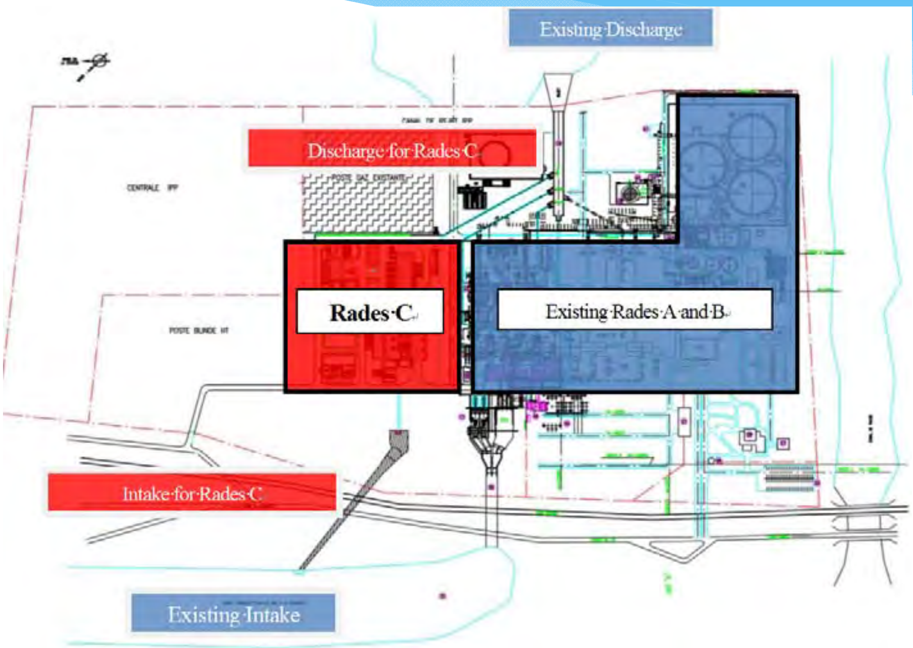
Rades C CCPP Construction

2. Project Overview

Project Overview

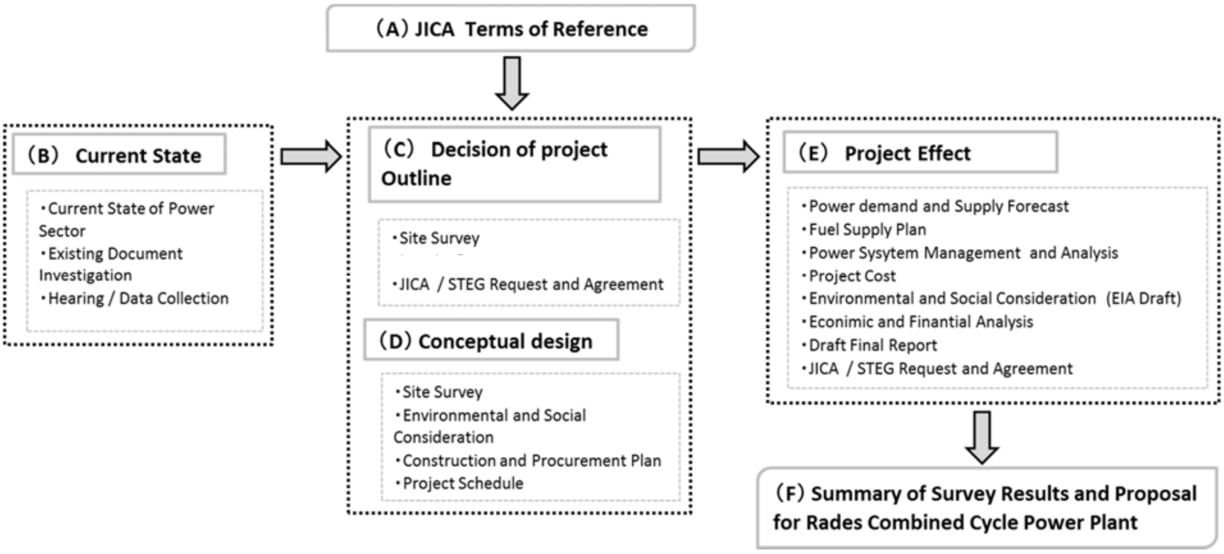
item	Contents
Type	CCPP (Combined Cycle Power Plant)
Capacity	430 to 500MW
COD (Commercial Operation Date) for GT	2017
COD for CCPP	2018
Site	Rades city in Tunisia
Owner	STEG

Site Layout Plan

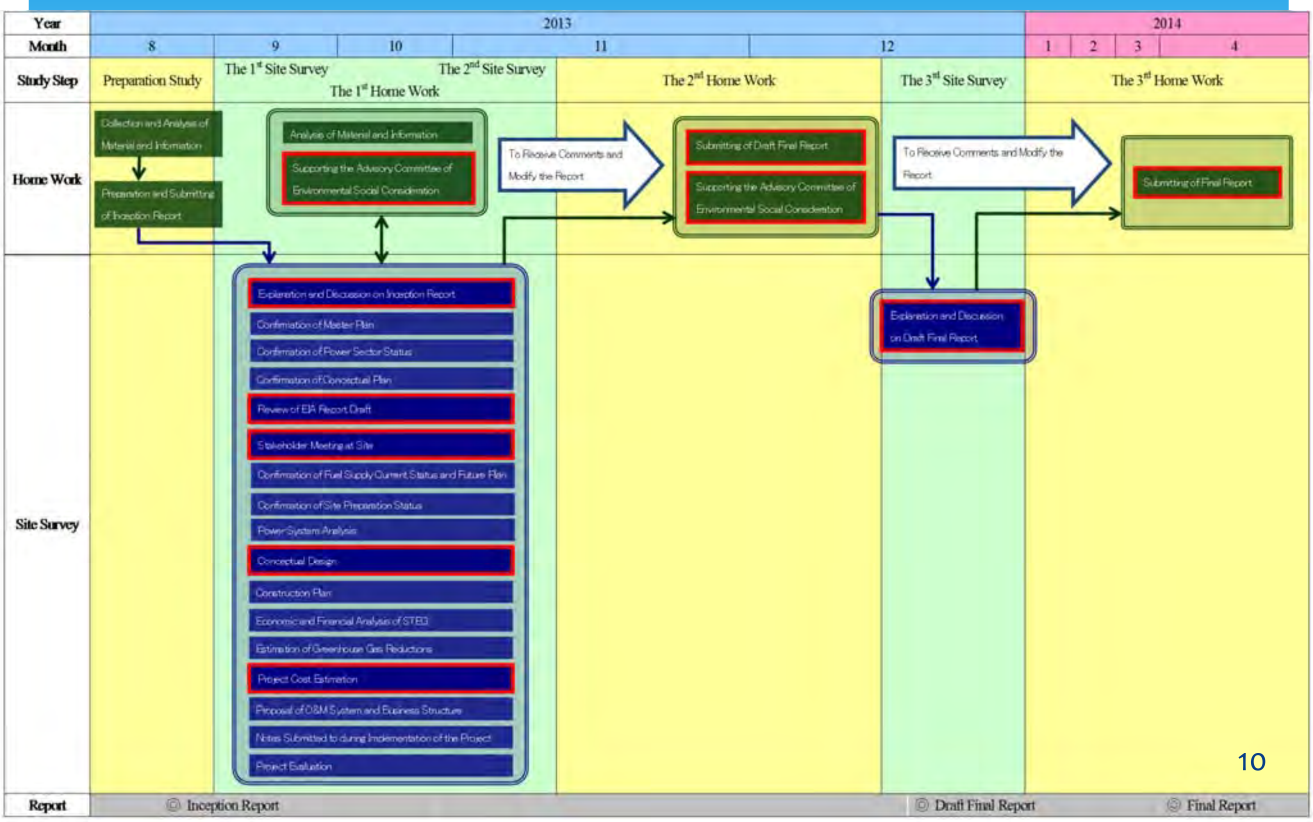


3. Study Items and the Schedule

Study Items and the Schedule



Study Items and the Schedule



4. Socio-economic Situation

Socio-economic Situation

* Total population: 10.777 million in 2012, economically active population of 8.315 million (2nd q. of 2013)
* Unemployment rate: around 30%, 90% of them is under 30yrs.
* GDP: 29.43 billion TND in 2012, annual growth rates of - 1.9% in 2011 but 3.3% in 2012, projected 4.6% in 2014.
* Inflation: 5.6% in 2012, higher inflation by higher international prices of import goods, depreciation of currency, etc.
* Balance of payment: expanding trade deficit to 10.1% of GDP in 2012.
* Exchange rate: depreciating TND/USD to 1.5618TND/USD in 2012.
* Government finance: the primary and overall balances deteriorated, the overall deficit reached 6% of GDP
* External debt: 38.8% of GDP, debt service ratio of 10% in 2011

Electricity Tariff

Tariffs		Price of Electricity (mill TND/kWh)			
		Day	Peak	Evening	Night
Low Voltage (LV)					
Economic bracket (1 to 2 kVA and ≤ 50kWh/year)		75			
Economic bracket (1 to 2 kVA and > 50kWh/year)	1 to 50 kWh/month	92			
	≥ 51 kWh/month	133			
Ordinary bracket (>2kVA)	1 to 300 kWh/month	133			
	≥ 301 kWh/month	186			
Medium Voltage (MV)					
Normal		125			
Time shifts "postes horaires"		110	168	133	85
Water pumping		126	156	Load shedding	85
Secours (tariffs for self-producers that consume in case of necessity)		128	180	150	90
High Voltage (HV)					
4 Postes Horaires		106	164	129	81
3 Postes Horaires		122	150	-	81
Secours		124	176	146	86

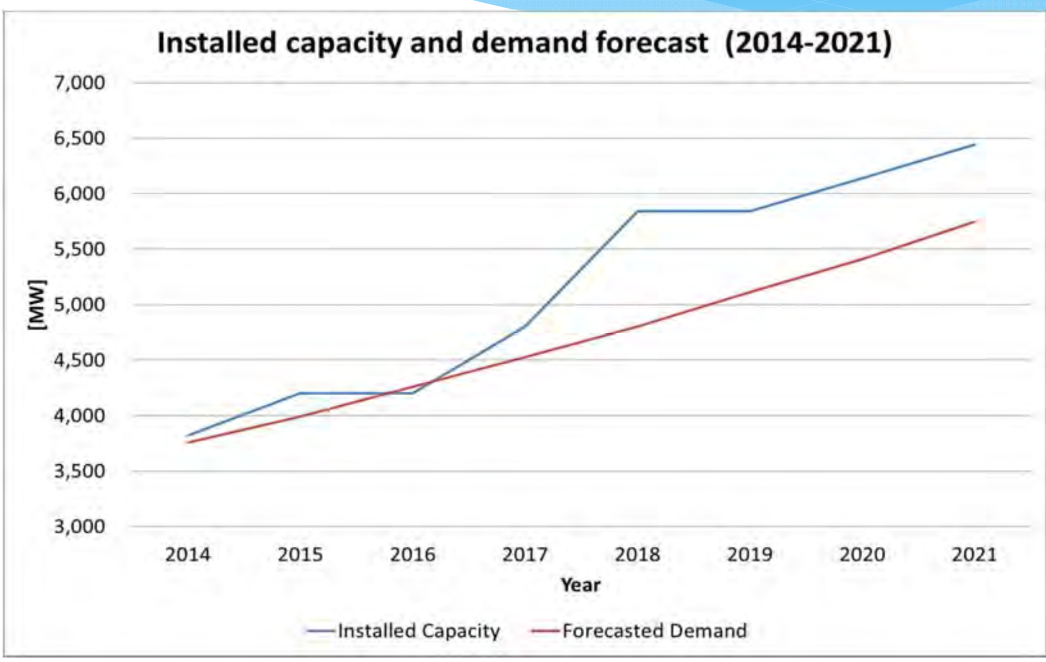
5. Overview of Power Sector in Tunisia

Overview of Power Sector in Tunisia

Power Plant Development Plan

Name of Plant	Type of Plant	Location	Capacity (MW)	Year of Initial Operation
Sousse C	CC	Sousse	424	2014
Sousse D	CC	Sousse	424	2015
Rades C	CC	Radès	450	2017 (GT) 2018 (CC)
Mornaguia #1	GT	Mornaguia	300	2017
Mornaguia #2	GT	Mornaguia	300	2017
(Centrale #1)	CC	(Not decided)	450	2018
(Centrale #2)	CC	(Not decided)	450	2019
(Tac 2020)	GT	(Not decided)	300	2020
(Tac 2021)	GT	(Not decided)	300	2021
Total	-	-	3,398	-

Installed Capacity and Demand Forecast



6. Fuel supply Plan

Prediction of Natural Gas Consumption and Supply Plan

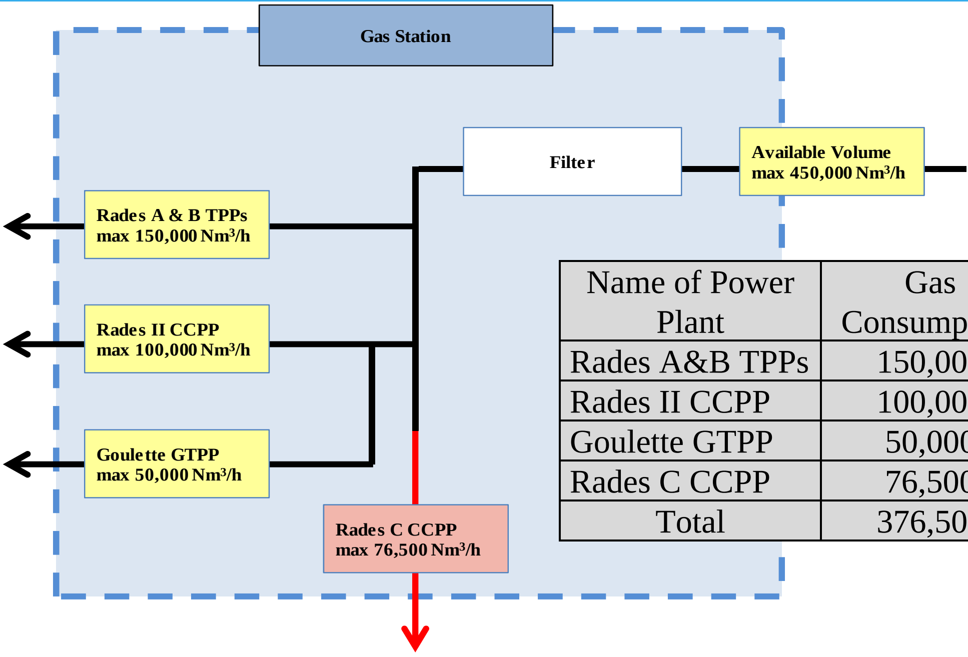
Estimated Natural Gas Consumption Volume and Planned Supply for the next 10 year

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1.Production	2,747	2,716	2,542	3,027	2,791	2,358	2,071	1,963	1,751	1,545
2.Importation	2,665	2,828	3,626	4,284	4,660	4,660	5,036	-	-	-
3.Consumption	5,432	5,544	5,601	5,927	6,270	6,563	6,903	7,172	7,529	7,592

To ensure a stable supply of natural gas over the long term, it is essential to implement the following:

- ✓ **Implementation of the "South Tunisia Gas Project" according to the schedule.**
- ✓ **In the import contract with Algeria which expires in 2019, efforts should be made to increase the purchase volume and increase the contract period.**
- ✓ **Efforts should be made to develop new gas fields in Tunisia.**

Hourly Consumption of Natural Gas of Each Unit at Rated Output



Name of Power Plant	Gas Consumption	Remark
Rades A&B TPPs	150,000	−
Rades II CCPP	100,000	−
Goulette GTPP	50,000	−
Rades C CCPP	76,500	−
Total	376,500	< 450,000

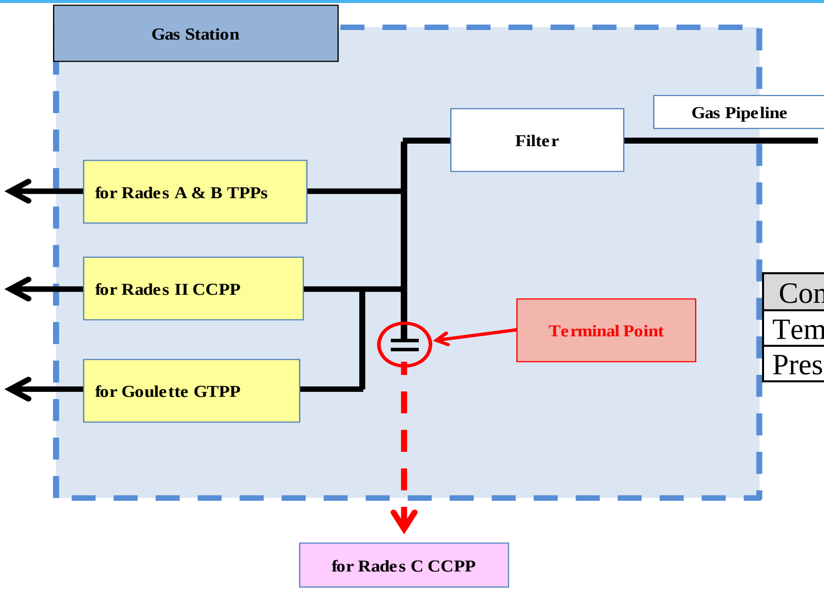
Natural gas can be supplied in the volume of 450,000 Nm3/h. By contrast, the total of natural gas consumption of each power plant is 376,500 Nm3/h. Therefore, this shows that there is sufficient natural gas that can be supplied to the Rades C CCPP.

Fuel Gas Supply System
(1) Specifications of Natural Gas

Composition	Unit	Value
Methane	mol%	85.76
Ethane	mol%	7.26
Propane	mol%	1.64
i-Butane	mol%	0.21
n-Butane	mol%	0.33
i-Pentane	mol%	0.07
n-Pentane	mol%	0.07
Hexane	mol%	0.06
Nitrogen	mol%	4.02
Carbon dioxide	mol%	0.53
Helium	mol%	0.05
Total	mol%	100
Heating Value (LHV)	kcal/m^{3}N	9,057.23
Specific Gravity	kg/m^{3}N	0.829
Maximum content of H_2S	mg/m^{3}N	7
Temperature	^oC	Max. 50
Pressure	MPa	3.3 ~ 7.6

Natural gas will be used as the fuel for Rades C CCPP as well as for Rades A&B TPPs. The gas turbine shall be designed to operate on the specified natural gas.

Fuel Gas Supply System
(2) Location of the terminal point



Composition	Unit	Value
Temperature	oC	Max. 50
Pressure	MPa	3.3 ~ 7.6

Natural gas is separated at the terminal point and will be supplied to Rades C CCPP. After that, the natural gas will be connected to a fuel gas compressor so that the pressure can be adjusted to the level required at the inlet of the gas turbine.

7. Basic Design

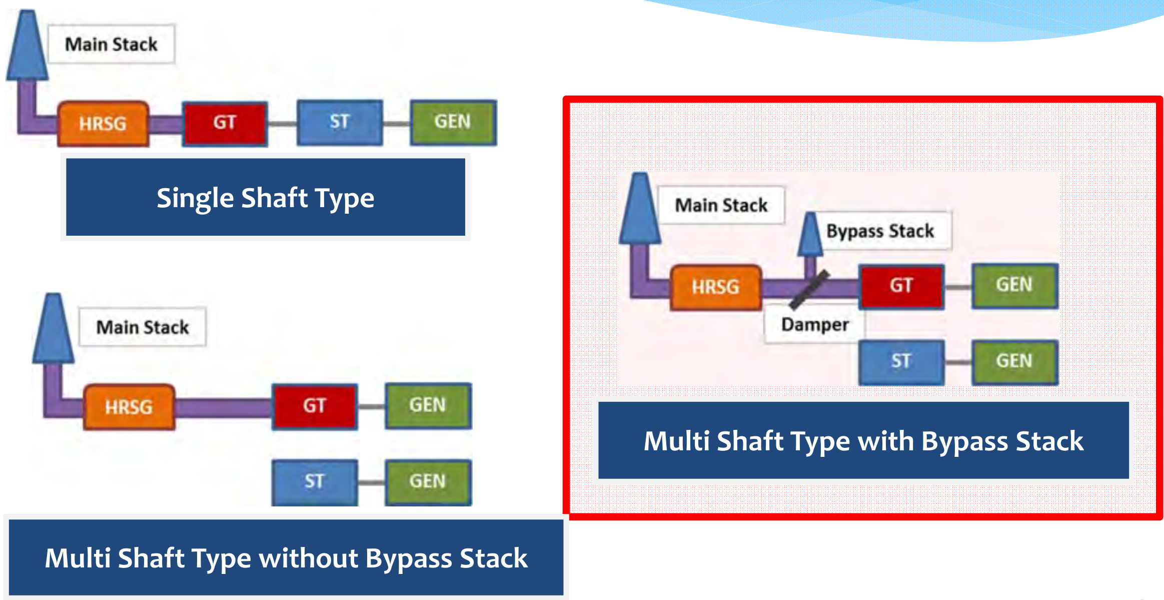
Condition and Specification of Basic Design for CCPP 1/2

Description	Condition and Specification	
	Evaluation Point	Range
Type of plant	Combined cycle power plant (CCPP)	
Type of gas turbine	F class gas turbine with specified commercial experience	
Type of shaft arrangement	Multi-shaft arrangement with a bypass stack	
Type of operation	Continuous operation for base load	
Type of cooling system	Once-through type of sea water	
Dry bulb temp. (°C)	20	10 to 40
Barometric press. (kPa)	101.3	
Relative humidity (%)	70	20 to 90
Cooling water temp. (°C)	25.0	15.5 to 30.0

Basic Design Condition and Specification of CCPP 2/2

Description	Condition and Specification	
	Evaluation Point	Range
Type of fuel	Main fuel : Natural gas Standby fuel : Diesel oil	
Supply press. of natural gas at TP (MPa)	5.5	3.3 to 7.6
Supply temp. of natural gas at TP (°C)	25	15 to 50
Conditions to define the max. capacity of bottoming and electrical systems	Dry bulb temperature : 10 °C Relative humidity : 70 % Cooling water temperature : 15.5 °C	
Economically operable service life (years)	25	
Make-up water source for processing	Desalinated sea water	

Type of Shaft Configuration



Comparison of Shaft Configuration

Comparison item	Single Shaft	Multi-shaft with B/S	Multi Shaft without B/S
Efficiency	Base	Slightly lower	Slightly lower
Gas Turbine Simple Cycle Operation	No	Yes	Conditionally yes
Start-up and Shutdown Operation	Base	Slightly complicated	Slightly complicated
Starting Device Power	Base	Slightly lower	Slightly lower
Maintenance	Base	Slightly expensive	Slightly expensive
Installation Footprint Requirement	Base	Slightly spacious	Slightly spacious
Construction Cost	Base	Expensive	Expensive

OEM Manufacturer of F class Gas Turbine

Model No. of Gas Turbine	Manufacturer
GT 26 (AQC)	Alstom
9FB	General Electric
M701F4	Mitsubishi Heavy Industries
SGT5-4000F	Siemens

The OEM is defined as the manufacturer who has conducted the full development of the prototype of GT to be proposed and has been performing successive upgrades.

Criteria for Commercial Operating Experience of Similar Reference Gas Turbines

1. The total successful commercial operating hours of at least three (3) gas turbines shall be not less than 30,000 actual operating hours.
2. One (1) out of three (3) gas turbines shall be in the outside the domicile country of the gas turbine manufacturer.
3. The successful commercial operating hours of the unit having the longest operating hours of three (3) gas turbines shall be more than 16,000 actual operating hours.
4. The minimum successful commercial operating hours of each of the three (3) gas turbines shall be not less than 6,000 actual operating hours.

Confirmation of Similarity of Proposed Gas Turbine with Reference Gas Turbines

1. The similarity between the proposed and reference gas turbines shall be confirmed by the similarity evaluation sheet which shall be submitted to the Purchaser with the Bidding Proposal.
2. The format of the similarity evaluation sheet will be prepared by the Purchaser and attached to the Bidding Documents and shall be completely filled in by the Bidder.
3. The sample of the format is provided in the draft final report.

Performance Specs of Candidate Gas Turbine with Proven Operating Experience

Manufacturer	Alstom	GE	Mitsubishi	Siemens
Type of Model	GT 26	PG9371 (FB)	M701F4	SGT5-4000F
Type of Class	F	F	F	F
Gross Power Output (MW)	292.1	284.2	312.1	292.0
Gross Thermal Efficiency (%)	38.5	37.9	39.3	39.8
Pressure Ratio	34.7	18.0	18.0	18.2
Air Flow Rate (kg/s)	653.2	654.1	702.6	692.2
Exhaust Temperature (℃)	615	642	597	577
Specific Power Output (kW/kg/s)	447	434	444	422
Fuel to Air Ratio (%)	2.37	2.34	2.31	2.16

Note 1. Above figures are made up with GT data from GTW 2010 Handbooks (Vol. 28)

2. Above figures are for ISO conditions on Natural Gas.

3. Efficiency is based on LHV of natural gas fuel.

4. LHV is assumed to be 49,000 kJ/kg.

Performance Specification of CCPP by Candidate Gas Turbine

Manufacturer	Alstom	GE	Mitsubishi	Siemens
Type of Model	KA 26-1	109FB	MPCP1(M701F)	SCC5-4000F
Model of Gas Turbine	GT 26	9FB	M701F4	SGT5-4000F
Type of Bottoming Cycle	Reheat Triple-pressure	Reheat Triple-pressure	Reheat Triple-pressure	Reheat Triple-pressure
Plant Net Power Output (MW)	424.0	437.2	464.5	423.0
Plant Net Thermal Efficiency (%)	58.3	58.6	59.5	58.4
Condenser Pressure (kPa)	-	4.1	5.1	-

Note 1. Above figures are cited from Gas Turbine World 2010 GTW Handbook (Vol. 28).
2. Above figures are for ISO conditions on Natural Gas.
3. Efficiency is based on LHV of Natural Gas.

Expected Performance Values of CCPPs by Candidate Gas Turbines at PE Point

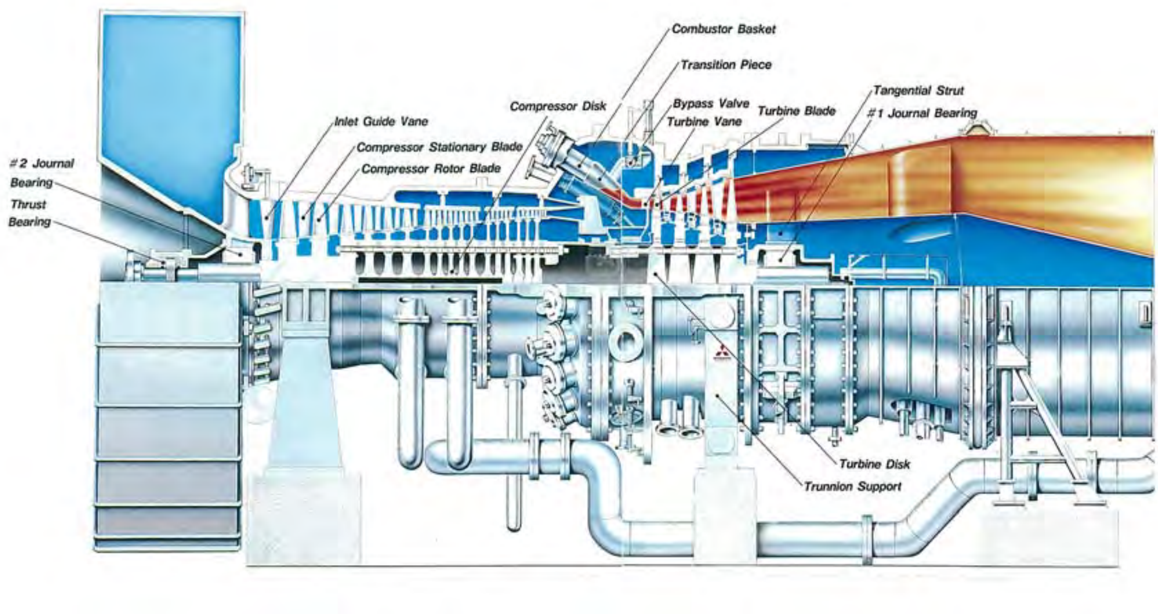
Model of Gas Turbine	GT 26	9FB	M701F4	SGT5-4000F
Plant Gross Power Output (MW)	417.0	428.7	443.8	409.9
GT Gross Power Output (MW)	274.1	274.7	297.4	274.4
ST Gross Power Output (MW)	142.9	154.0	146.4	135.5
Plant Gross Thermal Efficiency (%)	57.3	57.7	57.8	57.7
Plant Net Power Output (MW)	408.7	420.1	434.9	401.7
Plant Net Thermal Efficiency (%)	56.1	56.5	56.6	56.5

1. The requirement range of plant net power output for bidding documents should be specified at 400 MW ~ 460 MW in consideration of proper allowance. The nominal plant power output should be 420 MW as the mean value of above range.
2. The requirement of thermal efficiency for bidding documents should be specified as "not lower than 54.0 %" in consideration of proper allowance.

Design Concept for Gas Turbine Facilities

1. Open cycle single-shaft industrial heavy duty type
2. Standard design proven gas turbine with enough operating experience from OEM manufacturer
3. F class model of which turbine inlet temperature is 1,200°C to 1,300°C on ISO definition
4. Equipped with dry low NOx combustion system on natural gas
5. Maximum power output is defined at 10 °C dry bulb ambient temperature
6. Power augmentation system by evaporative type inlet air cooling is equipped

Longitudinal Cross Section of Typical Gas Turbine



Inlet Air Cooling System Study Results
Performance Parameter

Type of System	Evaporative	Fogging	Chilling
Inlet temperature drop (°C)	7.2	8.5	20.0
Augmented power output (kW)	13,200	15,600	37,600
Additional total auxiliary power (kW)	20	80	11,740
For pumps (kW)	20	80	440
For refrigerator (kW)	-	-	11,100
For cooling tower fan (kW)	-	-	200
Augmented net power output (MW)	13,180	15,520	25,860
Increased fuel consumption (kg/hour)	1,951	2,304	5,429
Heat rate (kJ HHV/kWh)	7,460	7,460	10,580

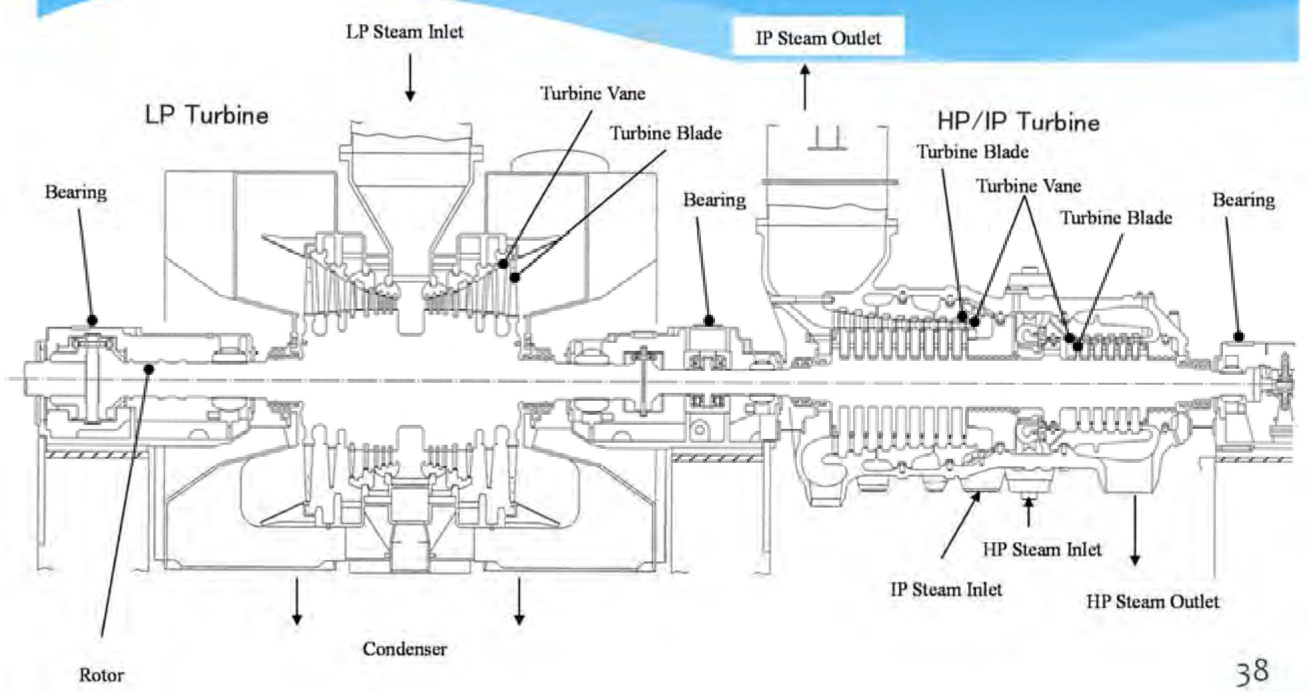
Inlet Air Cooling System Study Results
Economic Parameter

Type of System	Evaporative	Fogging	Chilling
Capital cost (1,000 US$)	1,811	1,090	19,800
Levelized annual fuel cost (1,000 US$)	1,263	1,491	3,314
Levelized annual maintenance cost (1,000 US$)	11	7	120
Total present worth (1,000 US$)	13,200	14,500	52,300
Total present worth per kW (US$/kW)	1,000	930	2,020
Generation cost (US Cent/kWh)	13.6	12.6	27.5
Capital recovery cost (US Cent/kWh)	1.9	0.95	10.4
Fuel cost (US Cent/kWh)	11.6	11.6	16.5
Maintenance cost (US Cent/kWh)	0.1	0.05	0.6

Design Concept for Steam Turbine Facilities

1. Triple mixed-pressure, full-condensing, two-casing reheat turbine with downward exhaust
2. Full admission, sliding pressure design directly connected to generator
3. Equipped with surface cooling condenser cooled with once-through circulating sea water
4. Maximum capacity is defined on operating conditions of HRSG at 10 °C dry bulb ambient temperature

Cross Section of Typical Steam Turbine



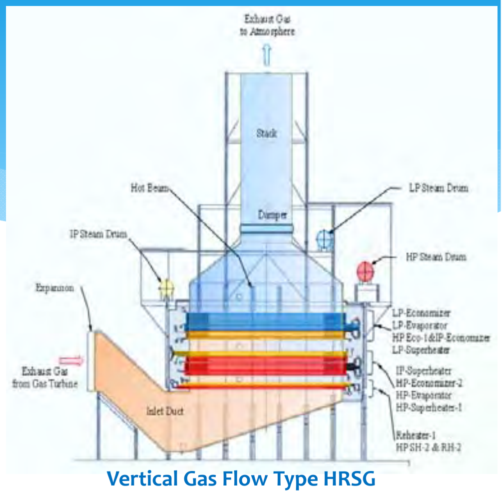
Design Features of HRSG

Heat Recovery Steam Generator (HRSG) will be of unfired, triple pressure, reheat, natural circulation or forced circulation, and in principle used in CCPP.

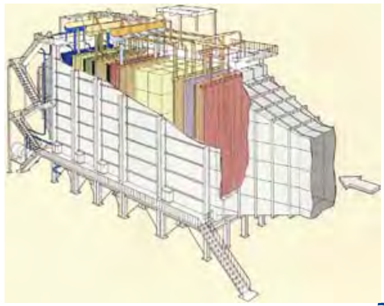
CCPP comprises one (1) gas turbine and one (1) HRSG assigned to one (1) steam turbine.

HRSG is designed to operate on the exhaust gas of the gas turbine when fired with either gas fuel or diesel oil.

An exhaust gas bypass system with bypass stack is incorporated to improve flexibility of the combined cycle operation.



Vertical Gas Flow Type HRSG



Horizontal Gas Flow Type HRSG

Common Facilities

1. Condensate and Feed Water System
2. Circulating Water System
3. Water Treatment System
4. Wastewater Treatment System
5. Auxiliary Steam System (including Auxiliary Boiler)
6. Fire Protection System, etc.

Water Treatment Plant

The source for service water and demineralized water shall be seawater for this project, even though the existing power plant have utilized the city water as a source water. Seawater desalination plant has the capacity to provide the treated water required for Rades C CCPP as well as for the existing power plants.

1. Demand of Demineralized Water

Item	Value	Remark
Demineralized water for Rades C CCPP	267 t/day	
Water for Demineralizer Regeneration	30 t/day	
Capacity of Demi. Plant (per train)	297 t/day	Say 300t/day x 2 trains

2. Demand of Service Water (Desalinated Seawater)

Item	Value	Remark
Demineralized water	297 t/day	From item a) above.
General service	20 t/day	Washing water in Building
Sealing water for pumps	51 t/day	For seawater pumps and chemical dosing pumps
HRSG blowdown drain cooling	428 t/day	
Service water for the existing TPPs Rades A & B	720t/day	
Total demmand of service water	1516 t/day	
Margin of 10%	152 t/day	
Required capacity of desalination plant per train	1,667 t/day	1,670 t/day

Water Treatment Plant

Design data for the desalination plant

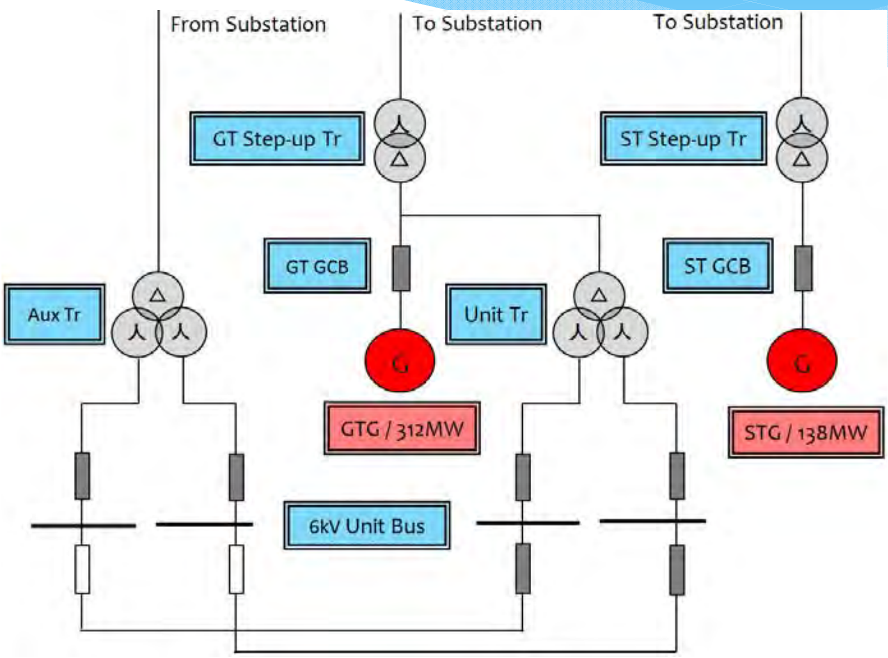
a. Installation: Indoor
b. Type: Seawater reverse osmosis
c. Number: 100% x two trains
d. Capacity: 70 t/h
e. Number of stage: To be defined by the contractor
f. Quality of treated water (typical):
   Total dissolved solid: < 10 mg/l
   Total iron: < 0.2 mg/l
   pH (@ 25°C): 6.5~7.0

Design data for Demineralized Plant

a. Installation: Steel structure (sheltered type)
b. Type: Mixed Bed Ion-Exchange Resin
c. Number: Two (2) trains
d. Capacity: 15 t/h
e. Number of stage: To be defined by the contractor
f. Quality of treated water (Typical):
   Conductivity @ 25°C: < 0.2 μS/cm
   Total Silica: < 0.02 mg/l
   Total Fe: < 0.01 mg/l
   Total Cu: < 0.005 mg/l
   CO_2: < 2 mg/l
   Sodium and Potassium: < 0.01 mg/l

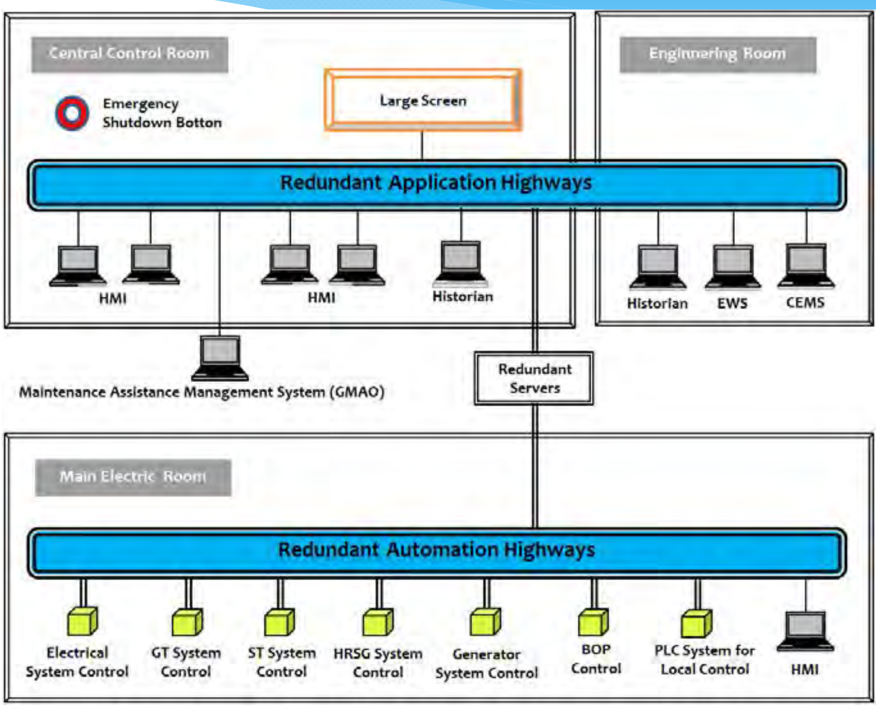
Electrical Facilities

Generator Main Circuit for Rades C in case of Multi Shaft Type Installation



C&I Facilities

Plant Control for Rades C by DCS



Civil and Architecture Facilities

1. Cooling Water Facilities
2. Tank Foundations
3. Waste Water Treatment System Foundations
4. Water Treatment System Foundations
5. Road, Drainage System and Boundary Fence
6. Switchyard Foundations
7. Stack
8. Landscaping
9. Powerhouse
10. Administration Building
11. Ancillary Buildings

Soil Layer

▼ GL±0.0= ＋2.00mNGT

GL±0.0m	Layer 1 Sandy Layer, NSPT values vary from 17 to 22
GL−7.0～−9.5m	Layer 2 Grey Clay with weak geomechanical characteristics
GL−21.0～−22.8m	Layer 3 Yellow fine sand with shell fragments with good geomechanical characteristics NSPT values vary 34/35 **This sand layer will be considered to be pile bearing layer**
GL−28.9～−30.3m	Layer 4 Grey Clay with weak geomechanical characteristics
GL−40.0m	

Location of the Cooling Water route of Rades C CCPP

Equipment Procurement Plan

Categories	Item	Procurement Countries		
		Tunisia	Other Countries	Japan (for reference)
Equipment	Gas Turbine		○	○
	Heat Recovery Steam Generator		○	○
	Steam Turbine		○	○
	Fuel Supply System	△	○	○
	Waste Water System	△	○	○
	Fire Fighting System	○	○	○
	Electrical System	○	○	○
	Protection and Control System		○	○
	Substation	○	○	○
	Transmission Line	○	○	○
	Ancillary	○	○	○
Civil and Building		○		

8. Power System Analysis and Grid Connection Plan

The objective of power system analysis

- To verify the expected impact on the power system if Rades C CCPP is installed.

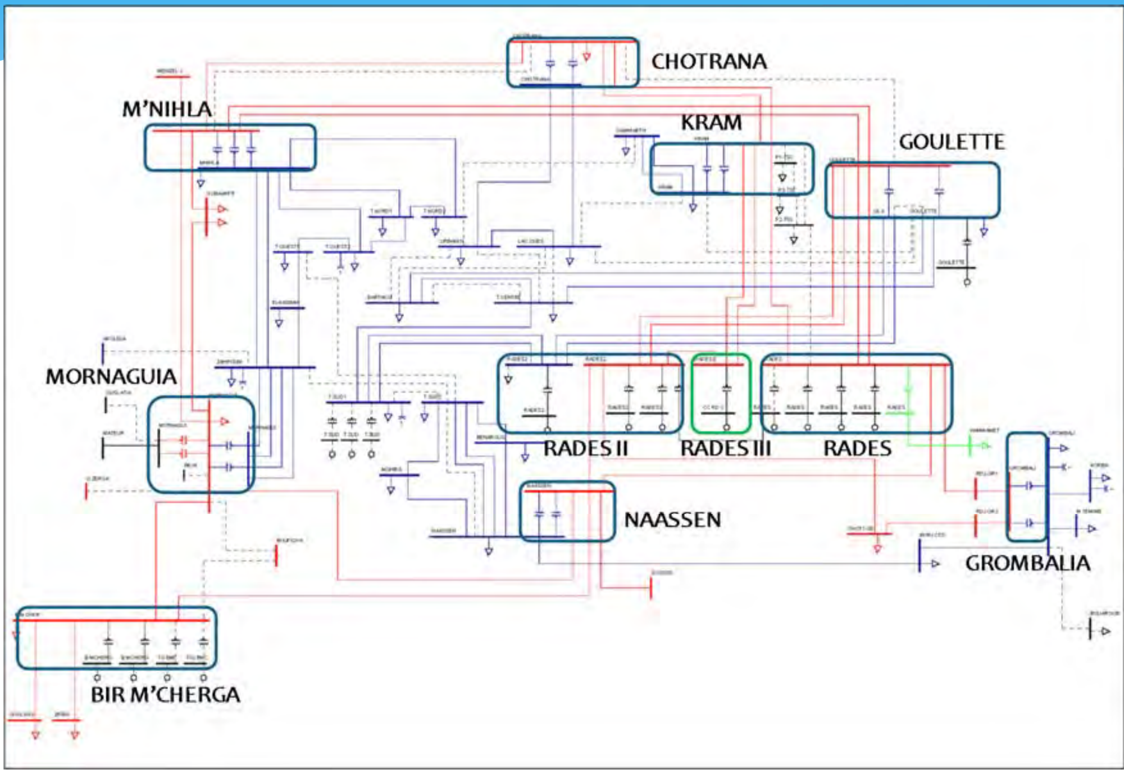
The type of power system analysis

- Power Flow Analysis
  Verify that the operating voltage will not exceed the criteria value.
  Verify that there is no overloaded equipment.
- Fault Current Analysis
  Verify that the fault current will not exceed the criteria value.
- Dynamic Stability Analysis
  Verify the system's stability even if a fault occurs in nearby Rades C CCPP.

The data of power system analysis

- Use the data provided by STEG
- The data contains a High Voltage system of the whole power system in Tunisia
- The simulated disturbance in Tunis suburbs

The system diagram of Tunis and suburbs

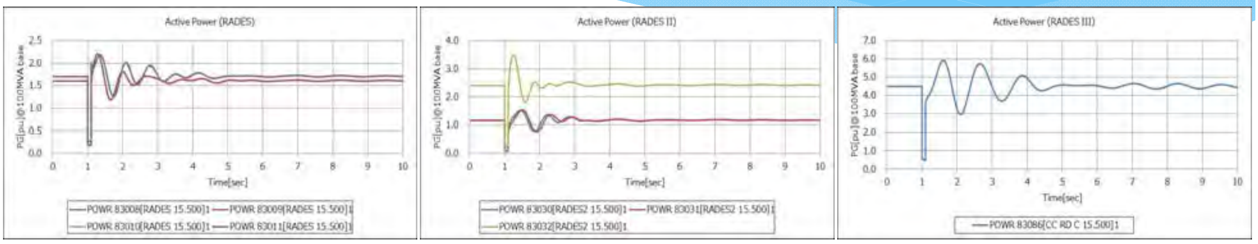


The results of power system analysis

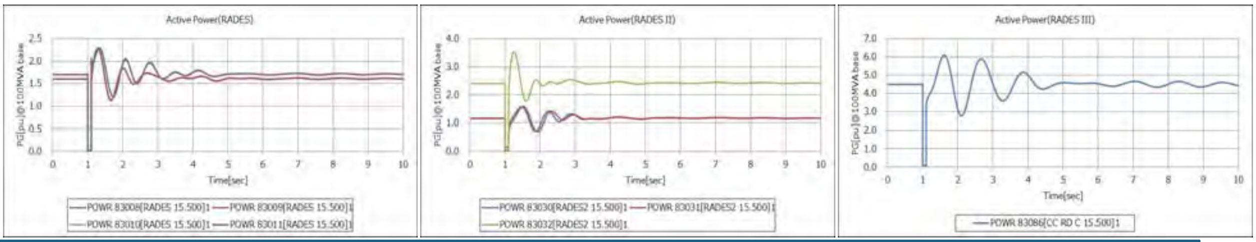
- **Power Flow Analysis**
  - In normal conditions
    - ✓ All buses voltages were with in + / - 7% from the rated voltage.
    - ✓ There was no equipment more than 100% of rated capacity.
  - In N-1 conditions
    - ✓ All buses voltages were with in + / - 10% from the rated voltage.
    - ✓ There was no equipment more than 120% of rated capacity.
- **Fault Current Analysis**
  - ✓ The fault current did not exceed the criteria current at all buses.
    - Example - The maximum fault current
      400kV bus 5.30kA at MORNAGUIA
      225kV bus 27.02kA at RADES II
      90kV bus 20.19kA at GOULETTE
- **Dynamic Stability Analysis**
  - ✓ The power system could still be operated in a stable way.

Examples of dynamic stability analysis

Fault transmission line : M'NIHLA – CHOTRANA



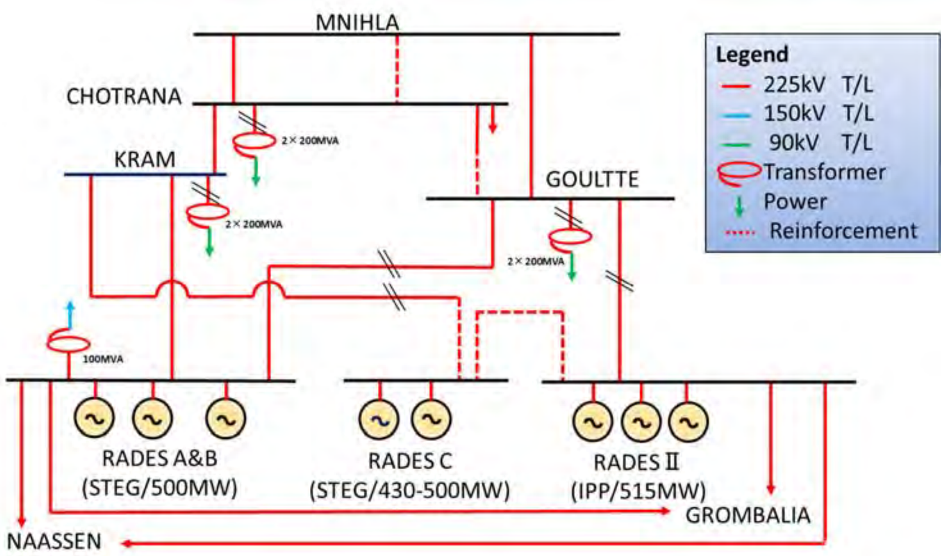
Fault transmission line : RADES – KRAM



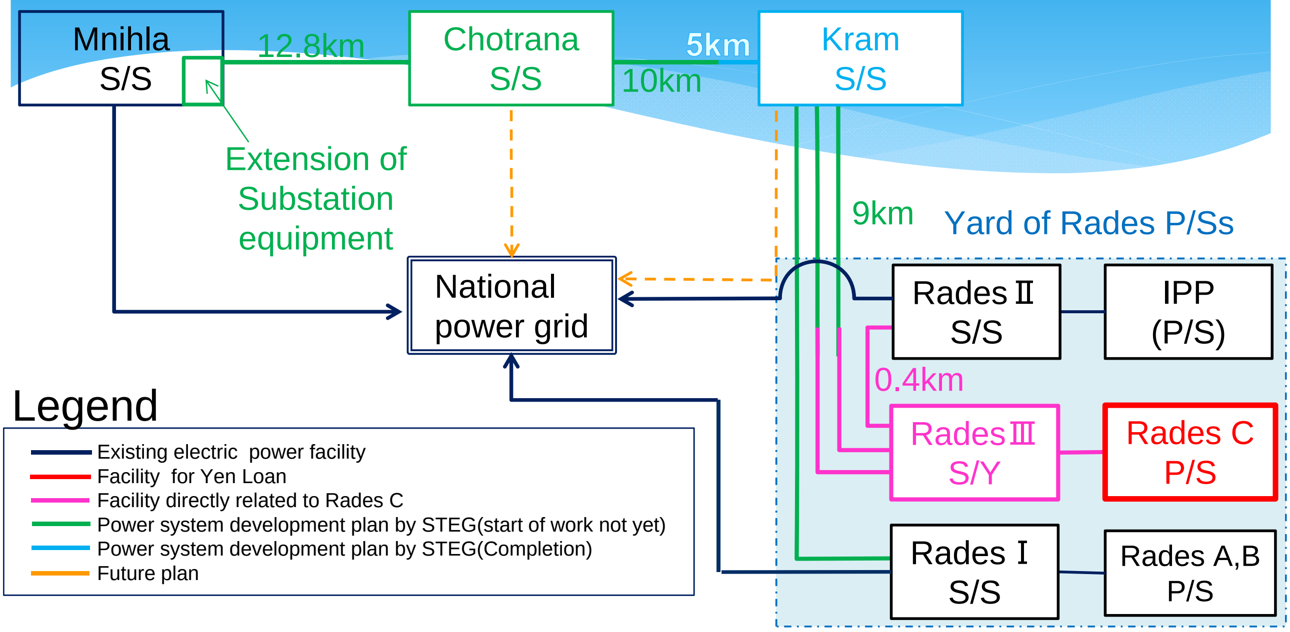
According to dynamic stability analysis, Generators power swing converge without divergence.

The power system could still be operated in a stable way.

Transmission Lines and Substation Facilities in Tunisia



Results of Transmission lines and substations survey



All transmission lines and substation for transmitting power generated by Rades C will be financed by EIB (European investment bank) and etc.

9. Environmental and Social Considerations

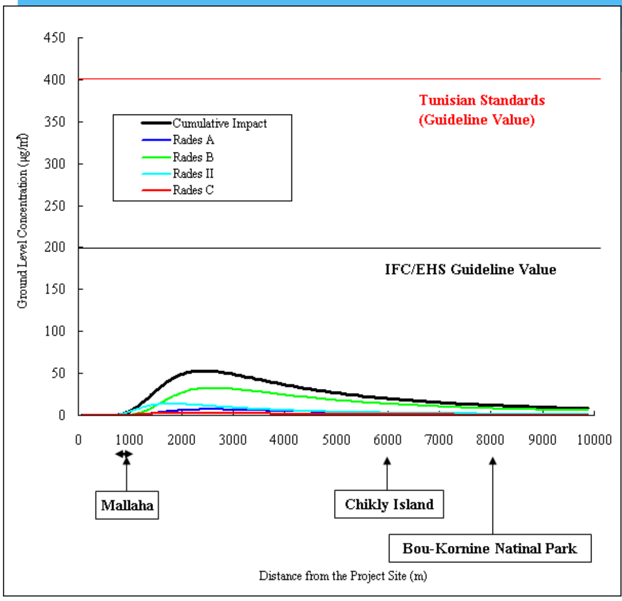
Comparison of Alternatives Including Zero Option

1. Zero Option : Predicted problem of power shortage will not be solved.
2. Comparison with Renewable Energy : Given the current technical and economic aspects, renewable energy can not replace the proposed CCCP as basic power source.
3. Alternative Site : Proposed site does not require land acquisition , resettlement of residence nor new infrastructure construction.
4. Comparison with Oil or Coal as fuel : Natural gas is best among three fuel candidates in terms of easy and stable supply from existing gas station and its friendly nature to environmental and social aspects.
5. Comparison of Power Generation Method : Combined cycle is better than other conventional thermal power generation methods.

Environmental Impact Assessment

- In accordance with Tunisian law, this project is classified as category B which is required to carry out an environmental impact assessment (EIA) by an independent outside consulting firm.
- STEG concluded a contract with a Tunisian firm (TPE) for elaborating an EIA which was finally completed in December 2013. STEG then submitted it to ANPE for approval on December 10, 2013 and received no objection letter from ANPE on February 13, 2014 (with some conditions).
- Since the project is proposed to be constructed in the same compound as existing Rades A & B power plants of STEG and just next to the Rades II IPP power plant, cumulative impacts on atmospheric diffusion as well as on thermal effluents diffusion by the four generators in total are of particular importance.
- Impacts on other environmental and social aspects are considered by the EIA not to change substantially the current situation. However, it is quite important to implement Environmental Management Plan as well as Environmental Monitoring Plan for both construction phase and operation phase and as agreed between STEG and Japanese side.

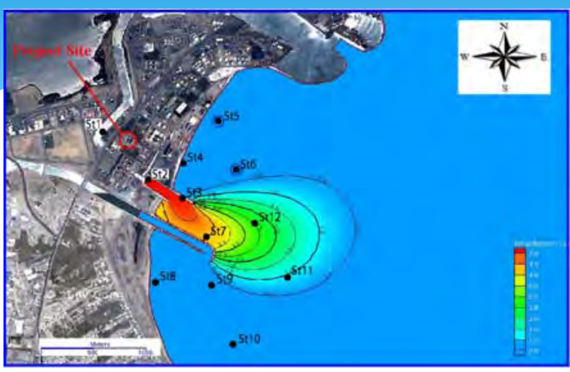
Simulation results of Atmospheric Diffusion by JICA Study Team (NO_2)



Cumulative Impact by four Power Plants
（NO2; 1 hour average time)

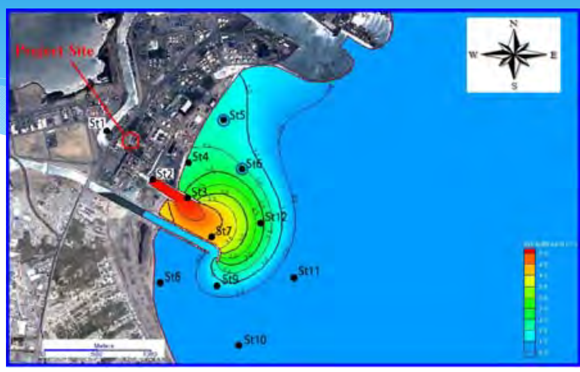
- Cumulative atmospheric diffusion by four power plants in terms of the maximum ground concentration value (1 hour average time) does not exceed the Tunisian standard (guideline value) and IFC/EHS guideline value.
- Since, the occurrence frequency of north or northeast wind, blowing towards Mallaha residential area from the project site is about 10%, our prediction of the maximum ground concentration as long term impact by four power plants, will not likely exceed even yearly standards of Tunisian Standards (Guideline Value), which is 150μg/m3.

Simulation Results of Thermal Effluents Diffusion by EIA



Note: Sea-grass bed was found at St.5 and St.6

East wind



Note: Sea-grass bed was found at St.5 and St.6

West wind

The sea-grass bed which were found by the EIA study may fall within the scope of the temperature rise of 1 °C. However, the dispersing scope is estimated to be larger than real scope in this simulation, as the calculation was made with the "2 Dimension Model", in which thermal effluents are assumed to disperse only on the surface. In addition, it is quite likely that the sea-grass bed, which is located at the bottom of the sea, will not be affected by the thermal effluents, because the thermal effluents will be diffused on the surface layer of the sea as their density is smaller than the surrounding seawater.

Stakeholders' meeting

- First stakeholders' meeting was organized on September 20, 2013 in order to explain the outline of the project to the people concerned and to obtain their opinions on the scoping as well as on the TOR of the EIA. Various organizations (central and local administration, local economic groups, NGO and local residents) participated and asked many questions, many of which were to be answered after the completion of the EIA.
- Second and third stakeholders' meetings were held on November 13 and 27, 2013 respectively, with participants from enlarged organizations including press people in the third meeting. Main findings and outcome of the EIA, namely cumulative impacts by four power plants on atmospheric diffusion and thermal effluents diffusion, were presented and active exchange of opinions and discussions were made by participants. In concluding three stakeholders' meetings, stakeholders expressed their no objection to the implementation of the project.
- By organizing three times as above, procedures were consistent with JICA's Guidelines for Environmental and Social Considerations.

Estimated Greenhouse Gas Reduction

- Since STEG is planning to construct in the future not only combined cycle power plants but also conventional power plants, applying combine margin (CM) for baseline CO_2 emission is considered to be more conservative and appropriate than applying build margin (BM).
- Using CM emission factor in Tunisia made public by IGES (Institute for Global Environmental Strategies), Japan and based on the assumption as follows, an annual reduction is estimated to be approximately 632 thousand tons of CO_2.
  - Gross power output of CCCP : 435 MW
  - Capacity factor : 85 %
  - Baseline CO_2 emission factor : 0.5360 ton/MWh
  - Project CO_2 emission factor : 0.3585 ton/MWh
- Estimated annual CO_2 emission by the project of 1,161 thousand tons is supposed to be equal to 0.004 % of the total world CO_2 generation from fossil fuel combustion in 2012 (34.5 billion tons).

Chapter 1 Preface

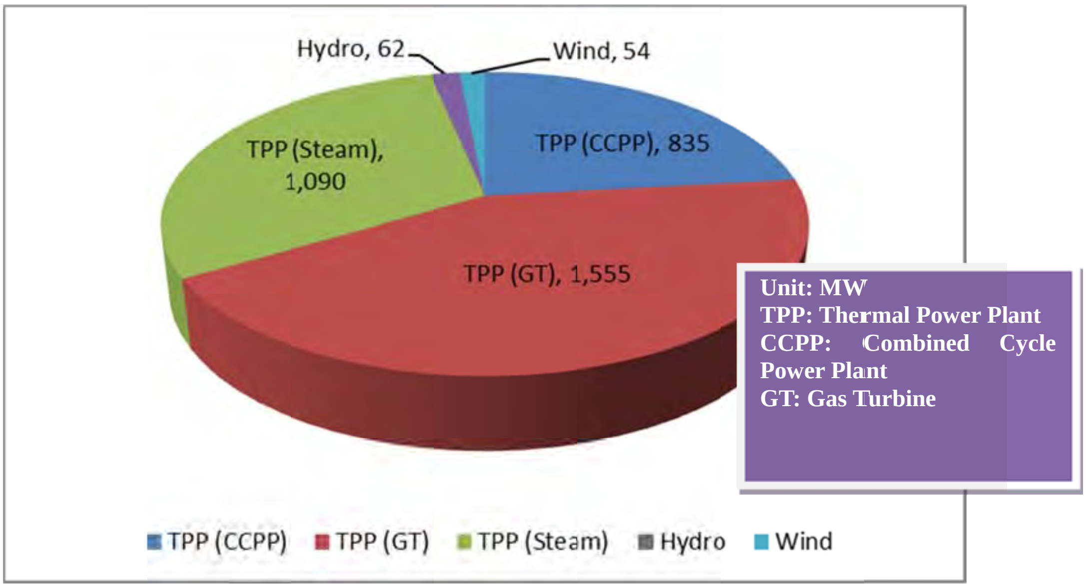
1.1 Background of Survey

The Government of Tunisia (GOT) and the Japan International Cooperation Agency (JICA) have had several preliminary discussions and confirmed the necessity of the Rades Combined Cycle Thermal Power Plant Construction Project (the Project). GOT requested a Japanese ODA Loan for the Project in August 2012 and the President of the Republic of Tunisia also requested a Japanese ODA Loan for the Project at the Tokyo International Conference on African Development (TICAD).

The scope and implementing arrangements of the Preparatory Survey are described in Chapter 4. The JICA Study Team (the Team) will investigate the feasibility of the Project including the conceptual design by a yen loan from the Japanese government which has been requested by GOT.

The background of this survey is as follows.

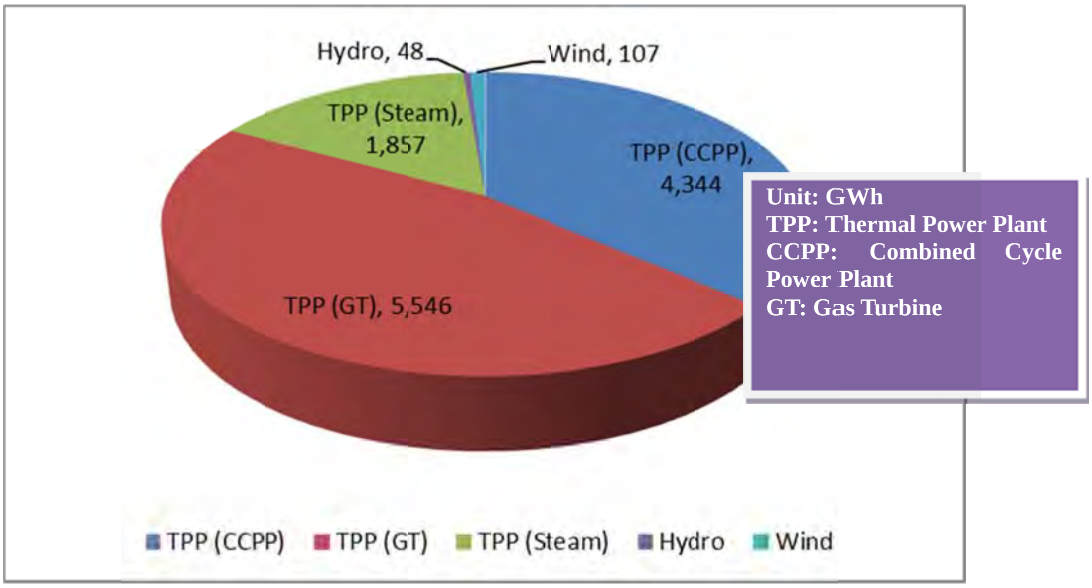
- After the Jasmine Revolution in 2011, the economy in Tunisia experienced negative growth in the same year. However, in 2012 it recovered at the annual rate of 3.6% and it is expected to have continued growth around 3.0%-4.0% for the coming years. Accordingly the demand for electricity in Tunisia is increasing and GOT has the challenge of developing new power resources.
- Société Tunisienne d'Electricité et du Gaz (the Tunisian Company of Electricity and Gas, STEG) forecasts that the rate of increase of demand for electricity between 2012 and 2016 will be 7.1% annually. In order to tackle the coming shortage of electricity, STEG is now constructing two new power stations in Sousse which will be in operation in 2014 and 2015. Even after the operation of these new power stations, Tunisia will face a power shortage in the near future.
- Therefore it is urgent to modernize existing power stations, as well as develop new power resources. Along with this economic growth, electricity demand in Tunisia has also increased. GOT is trying to develop new power plants. Although it is also trying to introduce renewable energy, the energy power source still heavily depends on thermal power plants.
  Figure 1.1-1 shows the STEG Power Generation Capacity by Type in 2010. Total generating capacity of STEG was 3,596 [MW]. Thermal Power Plants (TPPs) including steam power (Steam), combined cycle power (CCPP) and gas turbine power (GT) plants accounted for about 97% of the total power generation capacity.



Source: http://www.steg.com.tn

Figure 1.1-1 STEG Power Generation Capacity by Type in 2010

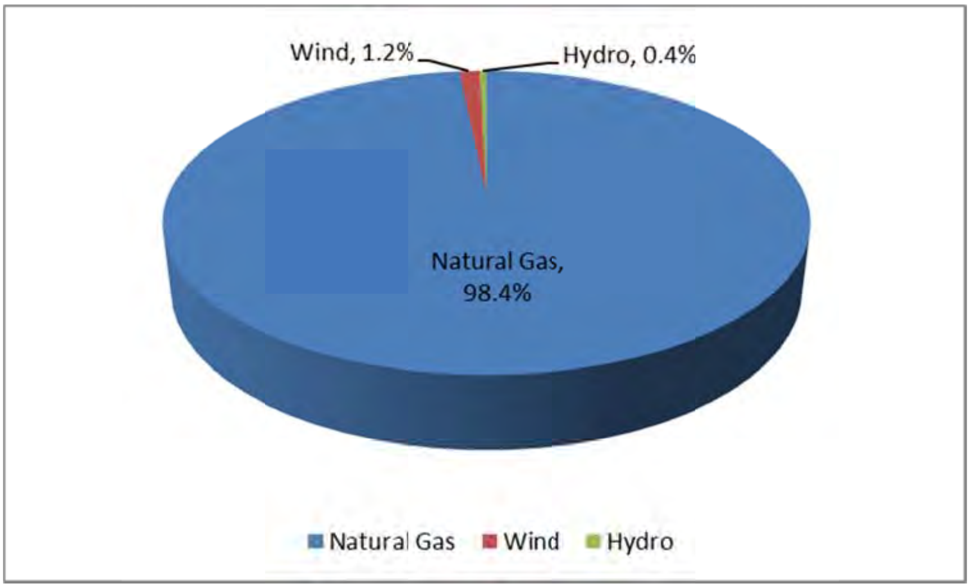
- Figure 1.1-2 shows the STEG Power Generation [GWh] by Type in 2011. Total annual power generation of STEG was 11,902 [GWh]. TPP including Steam, CCPP and GT plants accounted for about 99% of the total annual power generation.



Source: http://www.steg.com.tn

Figure 1.1-2 STEG Power Generation by Type in 2011

- Figure 1.1-3 shows the STEG Power Generation by Fuel Type in 2010. Natural gas accounted for 98% in total. However, as shown in Figures 1.1-1 and 1.1-2, the majority of natural gas is needed for thermal power plants. Plant efficiency by Steam and GT is low so that it is necessary for high-efficiency CCPPs to be installed instead of Steams and GTs as an urgent issue.



Source: http://www.steg.com.tn

Figure 1.1-3 STEG Power Generation by Fuel Type in 2010

- According to power demand forecasts of the entire country by STEG, demand will increase 7.1% a year for 2012-2016. To cope with power shortages in the future, STEG plans to operate new thermal power plants in Sousse by 2015. However, even after the operation of the Sousse C and D CCPP, power shortages are expected. Therefore it is necessary that new power development and modernization of existing power plants be executed urgently.
- The Project is to construct a new CCPP (430-500 MW equivalent) in Rades, near Tunis, to develop power generation capacity and make the power system stable.
- The primary objective of this preparatory survey is to confirm the feasibility of the Project based upon the official request for a Japanese ODA loan submitted by GOT in August 2012.

1.2 Purpose of Survey and Scope of Survey

1.2.1 Purpose of Survey

The purpose of the survey of the Project is to examine various aspects of the project such as technical and economic feasibility, environmental and social considerations and formulate a suitable project for Japanese ODA loan.

1.2.2 Scope of Survey

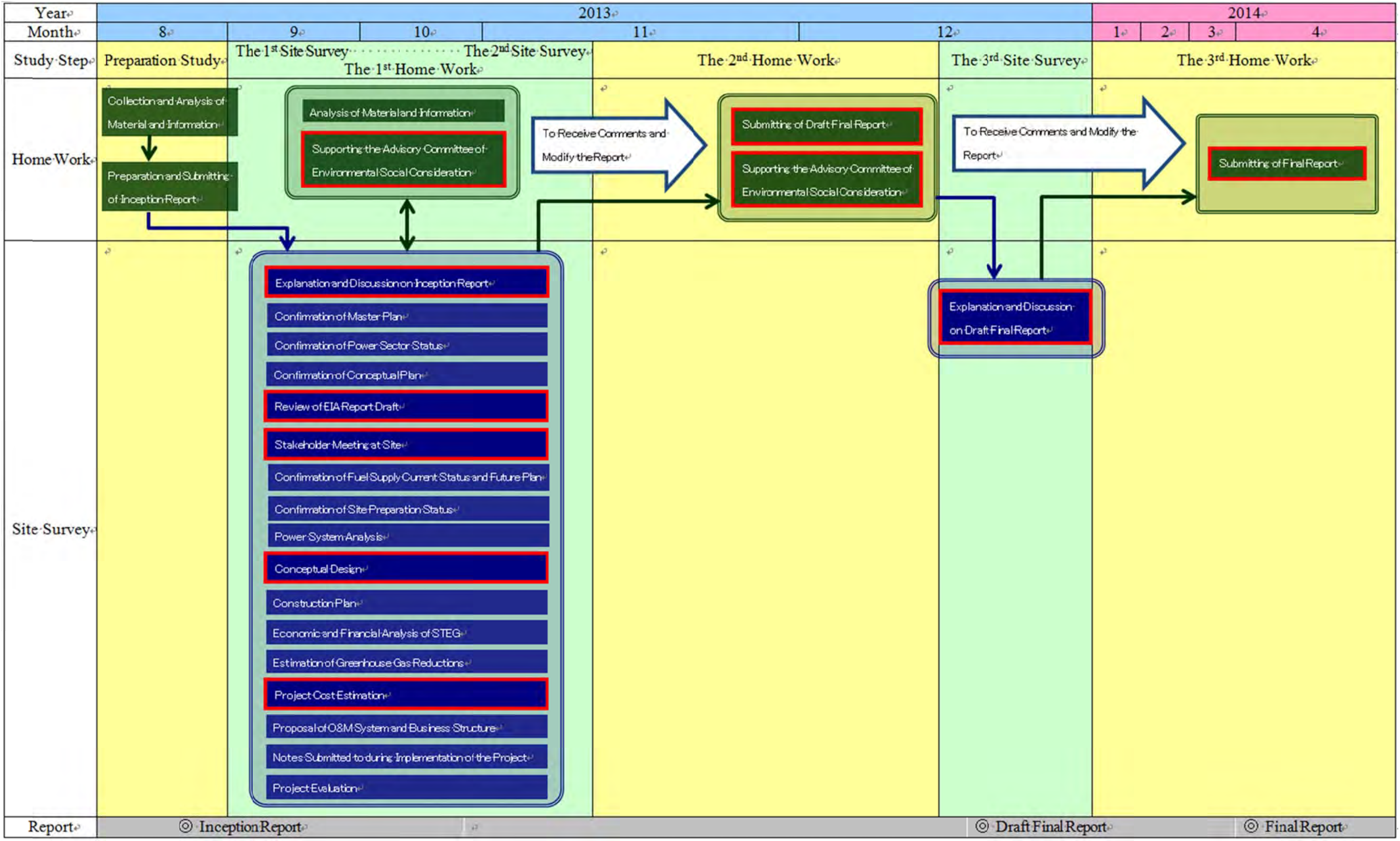
The scope of this survey is as follows:

(1) Confirmation of the power development plan studied by power sector of Tunisia
(2) Collection and confirmation of information about the power sector
(3) Collection and confirmation of information related to the modernization of the Rades Thermal Power Plant
(4) Check and review of the conceptual plan
(5) Check and review of the Environmental Impact Assessment (EIA) Report
(6) Check of the current situation and future prospect of fuel supply

(7) Check and examination intake and discharge water system
(8) Check of the present conditions of the Project candidate sites
(9) Support of holding a meeting with stakeholders on the site
(10) Support of the Advisory Committee in JICA related to environmental issues
(11) Survey on electrical network systems
(12) Supplementary survey of the EIA Report
(13) Conceptual design
(14) Inland transportation and construction plan
(15) Estimation of project cost
(16) Proposal about the Project scope for a yen loan
(17) Proposal about the implementation organization, management and operation and maintenance systems
(18) Survey related to project evaluation

1.2.3 Duration of the Study

A Schedule of the Study is shown on the next page.



Source: JICA Study Team

Figure 1.2.3-1 Schedule of the Study

1.3 Organization of the Team

The Team for the Survey is a consultant, Tokyo Electric Power Service Co., Ltd (TEPSCO), which has been entrusted by JICA with the consulting services for the Survey. The composition and designation of the Team is shown in Figure 1.3-1.

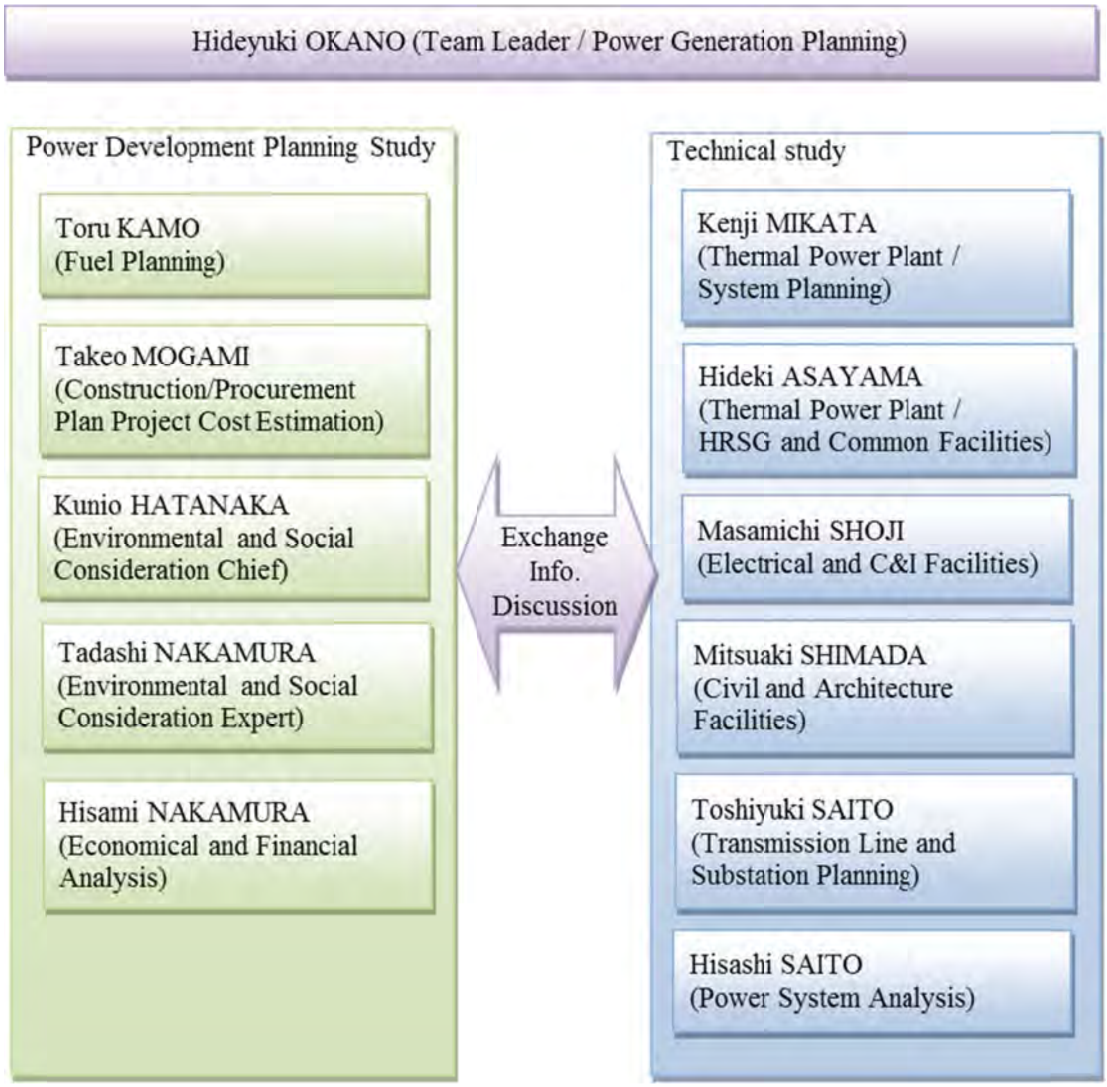


Figure 1.3-1 JICA Study Team

Chapter 2 Socio-economic Situation

2.1 Overview

2.1.1 Geography and Climate

Tunisia is located in the eastern portion of North Africa. It is bounded on the west by Algeria, on the north and east by the Mediterranean Sea, and on the southeast by Libya. Tunisia is at the crossroads of Europe, the Middle East and Africa. The total area of land is 162,155 km^2 with a long coastline of 1300 km which opens onto the Mediterranean.

The county has a variety of climates: the Mediterranean climate in the north and on the east coast, semiarid inland and Saharan in the south. The temperature of the country is the highest of 29.3°C in average in summer (July) in the south and the lowest of 11.4°C in average in winter (December) in the north. Rainfall is irregular but is concentrated during the cold season (3/4 of the total yearly rainfall). Rainfall amounts differ by region: 800 mm in the north, and 50 to 150 mm in the south.

2.1.2 Administrative Organization

Tunisia is divided into 24 governorates, which are the largest administrative division of the national territory[1]. Each governorate is subdivided into delegations which in turn are divided into sectors, called *Imada*, which represent the smallest administrative unit. On average, there are eight sectors per delegation. The country is made up of 264 delegations, which are divided into 2083 sectors.

In addition, there is another type of subdivision of the territory representing another partition of the country into municipal and non-municipal areas. These areas are labeled as municipal for town-planning purposes and are not necessarily related to the aforementioned administrative zoning. There are 264 communes (municipal areas) as of December 31, 2012.

The governors, delegates and village/ tribe leaders (*omdas*) who are respectively the chief regional authorities at the governorate, delegation and sector levels, are designated as civil servants. The municipality president and the members of the municipal councils are elected. Municipal elections take place every five years.

[1] Under the terms of a decree dated June 21st, 1956 and amended by the law of March 17th, 1969.

Table 2.1.2-1 Number of Subdivisions

Governorate	Number of Communes		Number of Sectors		Number of Delegations	
	As of 31/12/1990	As of 12/31/2012	As of 12/31/1990	As of 12/31/2012	As of 12/31/1990	As of 12/31/2012
Tunis	6	8	121	163	14	21
Ariana	11	6	67	48	8	7
Manouba	-	9	-	47	-	8
Ben Arous	8	11	46	76	7	12
Nabeul	23	24	90	102	15	16
Zaghouan	5	6	42	48	5	6
Bizerte	13	13	85	102	12	14
Béja	7	8	95	101	8	9
Jendouba	8	8	85	95	6	9
Le Kef	12	12	81	87	10	11
Siliana	10	10	79	86	9	11
Kairouan	12	12	110	114	11	11
Kasserine	10	10	93	106	12	13
Sidi Bouzid	9	10	105	113	11	12
Sousse	14	16	95	105	14	16
Monastir	31	31	70	79	13	13
Mahdia	14	14	94	99	10	11
Sfax	14	16	119	126	13	16
Gafsa	8	8	68	76	10	11
Tozeur	5	5	34	36	5	5
Kebili	5	5	33	43	4	6
Gabes	9	10	68	73	9	10
Medenine	7	7	87	94	8	9
Tataouine	5	5	54	64	6	7
Total	246	264	1821	2083	220	264

Source: National Institute of Statistics – Tunisia website (http://www.ins.nat.tn/indexen.php, as of October, 2013)

2.1.3 Political Situation

After obtaining independence from France in 1956, the Republic of Tunisia began in 1957. The Constitution of Tunisia was promulgated in 1959 and as of 2013, a new constitution is being drafted. In November, 2011, an election for a constituent assembly was held. It was the first free election in Tunisia since its independence. The Constituent Assembly appointed a Chairman of the Assembly and elected a President. Then, the President appointed a Prime Minister and the Prime Minister formed a new Cabinet in December, 2011.

Despite the political efforts for democratization and liberalization, the political situation of the country has been unstable and in turmoil. The current Cabinet led by Prime Minister Ali Laarayedh announced general elections for December, 2013, in order to establish a government in a democratic process and to ease political tension.

2.2 Socio-economic Conditions

2.2.1 Population

The total population of Tunisia was 10.777 million in 2012 which slightly increased from

10.328 million in 2008. The average annual population growth is 1.1%. The governorate with the largest population is Tunis. It is the sole governorate with a population of more than one million. The second largest governorate is Sfax with a population of 0.955 million. Besides Tunis and Sfax, the population tends to concentrate in the governorates located in the coastal areas, such as Nabeul, Sousse, Ben Arous, and so on.

Table 2.2.1-1 Population by Governorate (2008-2012)

(Unit: thousands)

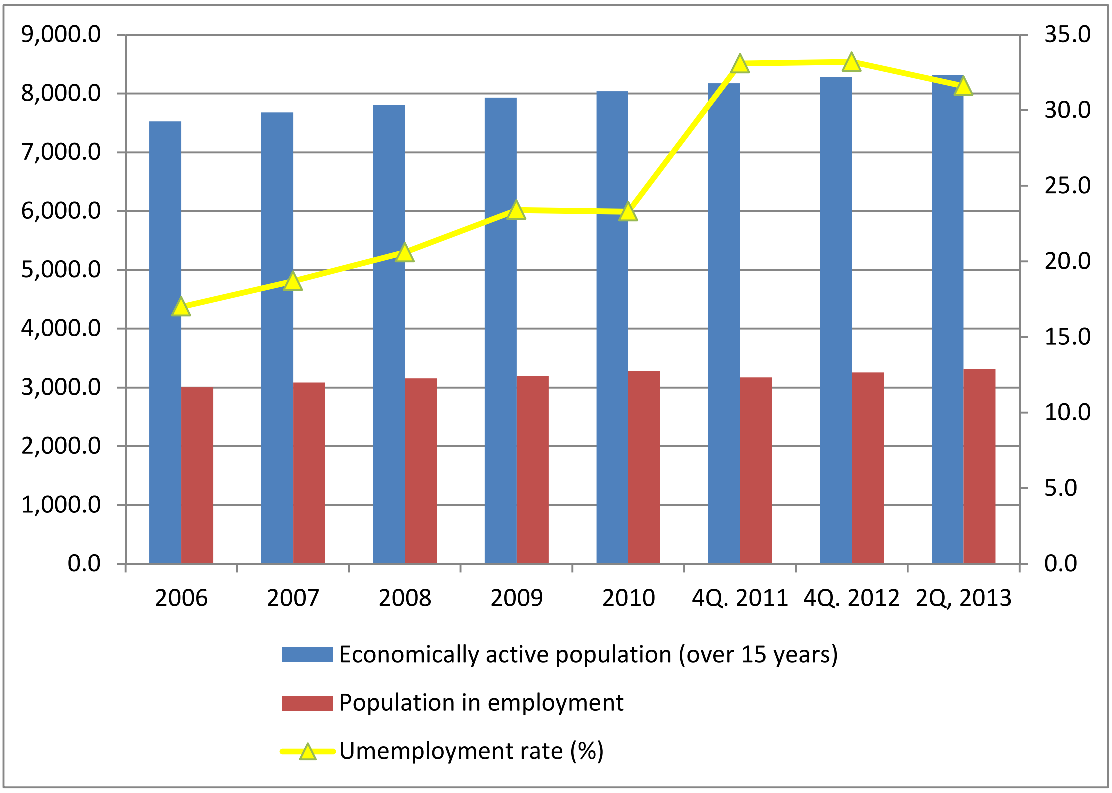
Year	2008	2009	2010	2011	2012
Tunis	993.9	996.4	999.7	1002.9	1003.7
Ariana	473.2	483.5	498.7	510.5	528.5
Ben Arous	555.4	565.5	577.2	588.7	600.9
Manouba	358	363	367.9	375.3	375.7
Nabeul	733.6	744.2	752.5	762.6	773.1
Zaghouan	167	169.4	170.4	172.3	174
Bizerte	539	543.2	546.7	551.5	556
Béja	304.4	304.7	305.7	307.3	305.4
Jendouba	420.7	422.3	423.2	426	424.2
Le Kef	256.8	257	256.5	258.1	255.1
Siliana	233.3	234.1	234	235.3	234
Kairouan	554.3	558.2	560.7	564.9	566.7
Kasserine	424.9	427.7	432.3	437.2	438.4
Sidi Bouzid	406.2	408.8	412.6	415.9	417.9
Sousse	590.1	600.4	612.1	622.1	641.7
Monastir	494.9	505.2	515.4	525.5	539.4
Mahdia	389.8	394.1	395.3	400.4	400.5
Sfax	905	918.5	930.1	944.5	955.5
Gafsa	332.4	335.1	338.4	341.7	344.5
Tozeur	101.3	102.3	103.5	104.8	105.9
Kébili	147.8	148.6	150.9	152.2	154.3
Gabés	354.6	358.3	361.2	366.1	367.5
Médenine	447.5	453.3	456	460	466.7
Tataouine	144.6	145.8	146	148	146.8
Total	10,328.9	10,439.6	10,547.1	10,673.8	10,777.5

Source: National Institute of Statistics – Tunisia website (http://www.ins.nat.tn/indexen.php, as of October, 2013)

2.2.2 Labor Force

The economically active population over 15 years of age of the country was 8.315 million in the second quarter of 2013. This means that around 75% of the total population is considered to be possibly engaged in some economic activities. However, only about 40% of the economically active population is actually engaged in economic activities. In addition, the unemployment rate of the country has rapidly deteriorated. For the period from 2006 to the second quarter of 2013, it dramatically increased from 17% to 31.6%, despite some fluctuation. Namely, one third of the population seeking employment cannot obtain employment under the current situation.

Around 90% of the unemployed population is under 30 years old. In particular, unemployment of university graduates is a serious problem. While 65,000 students graduate from university annually, approximately 20% of the university graduates cannot find employment. Therefore, job creation for the younger generation, in particular for those with higher education, has been a key issue to mitigate social instability.



Source: National Institute of Statistics – Tunisia website (http://www.ins.nat.tn/indexen.php, as of October, 2013)

Figure 2.2.2-1 Labor Force and Unemployment

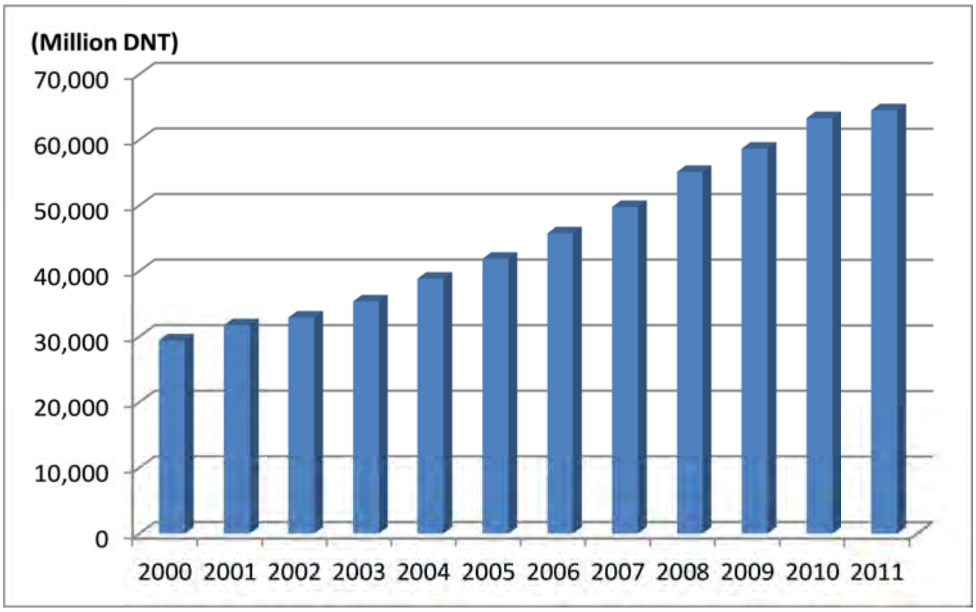
2.3 Macroeconomic Conditions

2.3.1 Gross Domestic Product

For the last decade, the Tunisian economy has had steady average growth. The Gross Domestic Product (GDP) at market price increased from 29.43 billion Tunisian dinars (TND) in 2000 to 64.56 billion TND in 2011. The average annual GDP growth rates are 5.2% for the five years under the 9th Development Plan (1997-2001), and 4.6% for the five years under the 10th Development Plan (2002-2006). Although the Tunisian economy experienced higher growth at 6.3% in 2007, the momentum was not able to be sustained. The annual growth rate decreased to 4.5% in 2008 and 3.1% in 2009 and 2010, respectively.

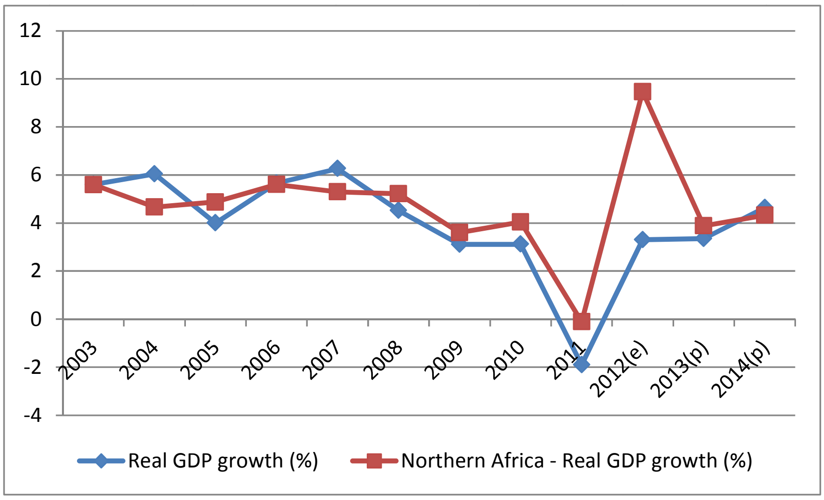
However, it turned to negative growth of 1.9% in 2011. After stagnation in 2011, the economy rebounded by 3.3% in 2012[2]. According to a projection by the Organization for Economic Cooperation and Development (OECD), the growth rate of real GDP is projected to be 3.4% in 2013 and 4.6% in 2014.

[2] The figure is estimation by OECD.



Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

Figure 2.3.1-1 GDP at Market Price (2000-2011)



Source: Organization for Economic Cooperation and Development, "African Economic Outlook", (http://www.africaneconomicoutlook.org/en/countries/north-africa/tunisia/ as of October, 2013)

Figure 2.3.1-2 GDP Growth of Tunisia and Northern Africa (2003-2014)

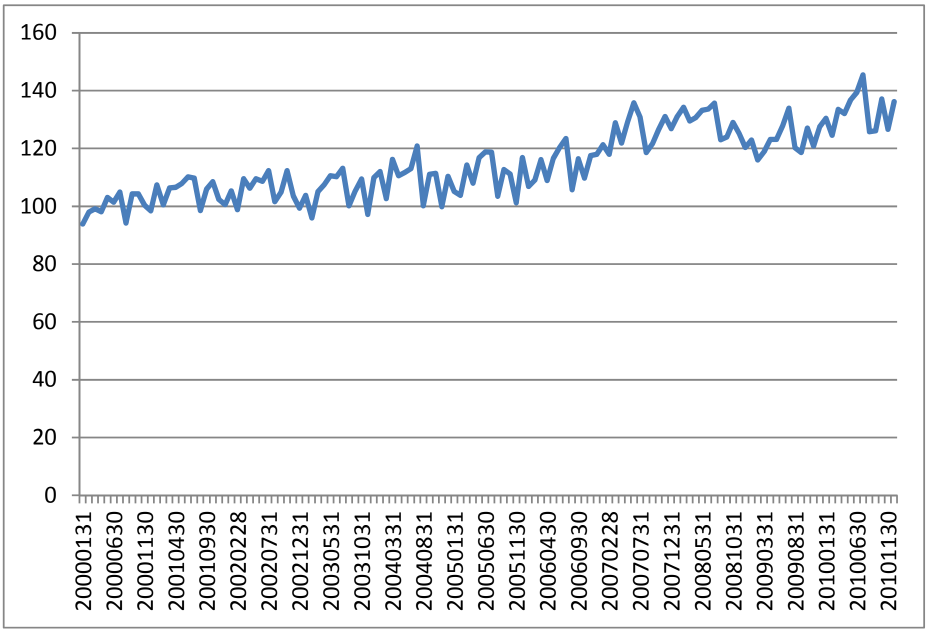
In the past, the Tunisian economy depended on the agriculture and natural resource sectors, including oil and phosphate. Over recent years, the economic structure has been diversified and the key economic sectors have shifted to the manufacturing and service sectors including tourism, transportation and information and communication technology (ICT).

On the other hand, a good agricultural season contributed to macroeconomic recovery in 2012. Also, a recovery of hydrocarbon and phosphate production led the growth. In addition, a relative recovery in tourism and foreign direct investment (FDI) pushed the upturn of the economy. While the European economic crisis and a decline in external demand adversely affected the exports of Tunisia, in particular, textiles, machinery, and electricity, overall production benefited from a more stable social climate in 2011 and continuous growth of domestic demand.

Political uncertainty constrains speedy economic decision making and strong economic recovery. It is expected that reforms to reduce high unemployment and the large deficits in the current account and budget should be achieved in order to bring about a stable climate for the restoration of investors' and public confidence.

2.3.2 Production Index

The industrial production index of the country has had upward trends for the last decade despite fluctuations as well. Based on the production level in 2000, the production index reached over 136 at the end of 2010. The vital manufacturing sector contributed to the expansion of industrial production. However, since the major players in the manufacturing sector in Tunisia have been export-oriented industries, such as textiles, machinery and electricity, the manufacturing sector was severely hit by lower demand from Europe due to the financial crisis in 2010. In 2012, hydrocarbon production contributed to a recovery of the Tunisian economy due to increased exports at favorable world prices.

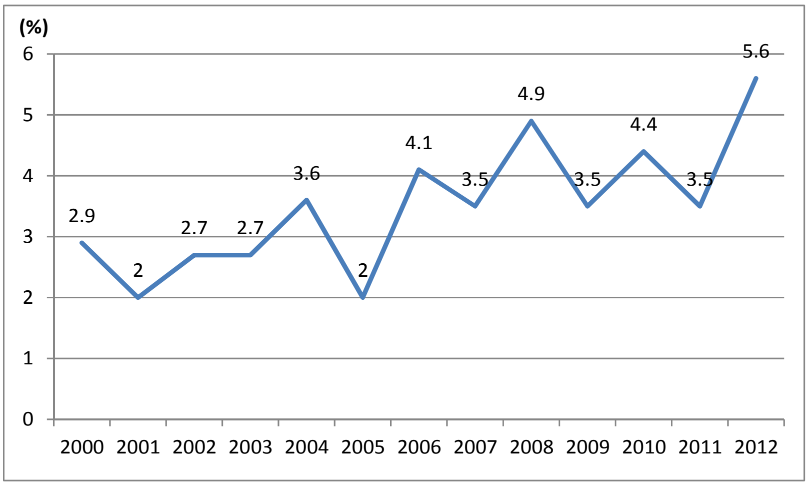


Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

Figure 2.3.2-1 Industrial Production Index (2000=100) (2000-2012)

2.3.3 Inflation and Monetary Supply

For the last 10 years, the inflation rate has been increasing. At the beginning of the 2000s, the inflation rate maintained low levels of around 2-3%. However, it ranged between 3.5% and 5% and reached 5.6% in 2012. Higher inflation was driven by higher international prices of certain imported goods, a depreciation of the dinar, expansionary fiscal policy allowing a larger payroll, weaker price controls, distorted distribution networks, and the smuggling of goods to neighbouring countries.



Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

Figure 2.3.3-1 Inflation Rate (2000-2012)

2.3.4 Balance of Payment

The trade balance of Tunisia has been in deficit and the trade deficit has been growing in terms of a percentage of GDP. It expanded from 7.9% in 2004 to 10.1% in 2012, and is projected to reach 13% in 2014. While the percentage of export value in GDP has been increasing from 31.5% in 2004 to 40% in 2012, the percentage of import value in GDP has also been increasing from 39.4% to 50.1% for the same period.

For many years, Tunisia has been committed to trade liberalization under the partnership with the European Union (EU). However, the European financial crisis hit the foreign trade of the country. In addition, the rise in international prices and the devaluation of the dinar induced the trade deficit to expand by 35%.

Table 2.3.4-1 Balance of Payment (% of GDP)

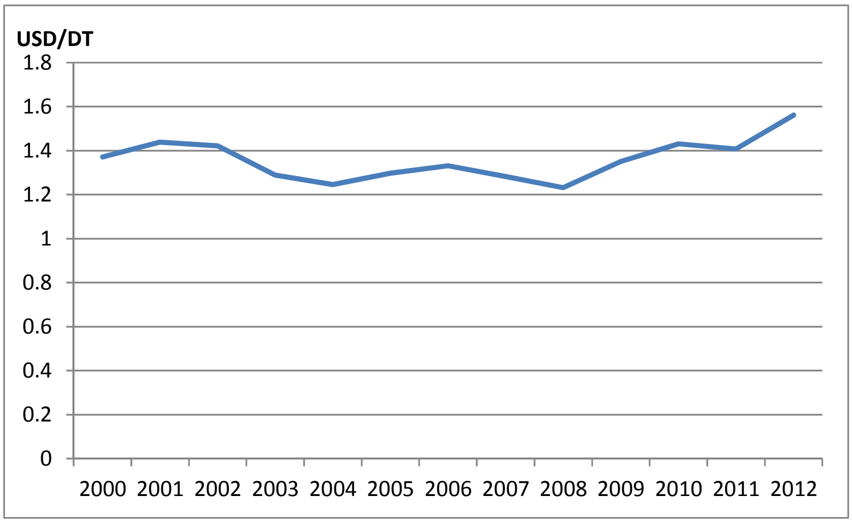
	2004	2009	2010	2011	2012	2013	2014
Trade balance	-7.9	-8.5	-7.6	-10.4	-11.8	-13.0	
Exports of goods (f.o.b.)	31.5	33.1	37,1	38.8	40.0	37.6	37.1
Imports of goods (f.o.b.)	39.4	41.6	44.6	49.2	50.1	49.4	50.1
Services	4.8	5.8	5.6	3.4	2.8	4.6	6.3
Factor income	0.4	-0.7	-1.7	-1.7	-1.8	-1.5	-1.1
Current transfers	0.4	0.5	-1.1	1.3	1.1	1.2	1.1
Current account balance	-2.4	-2.8	-4.8	-7.4	-8.0	-7.5	-6.7

Source: Organization for Economic Cooperation and Development, "African Economic Outlook", (http://www.africaneconomicoutlook.org/en/countries/north-africa/tunisia/ as of October, 2013)

2.3.5 Exchange Rate

The exchange rate of the Tunisian dinar (TND) against the US dollar (USD) has had a depreciating trend. It appreciated from 1.3707 USD/TND on average in 2000 to 1.2455 USD/DNT in 2004, but it has depreciated since 2009. In particular, it sharply devalued from 1.4078 USS/DNT in 2011 to 1.5618 USD/DNT in 2012. Also, the exchange rate against the euro (EUR) has depreciated. The trend of depreciation of the TND against key international currencies has been attributed to the sluggish of macroeconomic performance of the country.

In 2012, the annual average depreciation of the DNT was 2.5% against the EUR and 9.9% against USD. This was because of the depreciation of the EUR against the USD over 2012.



Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

Figure 2.3.5-1 Exchange Rate (USD/DNT) (2000-2012)

Since April 2012, the Central Bank of Tunisia (Banque Centrale de Tunisie) has adopted a more flexible approach to manage the exchange rate, and has based its reference rate on the average interbank exchange rate rather than a currency basket.

2.4 Government Finance and External Debt

2.4.1 Public Finance

After the revolution in January 2011, the Tunisian government has been making efforts to respond to pressing socioeconomic demands. Under such situation, an expansionary fiscal policy was taken in order to support a recovery and to boost public investment and consumption. However, this brought about an increase in the budget deficit. While the percentage of total revenue and grants in GDP was maintained in the range of 23-25% from 2009 to 2012, the percentage of total expenditure increased from 26.1% in 2009 to 31% in 2012. As a result, not only the primary balance but also the overall balance has deteriorated. The overall deficit reached 6% of GDP in 2012.

In order to improve public finance, the government announced adjustments to the prices of hydrocarbon products for 2013. It is a key policy challenge for the government to reform the subsidy system, particularly for fuels. However, these reforms may be accompanied by political difficulty.

Table 2.4.1-1 Public Finance (% of GDP)

	2009	2010	2011	2012	2013	2014
Total revenue and grants	23.4	23.4	25.7	25	25	25.3
Tax revenue	19.9	20	21.1	20.9	20.5	20.4
Oil revenue	-	-	-	-	-	-
Grants	0.3	0.1	0.6	0.2	0.5	1
Total expenditure and net lending (a)	26.1	24.3	29	31	30.9	30.1
Current expenditure	17.9	17.6	21.1	23.8	23.2	22.5
Excluding interest	15.9	15.8	19.3	21.3	21.4	21.2
Wages and salaries	10.7	10.7	11.9	11.4	11.2	11.4
Interest	2	1.8	1.8	2.6	1.9	1.3
Primary balance	-0.7	0.8	-1.5	-3.5	-4	-3.5
Overall balance	-2.7	-1	-3.4	-6	-5.9	-4.8

Source: Organization for Economic Cooperation and Development, "African Economic Outlook", (http://www.africaneconomicoutlook.org/en/countries/north-africa/tunisia/ as of October, 2013)

2.4.2 External Debt

The total external debt outstanding has been expanding from 17,550 million TND in 2003 to 25,391 million TND in 2011. On the other hand, the percentage of external debt outstanding in GDP decreased from 49.6% to 38.8% for the same period. Debt service, including principal and interest payment, increased from 1,402 million TND in 2003 to 2,991 million TND in 2006, then decreased to 1,757 million TND in 2008. Due to the depreciation of the dinar against the EUR and USD, the external debt service increased again to 2,313 million TND in 2009 and to 2,892 million TD in 2011. The debt service ratio in percentage of current receipts improved from 13.3% in 2003 to 7.7% in 2008. After that, it was maintained at around 10% from 2009 to 2011.

Table 2.4.2-1 External Debt Outstanding and Indicators

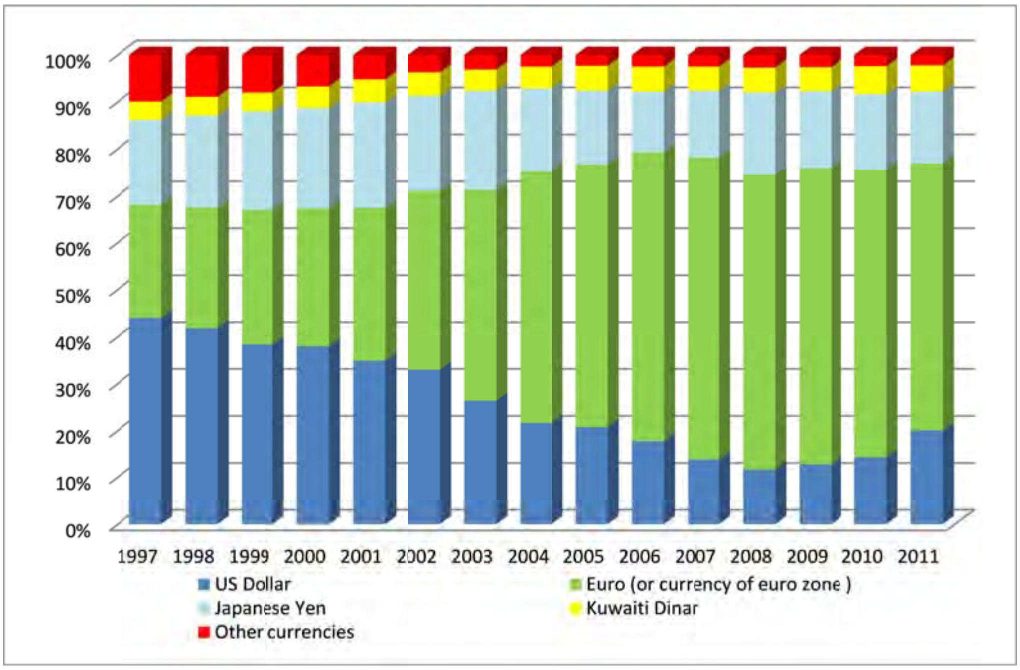
(Unit: TND millions)

Items	2003	2004	2005	2006	2007	2008	2009	2010	2011
Debt outstanding	17,550	19,408	20,373	19,683	19,728	21,301	21,977	23,582	25,391
Administration	12,529	13,209	14,025	13,286	13,300	14,560	14,716	15,551	16,690
Enterprises	5,021	6,199	6,348	6,397	6,428	6,741	7,261	8,031	8,701
Rate of indebtedness									
Outstanding/GANI in %	49,2	49,6	48,9	43,0	39,7	38,9	37,3	36,9	38,8
Outstanding/GDP in %	49,6	50,0	48,7	43,0	39,6	38,6	37,4	37,1	38,8
Service of debt	2,122	2,662	2,716	3,881	3,334	2,621	3,184	3,269	3,737
Principal	1,402	1,885	1,876	2,991	2,447	1,757	2,313	2,434	2,892
Interest	720	777	840	890	887	864	871	835	845
Debt service ratio									
In % of current receipts	13,3	14,3	12,8	16,4	11,7	7,7	10,6	9,3	10,6

Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

The structure of external debt by currency has changed over the last 15 years. In the late 1990s, around 40% of external debt was financed by US dollars and around 25-30% was financed by the euro. While the proportion of debt in EUR has been drastically expanded to more than

50% in the 2000s, the proportion of debt in USD has been reduced to around 20%. The proportion of debt in JPY has been in the 10-20% range for the same period.



Source: Bank Central de Tunisie, "Statistics", website of Bank Central de Tunisie (http://www.bct.gov.tn/bct/siteprod/english/indicateurs/comptes.jsp, as of October, 2013)

Figure 2.4.2-1 External Debt Outstanding by Currency (%)

Chapter 3 Overview of the Power Sector in Tunisia

3.1 Overview of the Power Sector in Tunisia

3.1.1 Organization

The Tunisian Company of Electricity and Gas (STEG), as a public and a non-administrative company, has the essential role to:

- Electrify the country
- Develop natural gas network
- Realize electrification and gas infrastructure

STEG is responsible for electricity and liquefied petroleum gas (LPG) generation. It is also responsible for the transmission and distribution of electricity and natural gas. STEG produces LPG and electrical energy, and provides the transport and distribution of electricity as well as natural gas on a national scale. Its principal objective is to provide electric energy and gas to the national market and meet the total needs of its customers (residential, industrial, tertiary, etc.).

- Production of electricity starting from various sources (thermal, hydraulics, wind mill, etc.).
- Transport of electricity: Management and development of the networks and high voltage stations.
- Distribution of electricity: Management and development of the networks and the medium and low voltage stations.
- Development and land distribution of natural gas: Management of the gas network infrastructure.
- Production of LPG.

Figure 3.1.1-1 shows the STEG organization chart.

Note DPSC: Department of Central Services
DPCC: Department of Communication & Cooperation
DPDC: Development Communication Department
SPCM: Permanent Secretariat for Tender Commission

Source: http://www.steg.com.tn

Figure 3.1.1-1 STEG Organization Chart

3.1.2 Overview of Existing Power Plants

Table 3.1.2-1 shows the existing power plants.

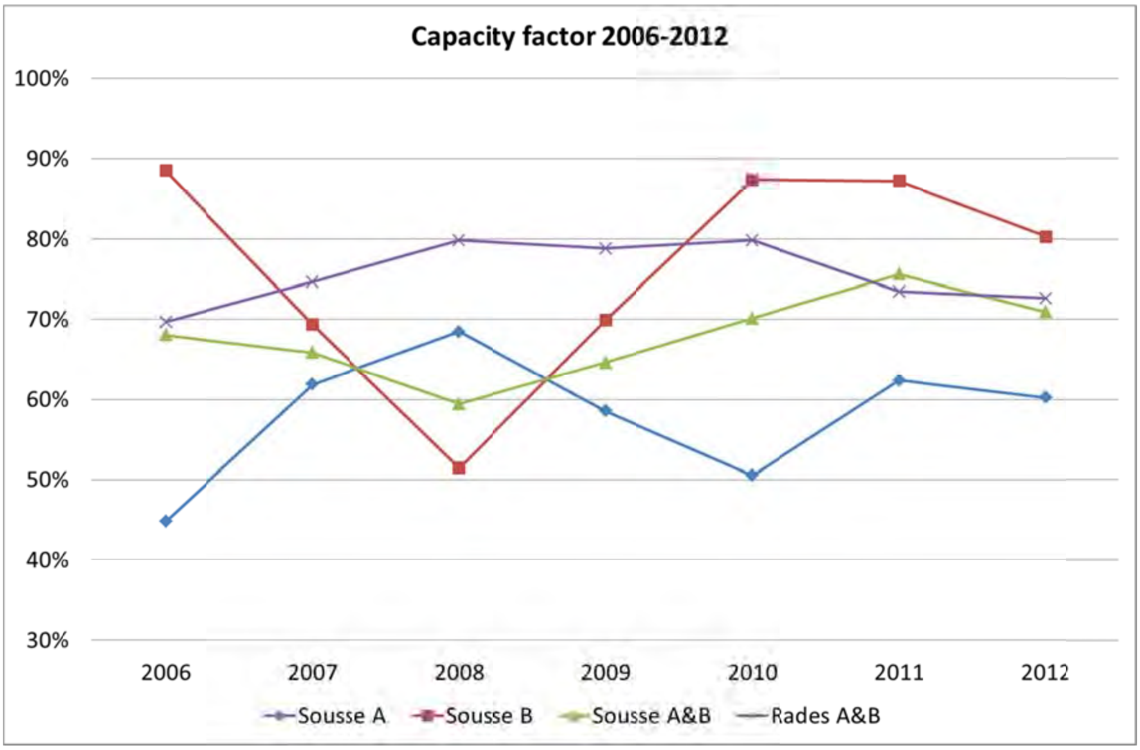
Table 3.1.2-1 Existing Power Plants

No.	Name of Plant	Type of Plant(1)	Location	No. of Units	Designed Capacity(2) (MW)	Actual Capacity(3) (MW)	Actual Capacity at 40 °C (4) (MW)	Year of Initial Operation	Retirement Year	Owner
1	Rades A #1	TV	Tunis	1	170	145	145	1985	2021	STEG
2	Rades A #2	TV	Tunis	1	170	145	145	1985	2021	STEG
3	Rades B #1	TV	Tunis	1	180	150	150	1998	2029	STEG
4	Rades B #2	TV	Tunis	1	180	150	150	1998	2029	STEG
5	Sousse A #1	TV	Sousse	1	-	160	160	1980	2016	STEG
6	Sousse A #2	TV	Sousse	1	-	160	160	1980	2016	STEG
7	Sousse B #1	TG	Sousse	1	-	118	310	1994	2025	STEG
8	Sousse B #2	TG	Sousse	1	-	118	-	1994	2025	STEG
9	Sousse B #3	TV	Sousse	1	-	128	-	1995	2025	STEG
10	Ghannouch	CC	Ghannouch	1	-	412	373	2011	2041	STEG
11	Goulette	TG	Goulette	1	-	120	105	-	2035	STEG
12	Thyna #1	TG	Thyna	1	-	120	100	-	2034	STEG
13	Thyna #2	TG	Thyna	1	-	120	100	-	2037	STEG
14	Thyna #3	TG	Thyna	1	-	120	100	-	2040	STEG
15	Feriana #1	TG	Feriana	1	-	120	100	-	2035	STEG
16	Feriana #2	TG	Feriana	1	-	120	100	-	2039	STEG
17	Bir M'cherga #1	TG	Bir M'cherga	1	-	120	100	-	2028	STEG
18	Bir M'cherga #2	TG	Bir M'cherga	1	-	120	100	-	2028	STEG
19	Bir M'cherga #3	TG	Bir M'cherga	1	-	120	100	-	2043	STEG
20	Bir M'cherga #4	TG	Bir M'cherga	1	-	120	100	-	2043	STEG
21	Bouchemma #1	TG	Bouchemma	1	-	120	100	-	2029	STEG
22	Bouchemma #2	TG	Bouchemma	1	-	30	27	-	2022	STEG
23	Bouchemma #3	TG	Bouchemma	1	-	30	27	-	2022	STEG
24	Kasserine #1	TG	Kasserine	1	-	30	27	-	2022	STEG
25	Kasserine #2	TG	Kasserine	1	-	30	27	-	2022	STEG
26	Sfax #1	TG	Sfax	1	-	20	17	-	2022	STEG
27	Sfax #2	TG	Sfax	1	-	20	17	-	2022	STEG
28	Tunis Sud #1	TG	Tunis Sud	1	-	20	18	-	2022	STEG
29	Tunis Sud #2	TG	Tunis Sud	1	-	20	18	-	2022	STEG
30	Tunis Sud #3	TG	Tunis Sud	1	-	20	18	-	2022	STEG
31	Korba #1	TG	Korba	1	-	20	18	-	2022	STEG
32	Korba #2	TG	Korba	1	-	30	27	-	2022	STEG
33	Menzel Bourguiba #1	TG	Menzel Bourguiba	1	-	20	18	-	2022	STEG
34	Menzel Bourguiba #2	TG	Menzel Bourguiba	1	-	20	18	-	2022	STEG
35	Zarsis #1	TG	Zarsis	1	-	30	27	-	2022	STEG
36	Robbana #1	TG	Robbana	1	-	30	27	-	2022	STEG
37	Rades II #1	TG	Rades	1	-	120	440	-	2027	Carthage Power
38	Rades II #2	TG	Rades	1	-	120	-	-	2027	Carthage Power
39	Rades II #3	TV	Rades	1	-	231	-	-	2027	Carthage Power
40	El Bibane	TG	-	1	-	27	-	2003	-	-
Total	-	-	-	40	-	3,496	3,469	-	-	-

Source: STEG

(1) Types of Plant are classified into steam (TV), gas turbine (TG) and gas turbine combined cycle (CC) in Tunisia.
(2) Design capacity is the rated capacity of the unit when it is installed. The base ambient air temperature is 20°C and seawater temperature is 25°C.
(3) Actual capacity is the maximum continuous capacity that the unit can generate without exceeding the manufacturer's operating parameters at the time in question. Base ambient air temperature is 20°C and base seawater temperature is 25°C.
(4) Actual capacity at 40°C is the current actual capacity at ambient air temperature of 40°C and seawater temperature of 30°C.
(5) Capacity Factor = Annual Power Energy Generation (MWh) x 100 / {Designed Capacity (MW) x 8,760}
(6) No IPP projects are planned for the next ten years.

Figure 3.1.2-1 shows the capacity factor of existing power plants



Source: STEG

Figure 3.1.2-1 Capacity Factor of Existing Power Plants

3.1.3 Overview of Power Transmission Facilities

(1) Power grid system

In Tunisia, the voltage of the transmission lines are composed of 400 kV, 225 kV, 150 kV and 90kV. The power grid of Tunisia constitutes an international linkage system with Algeria and Libya.

The 225 kV transmission lines, which are the backbone of the power system in Tunisia, pass through the center of the country and along the seashore of the Mediterranean Sea, connecting power stations which are localized in the country. The 150 kV and 90 kV transmission lines are mainly installed on the seashore and the eastern desert.

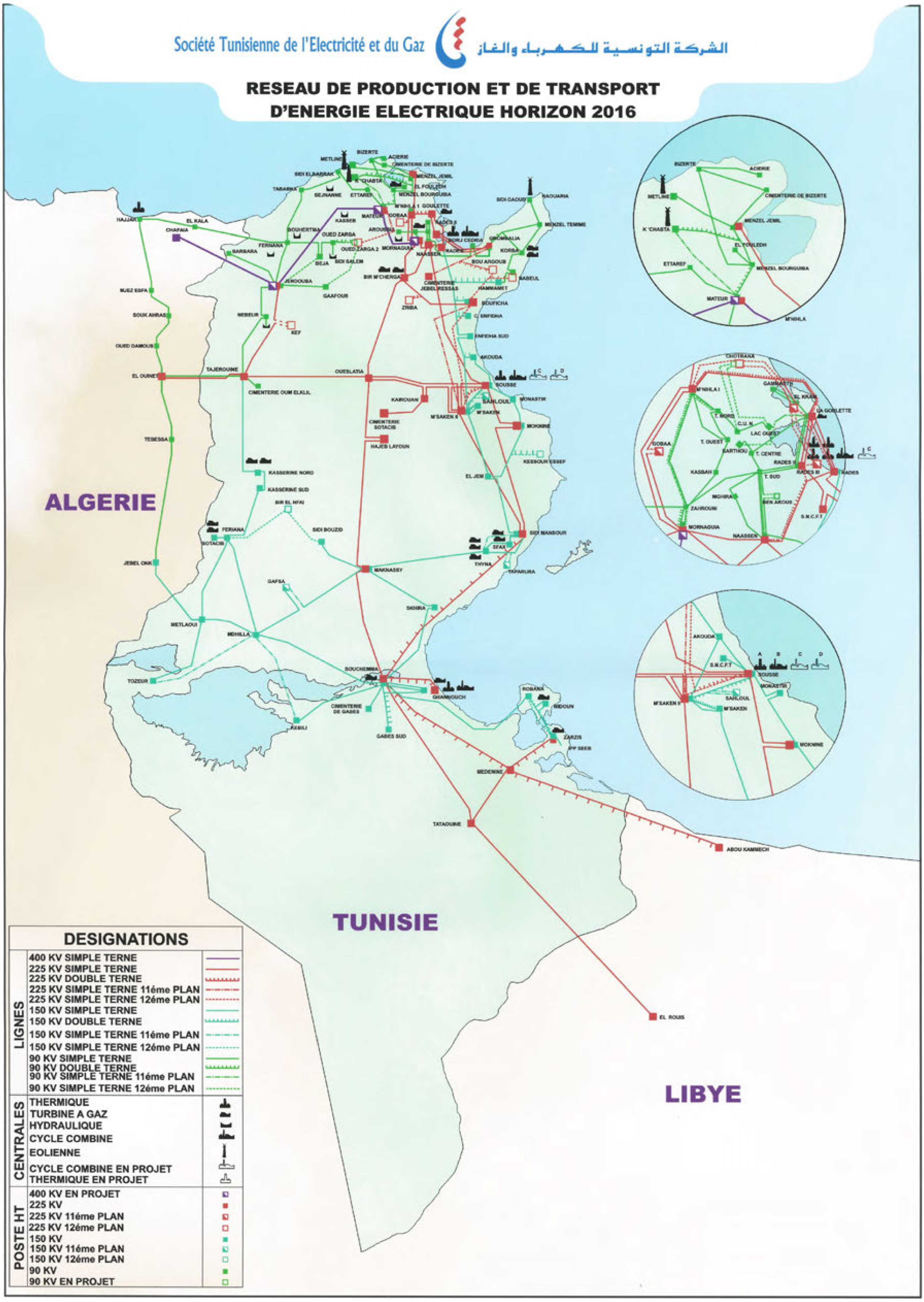
The main power consumption area is concentrated in the northern east seashore of the country, including Tunis which is the capital of Tunisia. In Tunis, circular 225 kV transmission lines have been installed and 90 kV transmission lines radiate to the inner city from 225 kV substations. If a single fault occurs, power can be supplied through other transmission lines. Therefore, the reliability of the power system is high.

The lengths of transmission lines in Tunisia are shown in Table 3.1.3-1.

Table 3.1.3-1 Overall Lengths of Transmission Lines

Year	Length of Transmission Lines (km)		
	225 kV	150 kV	90 kV
2011	2,821	1,883	1,249
2010	2,792	1,883	1,189
2009	2,787	1,812	1,188

Source: STEG Annual Report 2011



Source: STEG

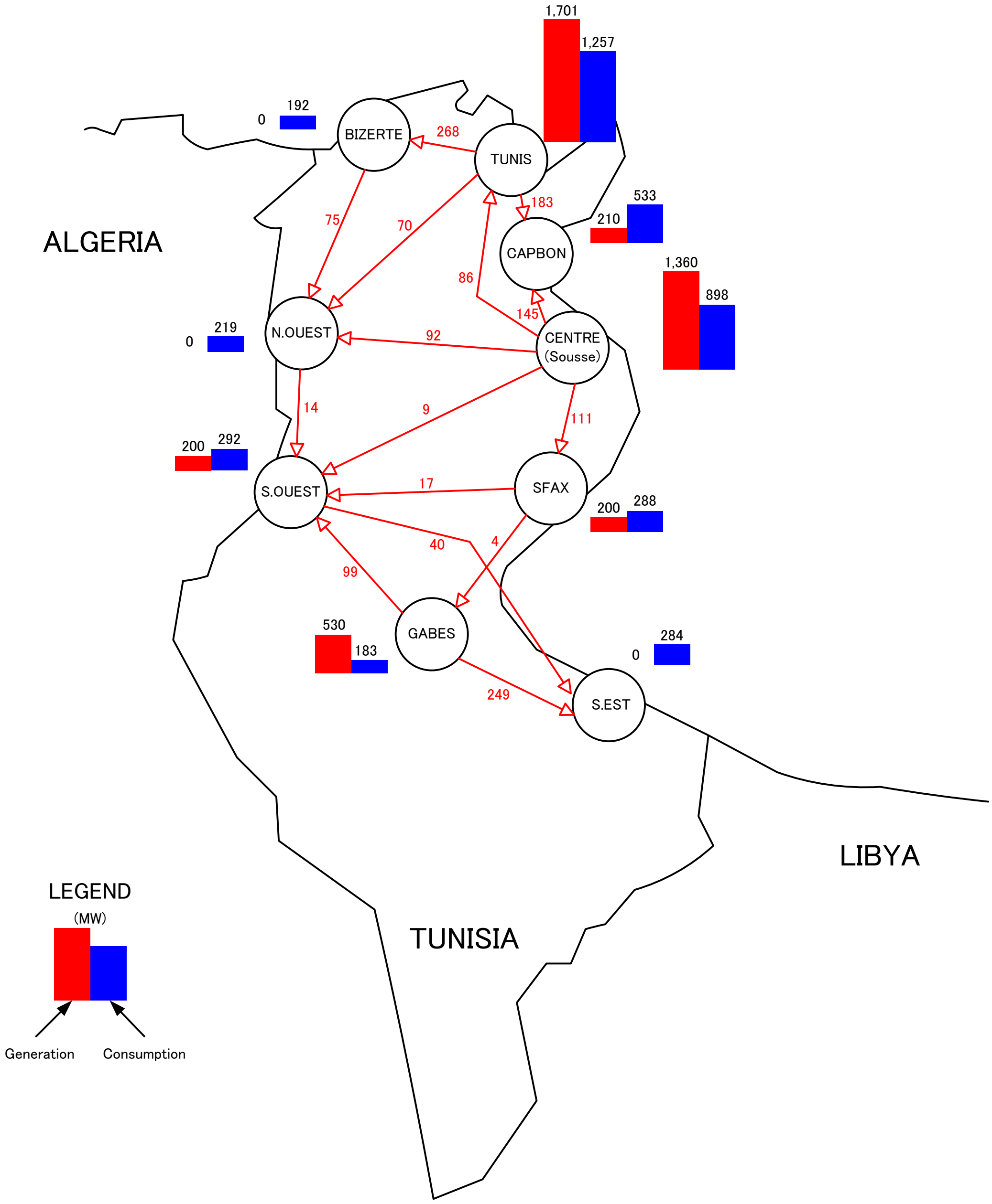
Figure 3.1.3-1 Power Grid System for Tunisia (2016)

(2) Power flow

The power flow situation of Power System Simulation for Engineers (PSS/E) produced by STEG is shown in Figure 3.3.1-2. The targeted power flow situation is calculated as of the expected peak load in 2017. Although Tunisia's power grid is connected to Algeria and Libya, which are adjacent to Tunisia, there is usually no interconnection of electricity between Tunisia and these countries.

The main areas of power consumption are Tunis, the capital of Tunisia, and Sousse, which are supplied with power from neighboring power stations. It is not necessary to transmit a large amount of power to the area of the northeast seashore, which demands a large amount of electricity, through long distance transmission lines since the power stations are adjacent to the area.

In the calculation of PSS/E, the maximum ratio of the normal current of each transmission line to the rated current is 75% in some transmission lines. However, almost all the transmission lines' ratios are less than 50%. The calculation shows that transmission lines of STEG have sufficient transmission capacity.



Source: JICA Study Team

Figure 3.1.3-2 Power Flow in the Tunisia Power System

(3) Loss in power transmission

According to the table below, the rate of losses recorded on the transport network electricity was a slight improvement over previous years:

Table 3.1.3-2 Loss in Power Transmission

Year	2009	2010	2011
Losses on the transmission system (%)	2.25	2.10	2.00

Source: STEG Annual Report 2011

3.1.4 Overview of Renewable Energy

Tunisia, which has been an energy-export country in the last century, has turned into an energy-import country in this century as a result of economic growth. In addition to this context, the high potentiality of the Mediterranean area for wind power generation and the long hours of sunlight (3,200 hours a year) in the Sahara desert area have enhanced the commitment of the government of Tunisia toward development of renewable energy.

Concerning wind power generation, STEG has installed the facility of 10MW in Sidi Daoud in 2001, and facilities of approximately 245MW generation have been installed up at the end of 2012.

The solar power generation is also promoted ahead under the leadership of ANME (Agence Nationale pour la Maîtrise de l'Energie) for the purpose of electrification of unelectrified farm villages in a remote area that cannot connect to the electricity network, but the generation capacity remains in a level of less than 6MW at the end of 2012.

Biomass power generation is also in a very limited level (0.4MW). The development target of the government of Tunisia by 2030, 1,755MW for wind power, 1,978MW for solar power, 300MW for biomass power, will not be easily attained for instability and high cost of these power generation methods.

3.1.5 Power Plant Development Plan and Power Demand Forecast

Table 3.1.4-1 shows the power plant development plan. STEG forecasts that the rate of increase of the demand for electricity between 2012 and 2016 will be 7.1% annually. In order to deal with the coming shortage of electricity, STEG is now constructing two new power stations in Sousse which will be in operation in 2014 and 2015. Even after the operation of these new power stations, Tunisia will face a power shortage in the near future.

On the other hand, Sousse A TPP (2 x 135 MW) is supposed to be retired in 2016 after 36 years of operation.

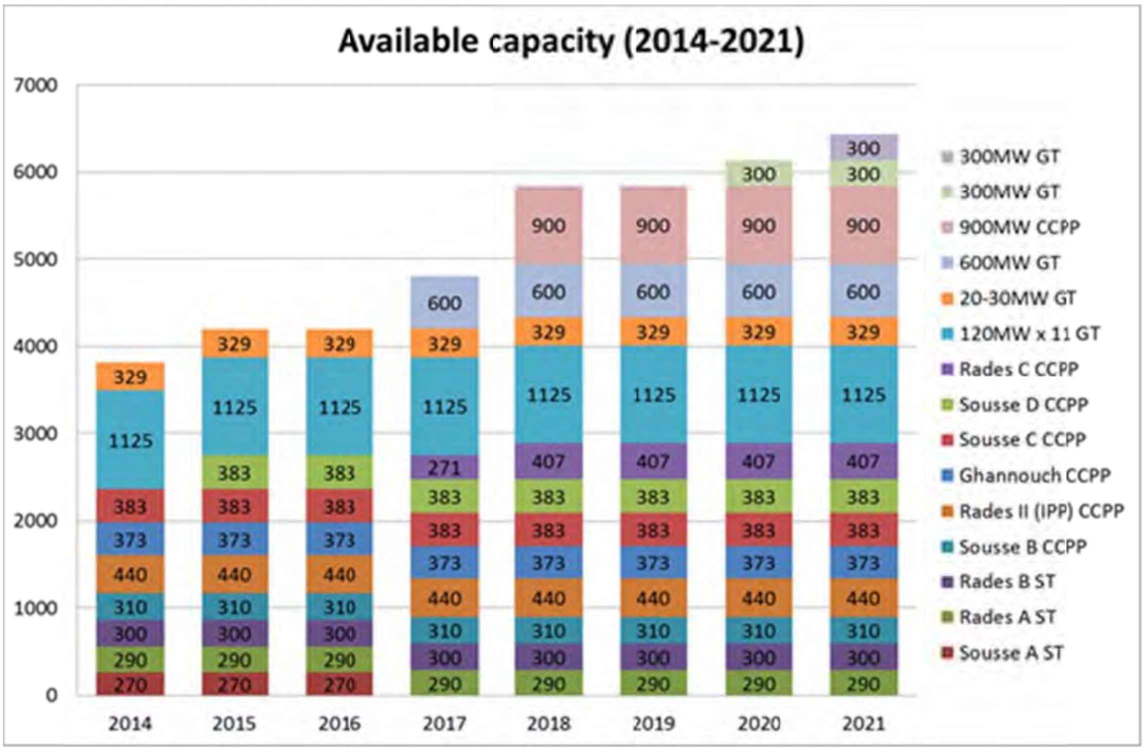
From this development prospective, the ELMED project is in the survey phase. It constitutes a generation capacity of 400 MW to 1,200 MW which are reserved for the local market and 800 MW for export to the Italian market via an interconnection with a capacity of 1,000 MW to be realized in partnership between STEG and Terna (the Italian grid operator).

Table 3.1.5-1 Power Plant Development Plan

No.	Name of Plant	Type of Plant(1)	Location	No. of Units	Designed Capacity(2) (MW)	Actual Capacity(3) (MW)	Actual Capacity at 40 °C(4) (MW)	Year of Initial Operation	Owner (8)
1	Sousse C	CC	Sousse	1	424	424	383	2014	STEG
2	Sousse D	CC	Sousse	1	424	424	383	2015	STEG
3	Rades C	CC	Radès	1	450	450	407	2017 (GT) 2018 (CC)	STEG
4	Mornaguia #1	TG	Mornaguia	1	300	300	-	2017	STEG
5	Mornaguia #2	TG	Mornaguia	1	300	300	-	2017	STEG
6	(Centrale #1)	CC	(Not decided)	1	450	450	-	2018	STEG
7	(Centrale #2)	CC	(Not decided)	1	450	450	-	2019	STEG
8	(Tac 2020)	TG	(Not decided)	1	300	300	-	2020	STEG
9	(Tac 2021)	TG	(Not decided)	1	300	300	-	2021	STEG
Total	-	-	-	9	3,398	3,398	1,173	-	-

(1) Types of Plant are classified into steam (TV), gas turbine (TG) and gas turbine combined cycle (CC) in Tunisia.
(2) Design capacity is the rated capacity of the unit when it is installed. The base ambient air temperature is 20°C and seawater temperature is 25°C.
(3) Actual capacity is the maximum continuous capacity that the unit can generate without exceeding the manufacturer's operating parameters at the time when in question. Base ambient air temperature is 20°C and base seawater temperature is 25°C.
(4) Actual capacity at 40°C is the current actual capacity at ambient air temperature of 40 °C and seawater temperature of 30°C.
(5) Capacity Factor = Annual Power Energy Generation (MWh) x 100 / {Designed Capacity (MW) x 8,760}
(6) Availability Factor = (8,760 - Outaged Hours) x 100 / 8,760
(7) Type of Fuel: NG: Natural Gas, HO: Heavy Oil, DO: Diesel Oil, CrO: Crude Oil, and Coal: Bituminous, subbituminous or lignite.
(8) No IPP projects are planned for the next ten years.

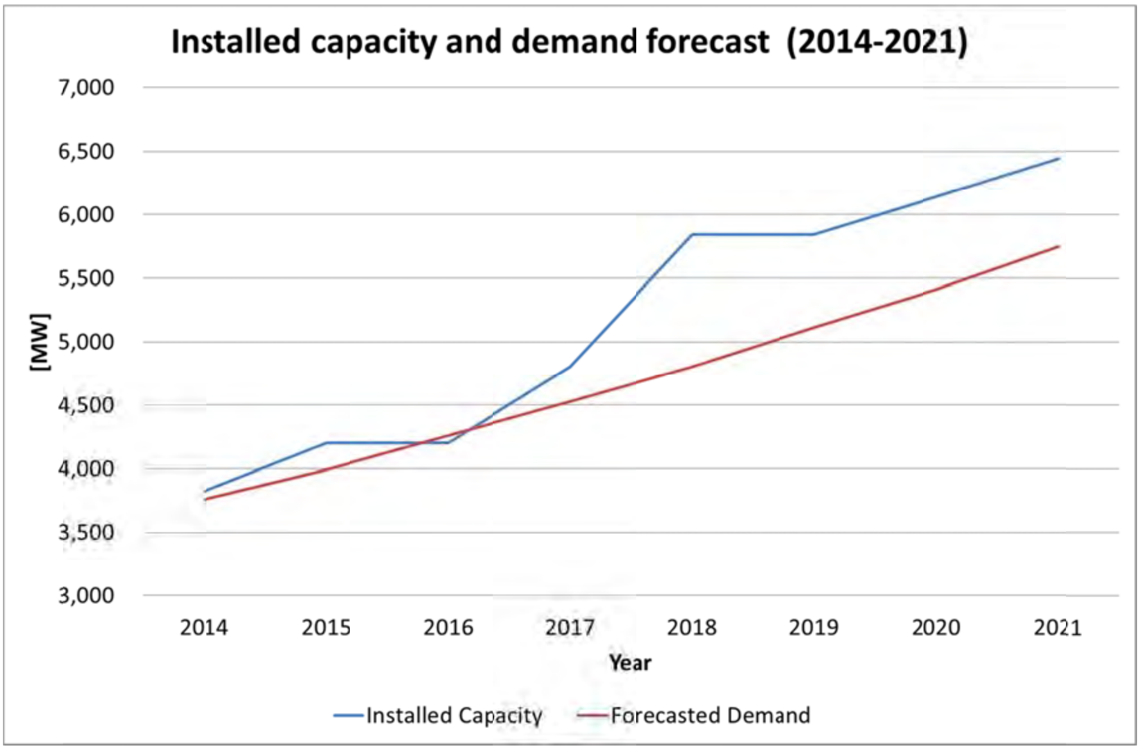
Figure 3.1.4-1 shows available capacity. It is expected that available generating capacity will be approximately 4,203 [MW] in 2016.



Source: STEG

Figure 3.1.5-1 Available Capacity (2014-2021)

Figure 3.1.4-2 shows available capacity and demand forecast. It is expected that maximum power demand will be approximately 4,260 [MW] in 2016. Therefore, a shortage of power supply is expected of 57 MW in 2016. In order to deal with the power demand increase, it is necessary to construct new thermal power plants in the order of 450 MW by 2016. It is important for STEG to urgently carry out this Rades C CCPP project.



Source: STEG

Figure 3.1.5-2 Installed Capacity and Demand Forecast (2014-2021)

3.2 Electricity Tariff

The electricity and gas tariffs are determined by the Ministry of Industry. The tariffs are set at the end of each fiscal year, reflecting the international prices of crude oil and gas, the financial balance of business entities including STEG, and the possible amount of subsidy by the government. The electricity tariffs are arranged by time slots for High Voltage (HV) and the Medium Voltage (MV), as well as pumping water for irrigation. The latest tariff table has been effective since September, 2012.

The average electric tariff in 2011 was 128.85 milliemes/kWh (0.078 USD/kWh). The tariff for low income households was only 75 milliemes/kWh (around 0.045 USD/kWh). The level of electricity tariff is relatively low since the government has been controlling fuel and energy prices in order to stabilize the economy. However, as mentioned in Chapter 2, the subsidy system has been reviewed to adjust fuel and energy prices.

Table 3.2-1 Tariff Table (as of September, 2012)

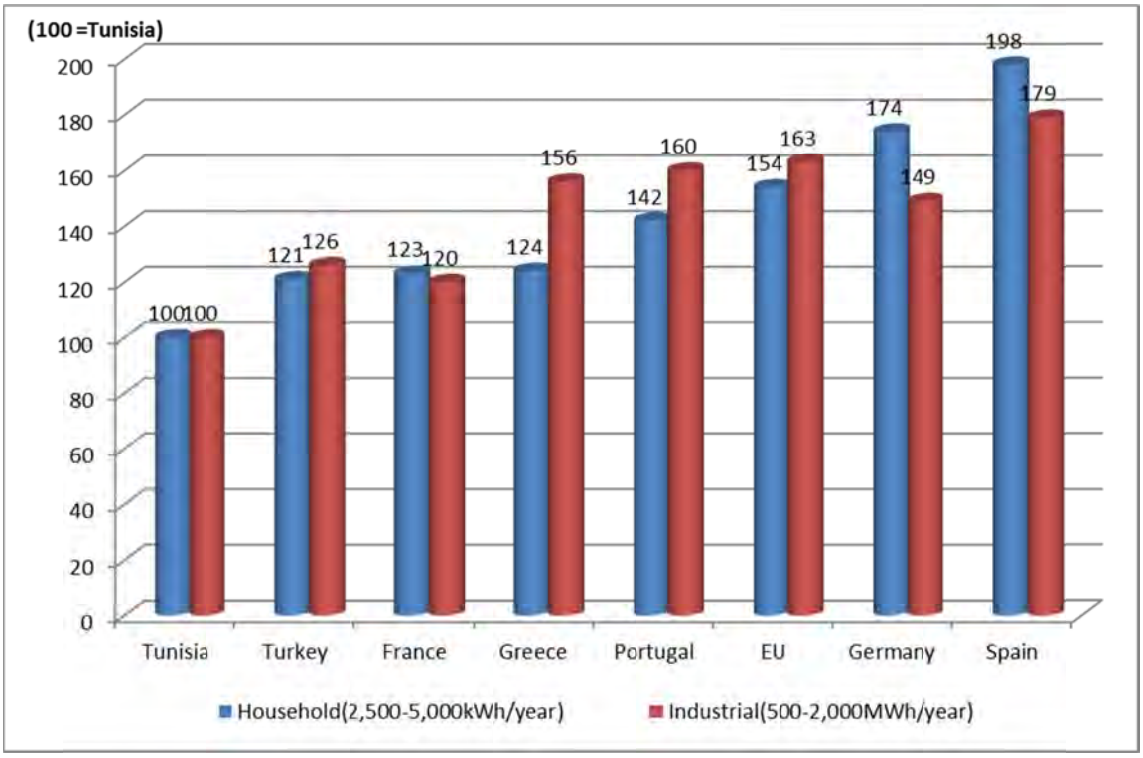
Category	Tariff		Royalty		Unit Price			
			Contract Fee (mill/Ab/month)	Output (mill/kVA/month)	Day	Peak	Evening	Night
Low Voltage	Economic Bracket (1&2 kVA or less than 50kWh/month) for the residential client only		-	300	75			
	Economic Bracket (1&2 kVA)	1-50 kWh/month	-	300	92			
		51 kWh/month and more	-	300	135			
	Normal Bracket (>2 kVA)	1-300 kWh/month	-	300	135			
		301 kWh/month and more	-	300	200			
	Public Lightinig		-	600	177			
	Water Boiler		500	-	177	Effacement	177	
	Heating and Airconditioning*4		-	300	200			
	Irrigation	Uniforme	300	300	110			
		3 time shifts "postes horaires"	1,000	-	92	200	N.A.	85
Medium Voltage	Uniforme			700*3	137			
	Postes horaires			4,000	123	185	147	94
	Water pumping			4,000	139	171	N.A.	94
	Agricultural usage			-	111	Effacement	145	87
	Pumping for irrigation			-	111	Effacement	N.A.	87
	Agricurtural irrigation			-	104	Effacement	120	80
	Security (tariff for self-producers that consume in case of necessity)			2,250	143	198	164	101
High Voltage	4 Postes Horaires			3,500	119	181	142	90
	3 Postes Horaires			3,500	135	164	N.A.	90
	Security			1,500	137	193	159	97

Source: STEG
Note: 1 DNT = 1,000 milliemes

The following figure shows tariff levels of EU average, five EU countries and Turkey in comparison with the tariff level of Tunisia. Through the international comparison of tariffs, the tariff level of Tunisia is low. In the case that the tariff level of Tunisia is 100, no country is below Tunisia.

In terms of tariffs for households, there is more than a 20 point difference between Tunisia and Turkey with the lowest levels among the compared countries. The highest level of tariffs for households is Spain with 198 compared to the tariff of Tunisia.

In terms of tariffs for industry, the difference between Tunisia and France, with the lowest level, is also 20 points. Spain provides the most expensive electricity for industrial use, as well, with 179 compared with the tariff of Tunisia.



Source: STEG Annual Report 2011

Figure 3.2-1 International Comparison of Electricity Tariffs

3.3 Financial Position of STEG

3.3.1 Balance Sheet

Total assets of STEG increased for the last five years: 4.107 billion TND in 2008 to 7.176 billion TND in 2012. The increase was mainly due to the expanded fixed assets for power supply facilities. Net fixed assets amount increased from 2.735 billion TND in 2008 to 3.918 billion TND. However, funding for capital investment was dependent on long-term loans rather than its own capital. While total liability steadily increased from 2.636 billion TND to 5.850 billion TND for the last five years, shareholders' equity fluctuated around 1.5 billion TND. In 2012, shareholders' equity reduced to 1.326 billion TND because of decreased retained earnings and expanded net losses.

Table 3.3.1-1 Balance Sheet of STEG (2008-2012)

	2008	2009	2010	2011	2012
Total Assets	4,107,016,065	4,812,494,373	5,565,737,792	6,425,141,483	7,176,889,282
Non Current Assets	3,405,247,061	4,031,398,929	4,683,905,660	5,100,045,536	5,354,799,984
Intangible Assets	1,729,118	1,953,569	2,245,958	2,829,256	4,427,631
Depreciation	-1,174,815	-1,691,541	-1,976,215	-2,342,928	-3,167,615
Fixed Assets	5,600,483,899	5,995,470,795	6,527,253,471	7,480,938,366	7,932,025,539
Depreciation	-2,865,193,021	-3,070,326,328	-3,300,764,936	-3,637,580,344	-4,013,793,484
Fixed asset in progress	645,345,728	1,081,119,644	1,432,830,631	1,233,505,683	1,412,894,148
Financial Assets	28,458,109	29,341,883	28,540,001	27,192,135	29,028,874
Provision	-4,401,957	-4,469,093	-4,223,250	-4,496,631	-6,615,109
Current Assets	701,769,004	781,095,444	881,832,132	1,325,095,948	1,822,089,298
Stocks	109,754,863	112,998,278	133,512,790	145,125,984	174,971,149
Provision	-12,771,039	10,845,985	-12,893,363	-13,667,382	-14,841,390
Trade payable	448,319,692	490,410,946	520,885,590	793,497,116	915,034,699
Provision	-45,704,656	-45,196,242	-36,206,608	-57,248,346	-84,226,172
Other current assets	41,941,213	41,306,435	42,325,399	39,510,123	41,690,711
Provision	-7,138,050	-8,410,944	-7,728,000	-7,559,226	-6,984,745
Other financial assets	3,845,273	3,552,891	3,482,305	3,446,537	2,642,022
Cash & Cash equivalent	163,521,708	175,588,095	238,454,019	421,991,142	793,803,024
Total Liabilities and Equity	4,107,016,065	4,790,802,405	5,565,737,793	6,425,141,484	7,176,889,282
Total Liabilities	2,636,902,672	3,270,023,262	4,042,044,971	4,887,932,745	5,850,269,742
Non Current Liabilities	1,476,891,179	2,062,097,627	2,862,457,954	3,143,864,069	3,751,400,677
Loans and Borrowings	1,241,946,301	1,801,212,536	2,526,924,352	2,777,018,654	3,229,243,086
Guarantee deposit	143,278,097	163,990,439	181,181,520	196,855,950	213,466,033
Provision for risk and charges	90,657,781	95,885,652	153,343,082	168,980,465	307,682,558
Other non current liabilities	1,009,000	1,009,000	1,009,000	1,009,000	1,009,000
Current Liabilities	1,160,011,493	1,207,925,636	1,179,587,017	1,744,068,676	2,098,869,066
Bank overdrafts and other financial liabiliti	644,822,614	596,726,748	636,724,624	436,652,810	1,488,206,279
Trade payables and related accounts	227,817,654	222,739,487	267,090,462	962,203,805	352,586,499
Other current liabilities	287,371,225	388,459,401	275,771,931	345,212,061	258,076,288
Equity	1,470,113,393	1,520,779,143	1,523,692,822	1,537,208,739	1,326,619,540
Paid-in Capital	75,194,652	75,194,652	75,194,652	75,194,652	75,194,652
Legal Reserves	235,002	235,002	235,002	235,002	235,002
Other shareholders' equity	1,242,740,217	1,286,109,006	1,327,019,876	1,357,703,986	1,369,977,160
Retained earnings/accumulatede loss	169,942,458	150,330,708	130,390,847	121,243,292	37,005,408
Profit for the period	-17,998,936	8,909,775	-9,147,555	-17,168,193	-155,792,682

Source: STEG Financial Statements (2008-2012).

3.3.2 Income Statement

Sales of STEG have been steadily growing for the period from 2008 to 2012: 1.877 billion TND to 2.669 billion TND. The main source of revenue of STEG is electricity sales. It accounts for 70% of the total sales of the company. Besides electricity sales, 30% of total revenue is from gas sales, LPG sales and others. On the other hand, cost of sales, including fuel cost, has increased more rapidly from 2.944 billion TND to 5.187 billion TND. Fuel cost accounts for around 90% of the total cost of sales of 4.685 billion TND in 2012.

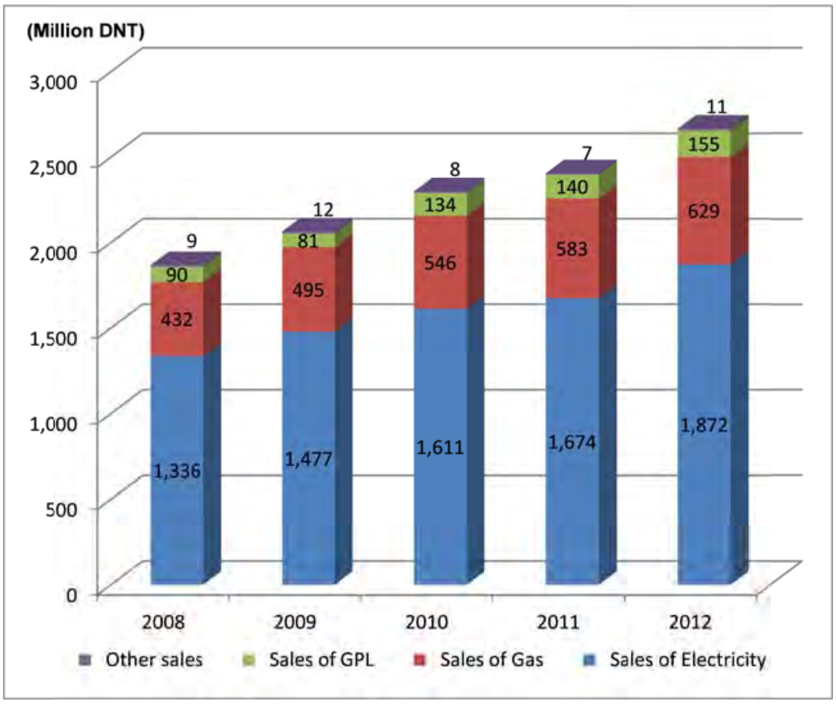
Since sales revenue of STEG cannot cover the cost of sales, the government provides STEG with a subsidy to cover a certain portion of fuel cost, including the import of gas from Algeria. The total amount of the subsidy to STEG was 2.733 billion TND, which was larger than its own sales revenue.

STEG has a heavy burden of financial expenses which exceeds operating profit. In particular, financial expenses considerably increased in 2012. In 2012, financial expenses were 0.287 billion TND while operating profit was 0.139 billion TND, which was less than 50% of financial expenses. As a result, net loss before tax was 0.136 billion TND in 2012. The main reason of the increased financial expenses was the large loss of exchange realized of 0.145 billion TD.

Table 3.3.2-1 Income Statement

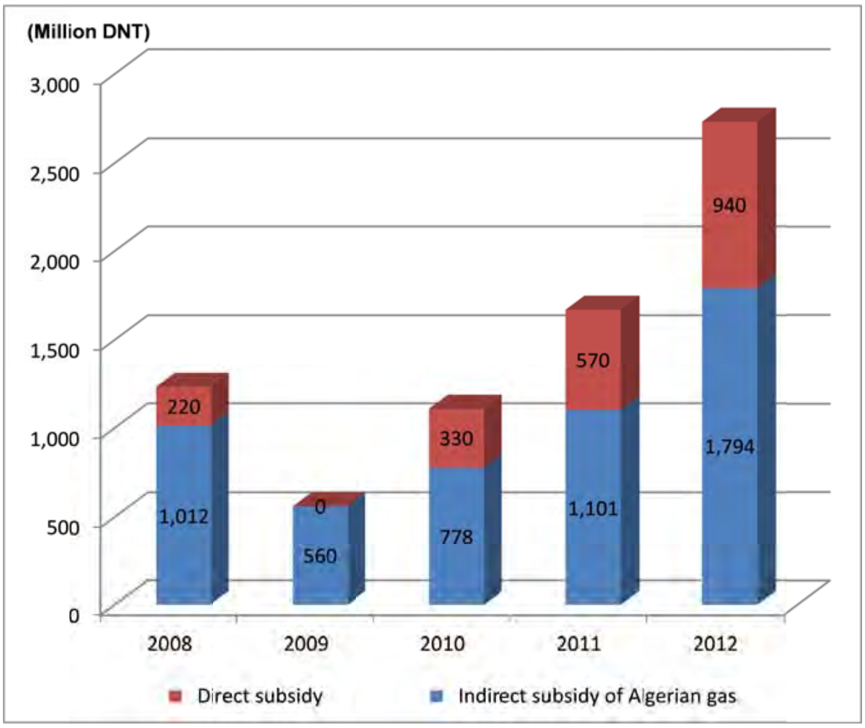
	2008	2009	2010	2011	2012
Sales	1,877,584,735	2,064,710,795	2,308,918,452	2,408,141,359	2,669,385,027
Operating subsidy	1,232,411,258	560,300,119	1,108,291,536	1,670,852,759	2,733,660,549
Cost of Sales	-2,994,429,007	-2,517,167,205	-3,267,066,657	-3,883,783,994	-5,187,677,878
Gross Margin	115,566,986	107,843,709	150,143,331	195,210,124	215,367,698
Other operating incomes	56,501,516	56,399,674	52,195,334	43,722,712	45,078,238
Selling, general & administartive expense	-32,689,949	-37,478,223	-36,243,605	-37,708,542	-42,278,025
Other operating expenses	-28,433,596	-19,685,319	-22,781,114	-50,197,910	-79,040,397
Operating Profit	110,944,957	107,079,841	143,313,946	151,026,384	139,127,514
Fiancial expenses, net	-129,482,848	-87,087,473	-136,374,613	-160,568,029	-287,018,152
Financial investment incomes	2,343,776	187,179	1,787,580	8,416,369	1,011,863
Other ordinary profits	6,120,396	4,011,998	7,731,555	3,978,318	11,815,932
Other ordinary losses	-4,716,722	-6,271,163	-14,140,920	-4,458,447	-1,112,853
Profit Before Income Tax	-14,790,441	17,920,382	2,317,548	-1,605,406	-136,175,695
Income Tax	-3,208,495	-9,010,607	-11,465,103	-15,562,787	-19,616,987
Net Profit after Tax	-17,998,936	8,909,775	-9,147,555	-17,168,193	-155,792,682

Source: STEG Financial Statements (2008-2012).



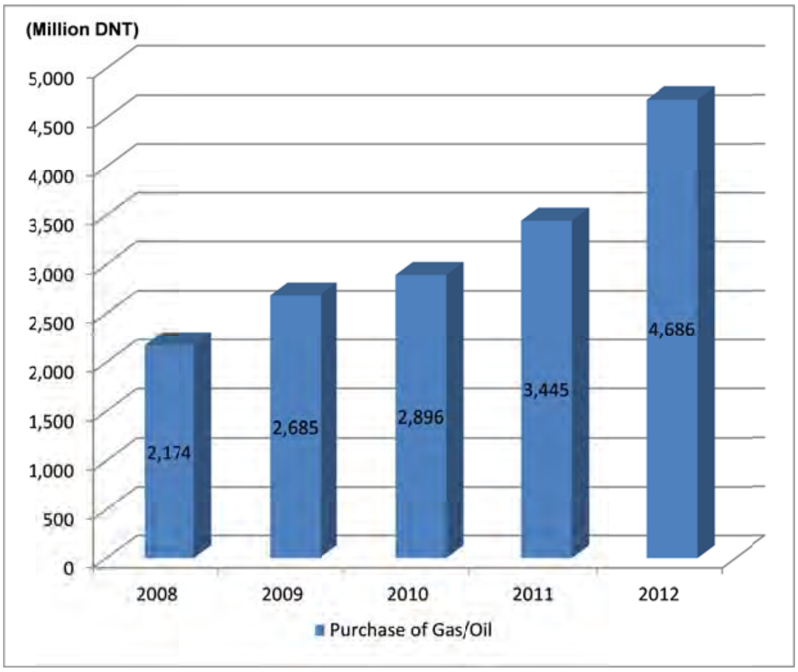
Source: STEG Financial Statements (2008-2012)

Figure 3.3.2-1 Sales Revenue of STEG



Source: STEG Financial Statements (2008-2012).

Figure 3.3.2-2 Other Revenue of STEG



Source: STEG Financial Statements (2008-2012)

Figure 3.3.2-3 Fuel Cost of Power Generation

Chapter 4 Survey of Rades Power Plant Facilities

4.1 Site Situation

4.1.1 General

The Rades C CCPP project site is located in an industrial area about 10km east of Tunis. It is planned to construct Rades C CCPP on land owned by the Tunisian government, the same as Rades A&B TPP. It is considered that Rades C CCPP will require a site area of approximately 5.4 ha.

Figure 4.1.1 illustrates the location of the Rades C CCPP.

Source: JICA Study Team

Figure 4.1.1 Location of Rades C CCPP

4.1.2 Site Selection

The Rades C CCPP is a project that follows on after the existing Rades A&B TPP. The project site for Rades C CCPP is located at the same site of Rades A&B TPP and is adjacent to the independent power producer (IPP) thermal power plant site of Carthage Power (Rades II CCPP).

The Port of La Goulette is adjacent to this project site so that it is convenient for the Project to execute procurement and transportation.

Figure 4.1.2 illustrates the location of Rades A, B TPP & C CCPP and the IPP Carthage Power plant (Rades II CCPP).

Source: JICA Study Team

Figure 4.1.2 Location of Rades A, B TPP & C CCPP (Planned) and the IPP Carthage Power Plant (Rades II CCPP)

4.1.3 Site Condition

4.1.3.1 Site Preparation

At the planned construction site for Rades C CCPP, approximately 5.4 hectares of the site required for power plant construction has been almost completely prepared. However, there are still some trees, bushes ruined buildings and small structures on the Rades C CCPP site. Once these ruined buildings and small structures have been used as warehouses for existing Rades A & B PP.
Therefore, these must be demolished and/or removed.

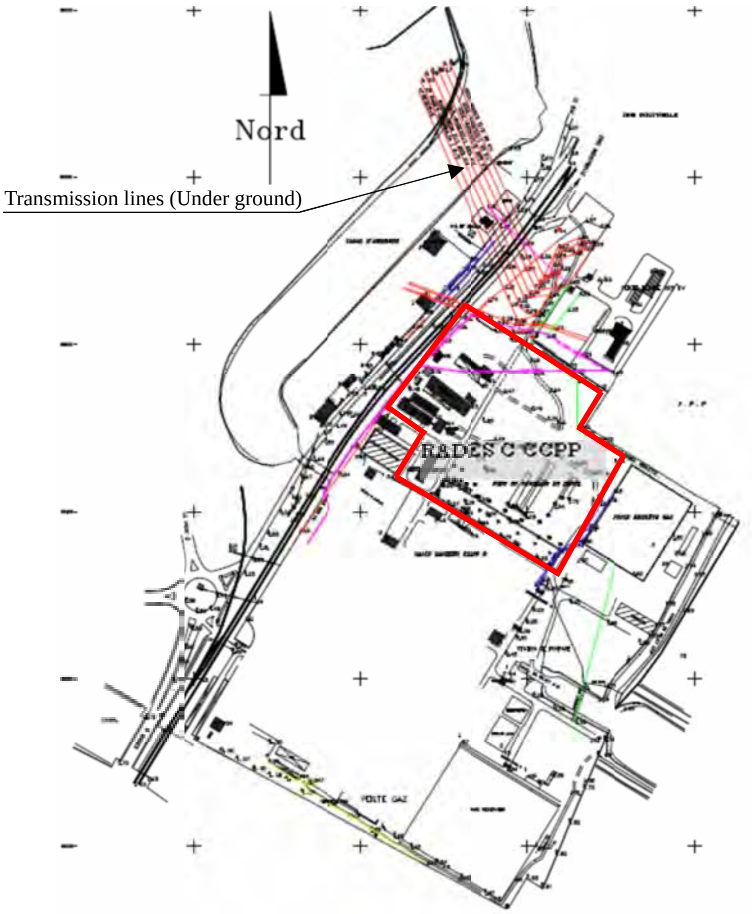
The prepared ground level of the candidate site for Rades C CCPP is approximately + 2.0m NGT (NGT: Tunisian Geodesic *Niveau* (Level)). It should be noted, however, that construction of the power plant requires a survey of the existing underground structures. If the existing underground structures remain, they must be relocated or removed.

Figure 4.1.3.1-1 illustrates the aspect of the Rades C CCPP site.

Source: JICA Study Team

Figure 4.1.3.1-1 Aspect of the Rades C CCPP Site

Figure 4.1.3.1-2 shows the topographic map of the Rades C CCPP site.



Source: JICA Study Team

Figure 4.1.3.1-2 Topographic Map of the Rades C CCPP Site

4.1.3.2 Physiographical and Geological Condition

The site of Rades C CCPP is located south of La Goulette Port, just east of the Salinas (salt flats). It is on a narrow piece of land that separates a lake from the Gulf of Tunis, slightly north of the mouth of the Oued Meliane River. The soil in this area is composed of modern alluvial deposits.

Coastal sand invades most of the area of the land but does not produce individualized dunes on the site.

The backbone of the Megrine-Rades hills is constituted of geological substratum. A preliminary study of geotechnical properties has been undertaken by STEG.

Source: JICA Study Team
Figure 4.1.3.2 Physiographical and Geological Condition of the Rades C CCPP Site

4.1.3.3 Soil Condition

Soil investigation work for RADES C CCPP was achieved. And Soil investigation work has finished on October 2013. The final results for geotechnical in-situ and laboratory test measurement are detailed within the report done by the soil investigation firm "Hydrosol Foundations".

According to the obtained result, the following geotechnical conditions can be considered.

Layer 1:
Sandy layer from ground level to -7m/-9.5m depthwith a top layer of embankment with 1m average thickness. NSPT values vary from 17 to22.
.
Layer 2:
Grey Clay with weak geomechanical characteristics vary from -7/-9.5m to -21/-22.8m depth from ground level.

Layer 3:
Yellow fine sand with shell fragments vary from -21/-22.8m to -28.9/-30.3m depth from ground level with good geomechanical carecteristics. Two NSPT were recorded (NSPT=34 and NSPT=35).This sand layer is considered to be pile bearing stratum.

Layer 4:
Grey Clay (weak geomechanical characteristics) with presence of madrepore and shell fragments varies from -28.9/-30.3m to -40m (limit of borehole) depth from ground level.

4.1.3.4 Seawater Level

Tide Sea Water level at Rades C CCPP is shown below.

HWL (High Tide Sea Water Level) = + 0.70m NGT
MWL (Mean Tide Sea Water Level l) = –0.26m NGT
LWL (Low Tide Sea Water Level) = –0.61m NGT

4.1.3.5 Groundwater Condition

According to Soil investigation reported by “Hydrosol Foundations”, the water table level is located between -1.1m and -1.5m depth from ground level.

4.1.3.6 Ground Level of the Site

The ground level of the project site corresponds to +2.0m NGT.

GL (Ground Level of Rades C CCPP) = + 2.00m NGT

4.1.3.7 Construction Area Characteristics (Seismicity)

The Tunis area is located in one of the earthquake zones of Tunisia. The Zaghouan fault that extends to the Gulf of Tunis is greatly responsible for the rare mild earthquakes in the region. In its history, Tunisia has had only three destructive earthquakes in Tunis or in the nearby areas (Utique in 410, and Tunis in 856 and 1758). Moreover, weak and moderate earthquakes occur once in a while, for example an earthquake occurred in 1970 and the intensity did not exceed 7 degrees on the Mercalli scale with a magnitude of 5.1.

In regards to destructive earthquakes, they are fortunately rare and may be similar to the one that struck Agadir (Morocco) in 1960 with an intensity of 10 and a magnitude of 5.7.

The measurement scale of the intensity of an earthquake is EMS 98 (European Micro-seismic Scale).

4.1.3.8 Meteorological Condition

(1) Ground meteorology
The area of the site of Rades C CCPP station has a mild, sunny Mediterranean climate characterized by a dry, hot season from May to September and by a temperate climate during the wet season between October and April.

(2) Marine meteorology
The seawater temperature is measured at the closest site to the power plant. The maximum mean monthly temperature is 30°C in August and 15.5°C in January compared to the annual mean temperature of 25°C.

(3) Rainfall
The rainy season for this area lasts five months from November to March, but it can sometimes last from September to May.

(4) Winds and Sirocco
The winds are distributed according to the season, and this phenomenon is controlled both by negative air pressure and the coastal location of the area. These winds are influenced by the sea, on the one hand, and by the land, on the other. The land winds from the west blow during the cold season and the winds from the east blow during the hot season, thus cooling the climate.

The sirocco is a wind from between southwest and southeast; it is a hot, dry wind causing a lot of suspended dust and sand particles. Most often, its speed is moderate with a maximum speed in the afternoon. It frequently blows in gusts. On the sea, it gets loaded with steam and becomes hardly bearable. Its duration is variable from a few hours to a few days. It can easily raise the temperature to 45°C.

(5) Tides
On the Tunisian eastern coast the tides occur during day time or night time. Everyday two full tides and two low tides with different heights are observed. The mean amplitude is about 0.5 meters.

4.1.3.9 Cooling Water

Possible cooling methods for Rades C CCPP include the once-through cooling method, the same method as for the Rades A&B TPP. The existing Rades A&B TPP depends on the once-through cooling method using cooling water supplied from Canal d'Ammenee (existing) and to be discharged into Canal de Rejet (existing).

Figure 4.1.3.9 illustrates the location of the cooling water route of Rades C CCPP.

A public road and railway intersect with the planned intake cooling water route. The construction method for the intake cooling water structure shall be given consideration so that it will not obstruct the public road and railway traffic.

In regards to the construction method for the Rades C CCPP intake cooling water, a pipe installing method called "pipe jacking method" is recommended.

Source: JICA Study Team

Figure 4.1.3.9 Location of the Cooling Water Route of Rades C CCPP.

Along the planned discharge cooling water route, there is no structure to disturb to construct a discharge cooling water pipe or culvert.

4.1.3.10 Foundation Design

Foundation design depends on the contractor load choice but hereafter foundation design can be considered according to French coads for deep foundations calculation that bearing depth for piles has to vary from 21.5m to24.5m for an average load capacity of 100 tonnes per pile.
The soil quality at the planned Rades C CCPP construction site is comparatively not very good. For the major structures of the adjacent Rades A&B TPP, the foundation structures were built using piles (i.e., concrete piles with the shape of a square cross-section type; 45cm (B) x 45cm (H) x 21m (L) (summary)). The foundation of the major structure of Rades C CCPP, in close proximity to Rades A&B TPP, is expected to be based on the piled foundation structure, the same as that of the major structure of Rades A&B TPP. Before the type of Rades C CCPP structure foundation is determined, a detailed soil investigation of the planned Rades C CCPP construction site shall be undertaken by the constructor. The foundation type will be determined after the detailed design has been completed based on the results of a detail survey.

At the Rades B TPP power plant site, a hard sand stratum (layer) exists at depths between 21m to 26m from ground level. This hard sand stratum is considered as the pile bearing stratum of Rades B TPP for major structure foundations.

4.2 Existing Facilities

4.2.1 Overview of the Existing Equipment in Rades A&B

(1) Outline of Rades A and B thermal power plants (TPPs)

An outline including the completion year, etc., of Rades A&B TPP is shown in Table 4.2.1-1.

Rades A TPP was put into operation in 1985 and its installed capacity is 340 MW (2 units of 170 MW).

Rades B TPP was put into operation in 1998 and its installed capacity is 360 MW (2 units of 180 MW).

Table 4.2.1-1 Outline of Rades A&B TPPs

	Rades A	Rades B
Completion year	1985	1998
Installed capacity	340 MW	360 MW
Manufacturer	MHI/ MELCO	Ansaldo
Electricity production	27% of power generation production by STEG	

Source: Rades Power Station

(2) Specifications of Main Equipment of Rades A&B TPPs

The specifications of main equipment of Rades A&B TPPs are shown in Table 4.2.1-2.

The main equipment such as boiler, steam turbine and generator was manufactured and supplied by Mitsubishi Heavy Industries (MHI) and Mitsubishi Electric Corporation (MELCO) of Japan.

Table 4.2.1-2 Specifications of Main Equipment of Rades A&B TPPs

		Rades A		Rades B	
		Unit 1	Unit 2	Unit 1	Unit 2
1	Steam turbine				
	Manufacturer	Mitsubishi Heavy Industries (MHI)		Ansaldo	
	Capacity	170 MW each		180 MW each	
	Type	Tandem compound, single casing, double flow condensing type		HD1R-MD1-ND31AU	
	Commissioning	March 1984		1997	
2.	Generator				
	Manufacturer	Mitsubishi Electric Corporation (MELCO)		Ansaldo	
	Type	MB-J		THR-2-232000	
	Commissioning	1984		1996	
3	Boiler				
	Manufacturer	MHI		Ansaldo	
	Capacity	530 t/h each		536 t/h each	
	Number of burners	28 each		12 each	

Source: Rades Power Station

(3) Operation records of Rades A&B TPPs
The operation hours of Rades A&B TPPs are shown in Table 4.2.1-3.

The operation hours of Rades A TPPs are over 200,000 hours.

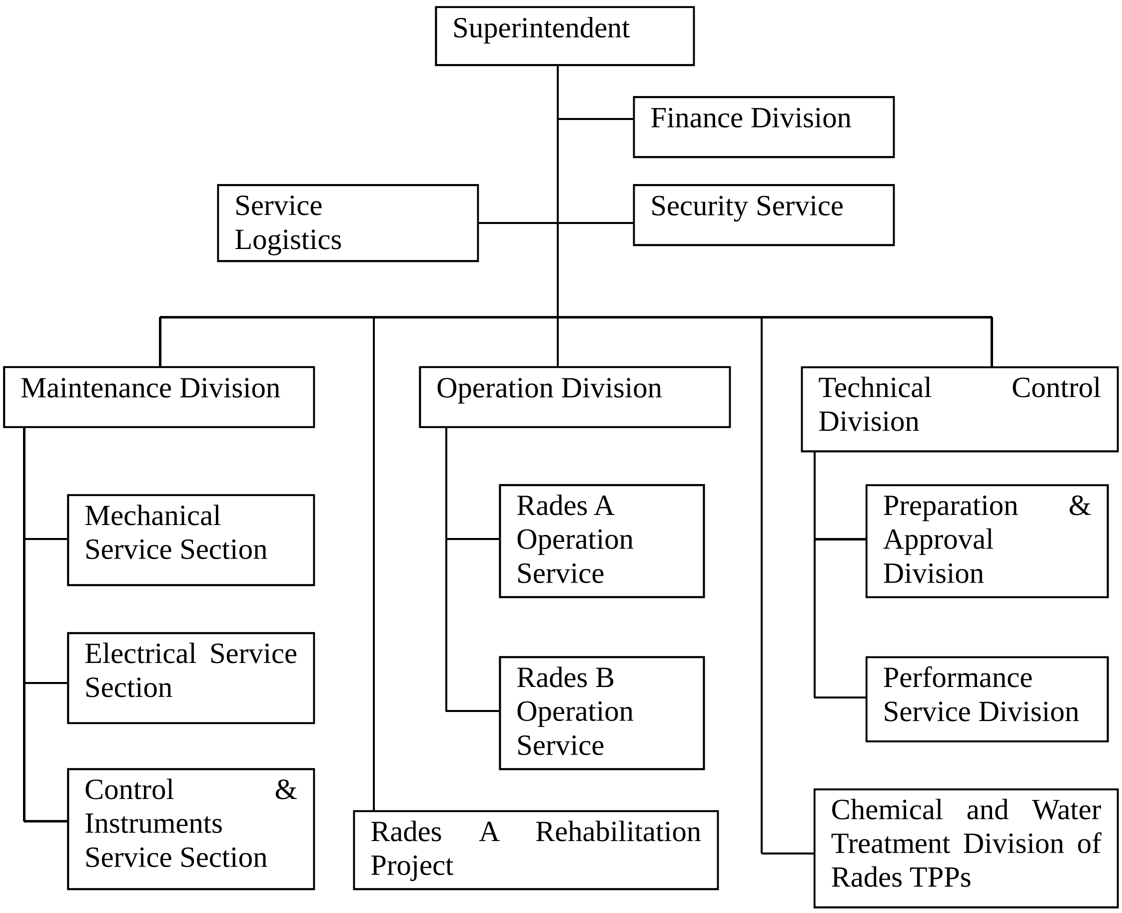
Table 4.2.1-3 Operation Hours of Rades A&B TPPs

		Rades A		Rades B	
		Unit 1	Unit 2	Unit 1	Unit 2
1	Start of operation	June 28, 1985	October 14, 1985	August 31, 1998	December 31, 1998
2	Operating hours	210,128	213,241	105, 732	102,121

Source: Rades Power Station

4.2.2 Organization Structure and Other Records of Rades A&B TPPs

(1) Organization structure of Rades A and B TPPs
The organization structure of Rades A and B TPPs is shown in Figure 4.2.2-1.



Source: Rades Power Station

Figure 4.2.2-1 Organization Structure of Rades A&B TPPs

(2) Number of Personnel of Rades A&B TPPs
The number of experts and staff of Rades A&B TPPs are shown in Table 4.2.2-1.

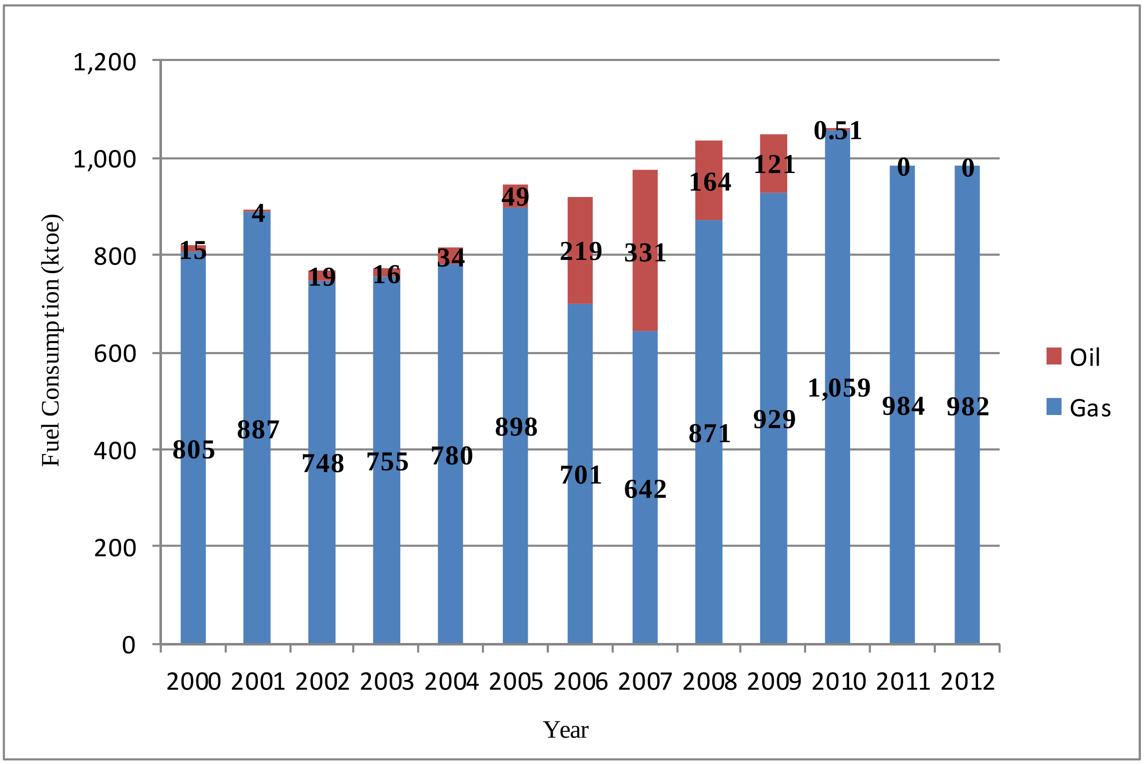
Table 4.2.2-1 Number of Experts and Staff of Rades A&B TPPs in 2013

Category	Number
Managers	47
Technical engineers	155
Operators	103
Total	305

Source: Rades Power Station

(3) Fuel Consumption of Rades A&B TPPs

The fuel consumption (gas and oil) from 2000 to 2012 of Rades A&B TPPs are shown in Figure 4.2.2-2.

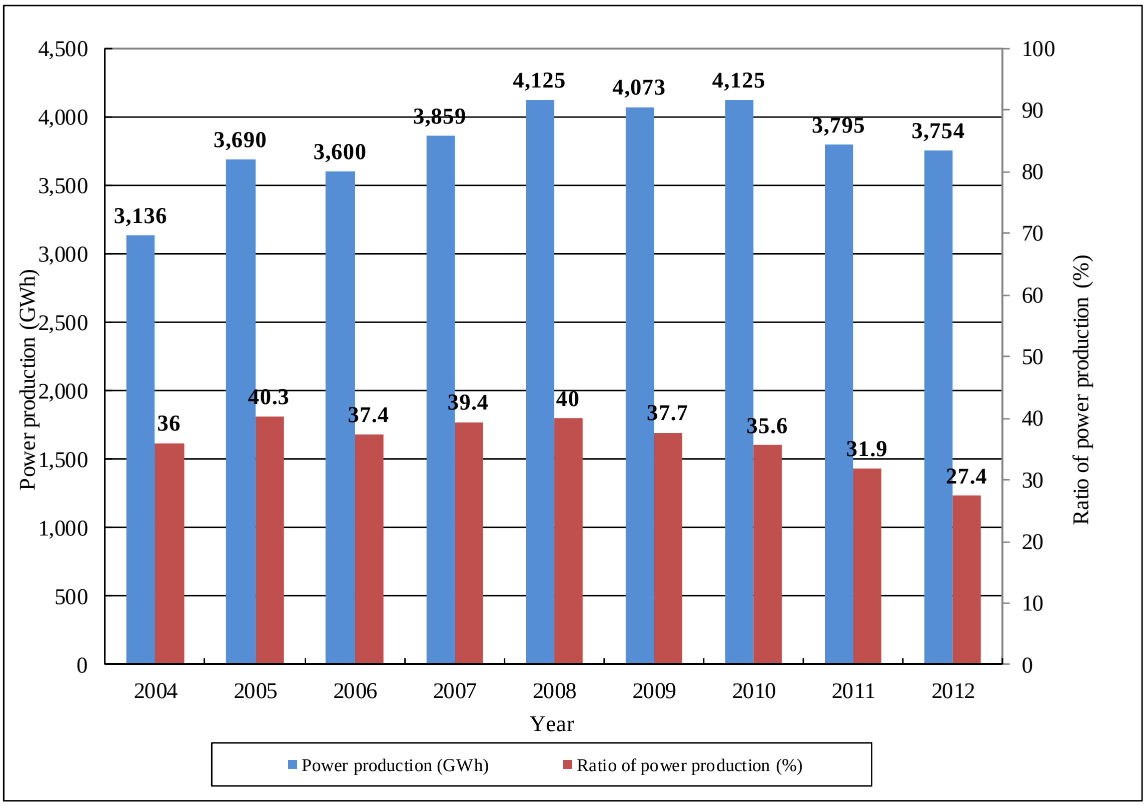


Source: Rades Power Station

Figure 4.2.2-2 Fuel Consumption (Gas and Oil) from 2000 to 2012 of Rades A&B TPPs

(4) Power Production and Its Occupation Ratio of Rades A&B TPPs

The power production and occupation ratios from 2004 to 2012 of Rades A&B TPPs are shown in Figure 4.2.2-3.



Source: Rades Power Station

Figure 4.2.2-3 Power Production and Occupation Ratios from 2004 to 2012 of Rades A&B TPPs

Chapter 5 Fuel Supply Plan

5.1 Overview of Natural Gas in Tunisia

Tunisia is an oil and natural gas producing country. According to statistics of the U.S. Energy Information Administration, the natural gas reserves in Tunisia are estimated at 2.3 trillion cubic feet (Tcf) as of 2012. This is smaller than those of neighboring countries, as Algeria has 159 Tcf of natural gas reserves and Libya has 53 Tcf of the same.

Tunisia has a great number of gas fields including the Misker gas field boasting the greatest production volume, followed by the Hasdrubal gas field. These two gas fields are located offshore east of Tunisia.

In addition, a gas pipeline runs across Tunisia, and is known by the name of the Trans-Mediterranean pipeline connecting Algeria and Italy. This gas pipeline is intended for Algeria to supply Italy with natural gas. The gas pipeline starting from Hassi R'mel of Algeria runs across Tunisia over the distance of approximately 370 km, and reaches Italy via Sicily. This pipeline allows Tunisia to receive 5.25% of the entire natural gas passing through the gas pipeline free of charge as a royalty fee. Further, natural gas is imported from Algeria through this gas pipeline in order to meet demand for natural gas in Tunisia.

It should be noted that natural gas is not exported from Tunisia.

Figure 5.1-1 illustrates the positional relationship between gas fields and gas pipelines in Tunisia.

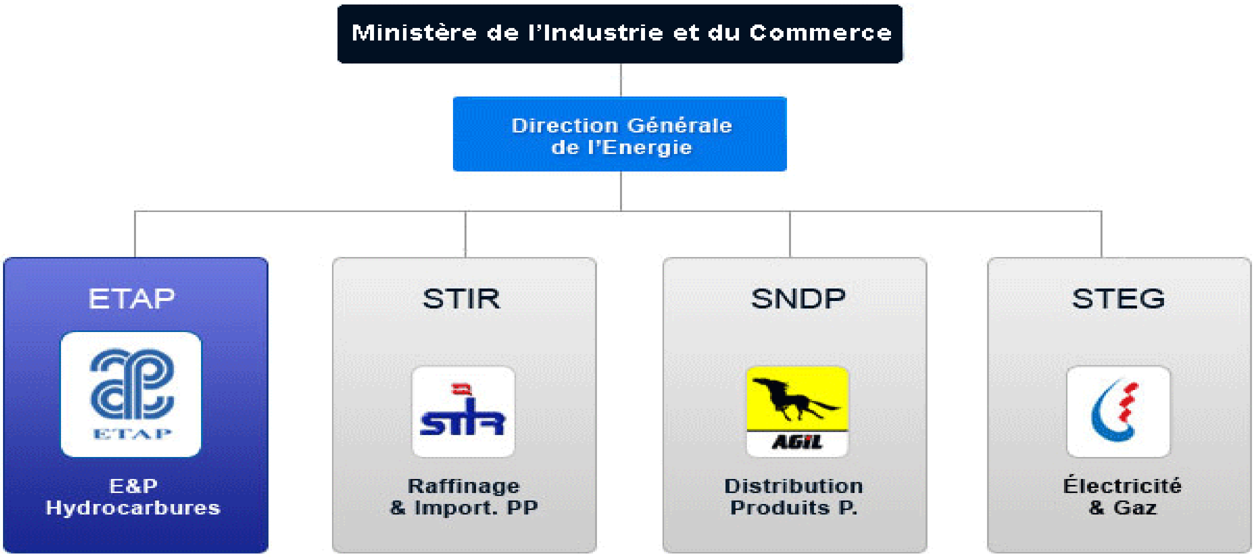
Source: STEG "RESEAU NATIONAL GAZ & GISEMENT HYDROCARBURES HORIZON 2016"

Figure 5.1-1 Positional Relationship between Gas Fields and Gas Pipelines in Tunisia

Figure 5.1-2 shows the organization chart of the oil and gas sectors in Tunisia and Table 5.1-2 shows the role assignment among companies.

In the gas business, the exploration and production of oil and gas fields is managed by the Entreprise Tunisienne d'Activité Pétrolière (the Tunisian Company of Petroleum Activities, ETAP) under the supervision of the Ministry of Industry (MOI). Transport and distribution of natural gas is managed by STEG.

In the field of petroleum business, refining of crude oil is managed by the Société Tunisienne des Industries de Raffinage (the Tunisian Company of Refining Industries, STIR), while oil distribution is managed by the Société Nationale de Distribution des Pétroles (the Tunisian Company of Oil Distribution, SNDP).



Source: STEG

Figure 5.1-2 Organization Chart of the Oil and Gas Sectors

Table 5.1-2 Role Assignment among Companies

Company	Role
ETAP (Entreprise Tunisienne d'Activité Pétrolière)	Management of exploration and production for oil and gas fields
STEG (Société Tunisienne d'Électricité et de Gaz)	Transport and distribution of natural gas
STIR (Société Tunisienne des Industries de Raffinage)	Refining of crude oil
SNDP (Société Nationale de Distribution des Pétroles)	Oil distribution

Source: STEG

5.2 Volumes of Production, Import and Consumption of Natural Gas (Performance Record)

Table 5.2-1 shows the volumes of production, import, export and consumption of natural gas recorded in the past five years. The natural gas production volume registers a gradual increase in and after 2008. After a peak is reached in 2010, the production exhibits a slight decrease in recent years, and 2,793 kilo ton equivalent oil (ktoe) was registered in 2012. Further, to meet domestic natural gas demand, Tunisia imports natural gas from Algeria. In 2012, 53% of the natural gas for domestic supply was produced in Tunisia, and 47% was imported from Algeria. The production volume shows an approximate 40% increase over that for 2008, and the import volume registers an approximate 40% increase.

The consumption of natural gas for 2012 was 5,236 ktoe. Approximately 70% of the overall natural gas consumption in Tunisia is consumed by power plants. The volume of natural gas consumed by power plants shows an increase of approximately 5.3% on average over the past five years. Similarly, there is an increase of 6.8% in the consumption of high pressure gases for industrial use, and middle and base pressure gases for commercial and household use. This is due to STEG's efforts to expand the gas supply area. STEG is targeting to attract 1,000,000 clients by 2015 by connecting 70,000 clients per year.

Table 5.2-1 Transition of Production, Import, Export and Consumption of Natural Gas

Unit: ktoe

	2008	2009	2010	2011	2012
1. Production	2,040	2,507	3,030	2,883	2,793
Gas Miskar	1,470	1,567	1,509	1,324	1,017
Gas Commercial South	501	672	740	608	594
Gas Chergui	69	261	273	278	259
Gas Hasdrubal	-	7	460	560	846
Gas Maamoura	-	-	48	113	77
2. Importation	2,207	1,952	1,825	1,895	2,442
Algeria	2,207	1,952	1,825	1,895	2,442
Royalty	1,000	835	773	731	798
Contractual Purchase	394	393	376	375	376
Additional Purchase	813	724	677	790	1,269
3. Consumption	4,227	4,447	4,855	4,777	5,236
STEG	2,481	2,629	2,916	2,853	3,211
IPP	660	626	636	649	619
HP, MP, BP*	1,086	1,192	1,303	1,275	1,406
4. Exportation	0	0	0	0	0

* HP: High pressure, MP: Middle pressure, BP: Base pressure
Source: STEG

5.3 Prediction of Natural Gas Consumption and Supply Plan

Table 5.3-1 shows the estimated natural gas consumption volume for the next ten years. The demand for natural gas is expected to register a 3.8% growth per year on average for the next ten years. The consumption of natural gas is estimated to reach 5,544 ktoe in 2014, and 7,592 ktoe in 2022. This prediction includes the volume of natural gas to be used in new power plants to be built in the future.

In addition, it appears that there will be a gradual decrease in supply after a peak was reached in 2010. To cope with this situation, a new development project under the name of the South Tunisia Gas Project (STGP) is currently being implemented. This project is intended to solve the problems of insufficient capacity in the gas pipeline for transporting natural gas produced in the south of Tunisia to Gabes, and in the gas treatment plant located in Gabes. This project includes a plan of constructing a new gas pipeline and reinforcing the gas treatment plant. This pipeline is also planned to be used by the Nawara gas field currently under development. This project is planned to be completed in 2016, and the volume of supply is estimated at 930 ktoe per year. However, even after the completion of the STPG, the still growing demand for natural gas is not expected to be able to be met by the volume of the natural gas produced in this country, which depends on imports to make up for insufficient domestic supply. The import agreement with Algeria will expire in 2019. Currently, the volume of import in and after 2020 is not specified in the supply plan.

Table 5.3-1 Estimated Natural Gas Consumption Volume and Planned Supply

Unit: ktoe

	2013	2014	2015	2016	2017
1. Production	2,747	2,716	2,542	3,027	2,791
Gas Miskar	939	875	652	583	535
Gas Commercial South	536	588	494	437	357
Gas Chergui	256	281	295	-	-
Gas Hasdrubal	980	934	906	888	826
Gas Maamoura	56	38	195	189	143
Gas STGP*	-	-	-	930	930
2. Importation	2,665	2,828	3,626	4,284	4,660
Algeria	2,665	2,828	3,626	4,284	4,660
Royalty	484	484	900	900	900
Contractual Purchase	395	395	376	376	376
Additional Purchase	1,786	1,949	2,350	3,008	3,384
3. Consumption	5,432	5,544	5,601	5,927	6,270
STEG, IPP	3,952	3,965	3,909	4,089	4,384
HP, MP, BP	1,480	1,579	1,692	1,838	1,966
4. Exportation	0	0	0	0	0

	2018	2019	2020	2021	2022
1. Production	2,358	2,071	1,963	1,751	1,545
Gas Miskar	487	442	410	374	343
Gas Commercial South	268	207	174	122	103
Gas Chergui	-	-	-	-	-
Gas Hasdrubal	596	453	428	325	169
Gas Maamoura	77	39	21		
Gas STGP*	930	930	930	930	930

2. Importation	4,660	5,036			
Algeria	4,660	5,036			
Royalty	900	900			
Contractual Purchase	376	376			
Additional Purchase	3,384	3,760			
3. Consumption	6,563	6,903	7,172	7,529	7,592
STEG, IPP	4,519	4,797	5,000	5,314	5,333
HP, MP, BP	2,044	2,106	2,172	2,215	2,259
4. Exportation	0	0	0	0	0

* STGP: South Tunisia Gas Project
Source: STEG

5.4 Possibility of Gas Supply to Rades C CCPP

5.4.1 Verification of Natural Gas Supply Agreement

Currently STEG has a contract with ETAP on the supply of domestically produced natural gas, which has been updated every year. In addition, STEG has a contract for the supply of imported natural gas with the Société National pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures (Sonatrach), which is an Algerian state-owned company. The natural gas import contract with Sonatrach is a long-term contract valid up to 2019. Imports from Algeria include royalty based imports as well as contractual and additional purchases. The import volume by contractual purchase is determined every year, and ranges from 375 to 395 ktoe per year. The lower limit of the import volume by additional purchase is fixed at 400 ktoe per year, and the upper limit is not determined. Currently, STEG's volume demands for natural gas can be met, and the gas can be imported.

STEG has been attempting to make monthly adjustments in the natural gas supply-demand program with MOI and ETAP in order to ensure a stable supply of natural gas.

5.4.2 Verification of the Estimated Required Supply Volume with Consideration Given to Project Life

As described in Section 5.3, the future natural gas supply plan has been determined. The supply of natural gas is confirmed until 2019 when the contract with Algeria terminates. In the meantime, whether the demand for natural gas can be met or not in and after 2020 depends on the import contract with Algeria. Currently the two governments are having discussions in regards to this import contract.

The abundance of natural gas reserve in Algeria is the 9th ranking in the world and this volume is approximately 70 times of Tunisia. The natural gas consumption in Algeria in 2011 is approx. 37% of the total of natural gas production and remaining gas is exported. The volume of imported natural gas of Tunisia is 1.6% of the total of natural gas production of Algeria. Currently, Algeria has a development plan of natural gas production. Accordingly, five (5) gas fields will product the natural gas from 2014, and the total of natural gas production will increase approximately 30% than current state. In considering of Algeria's plan, the team expects that it is highly possibility to increase the imported natural gas from Algeria in the future.

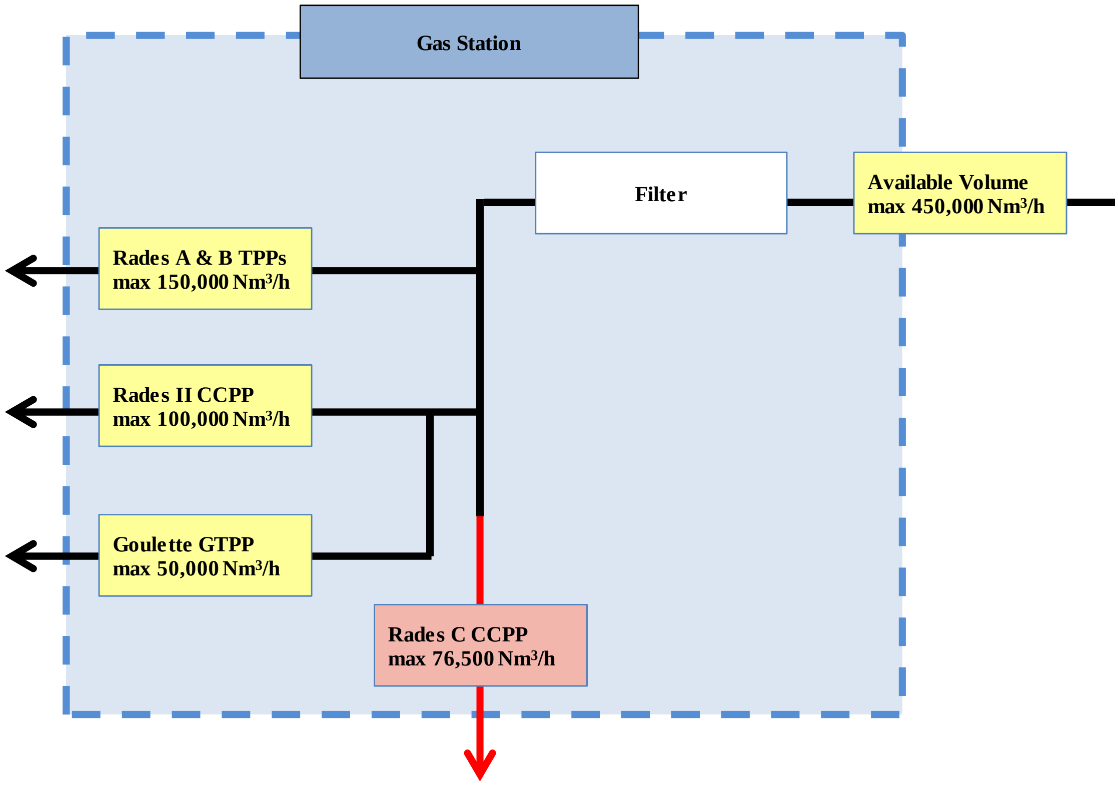
To ensure a stable supply of natural gas over the long term, it is essential to implement the following:

- Implementation of the STGP according to the schedule.
- In the import contract with Algeria which expires in 2019, efforts should be made to increase the purchase volume and increase the contract period.
- Efforts should be made to develop new gas fields in Tunisia.

Further, STEG is currently planning to build an approximately 260 km long gas pipeline from Mellitah, Libya, to Gabes, Tunisia. If imports from Libya can be realized, a more stable supply of natural gas can be ensured.

5.4.3 Verification of the Adequacy and Feasibility of the Project from the Viewpoint of Gas Supply

The gas pipeline used to supply natural gas to the three power plants of Rades A&B TPPs, Rades II CCPP and Goulette GTPP branches off inside the existing gas station, which is located in the premises of Rades A&B TPPs. Similarly, the natural gas supply pipe for Rades C CCPP will also branch off inside the existing gas station.
Figure 5.4.3-1 illustrates the schematic diagram of the natural gas pipeline.



Source: JICA Study Team

Figure 5.4.3-1 Schematic Diagram of the Natural Gas Pipeline

Table 5.4.3-1 shows the hourly consumption of natural gas at the time of rated output in each power plant. Natural gas can be supplied in the volume of 450,000 Nm^3/h. By contrast, the total of natural gas consumption of each power plant is 376,500 Nm^3/h. Therefore, this shows that there is sufficient natural gas that can be supplied to the Rades C CCPP.

Table 5.4.3-1 Hourly Consumption of Natural Gas of Each Unit at Rated Output

Unit: Nm^3/h

Name of Power Plant	Gas Consumption	Remark
Rades A&B TPPs	150,000	−
Rades II CCPP	100,000	−
Goulette GTPP	50,000	−
Rades C CCPP	76,500	−
Total	376,500	< 450,000

Source: JICA Study Team

Chapter 6 Basic Design

This chapter describes about the basic design of the Combined Cycle Power Plant (CCPP) to be introduced as Rades C power plant. For the purpose, initially conducted are the conceptual designs where design conditions and specifications are specified and types of essential components and facilities comprising of the Plant are discussed. The plant plot plan is also depicted based on past experiences with similar plant of the study team to confirm that the all the components and facilities necessary to complete the Plant are properly arranged in the candidate site area. Secondly, basic systems such as gas turbine, steam turbine, HRSG and so on consisting of the Plant are qualitatively designed based on the specified design conditions and study results of the essential components. Lastly, the construction schedule of the Plant is made out in consideration of results of the said basic design and the back ground of this project.

6.1 Conceptual Design

6.1.1 Design Conditions

Design conditions shall be specified to complete the feasibility study for this Project. However, not all the detailed design conditions have been decided because of the tight time schedule for discussion and study during the preparation period of the feasibility study. Some design conditions may be tentatively specified or assumed at this feasibility study stage and may be revised or finalized in the further detailed design stage of this project. The following Table 6.1.1-1 shows the design conditions necessary for completion of the preparatory survey on Rades Combined Cycle Power Plant Construction Project.

Table 6.1.1-1 Design Conditions and Specifications

Description	Conditions and/or Specifications	
(1) Basic Design Conditions	**Rated (Performance Evaluation Point)**	**Range**
a. Dry bulb temperature (°C)	20.0	10.0 to 40.0
b. Barometric pressure (kPa)	101.325	
c. Altitude (m)	2.0	
d. Relative humidity (%)	70.0	20.0 to 90.0
e. Wet bulb temperature (°C)	16.5	7.4 to 33.5
f. Temperature of cooling water	25.0	15.5 to 30.0
g. Type of fuel	Specified natural gas as main fuel diesel oil as standby fuel	
h. Supply pressure of natural gas at terminal point (MPa(g))	5.5	3.3 to 7.6
i. Supply temperature of natural gas at terminal point (°C)		Max 50.0
j. Conditions to define the maximum capability of bottoming and electrical systems	Ambient conditions: Dry bulb temperature 10.0°C Relative humidity 70.0% Wet bulb temperature 7.4°C	

Description	Conditions and/or Specifications
k. Economically operable service life	25 years with reasonable repair and/or replacement of consumable and/or normal wear and tear parts
l. Make-up water for processing	Demineralized water
m. Type of circulating cooling water	Sea water
(2) Specification of Main Equipment	
1) Plant	
a. Type of shaft arrangement	Multi-shaft arrangement with a bypass stack
b. Type of operation	Combined cycle operation with a function of GT simple cycle operation
c. Type of control system	DCS type
d. Type of steam turbine condenser cooling system	Once-through type
2) Gas turbine	
a. Type of supplier	Original equipment manufacturers who conducted the full development of the prototype of the proposed type of machine and have performed successive upgrades.
b. Application standards	ISO 3977 Part 3 or equivalent
c. Type of configuration	Open cycle, single shaft, heavy duty, natural gas fired, cold end drive, axial exhaust type
d. Type of installation	Indoor installation with sound attenuation enclosure
e. Rating	Continuous base load rating with the load weighing factor of 1.0 for EOH calculation
f. Rotating speed	3,000 rpm
g. Type of coupling	Directly coupled with generator by integrated solid coupling
h. Shaft strength	To be designed to withstand the transient torque due to short circuit or out-of-phase synchronization, whichever is greater.
i. Temperature class	F-class with a wealth of commercial operating experience
j. Shaft lateral vibration	As per ISO 7919-Part 4 “Gas Turbine ets”
k. Allowable speed variation range on continuous load operation	3,000 rpm ±3%
l. Dry low NOx combustion system for natural gas	Yes
m. Inlet air cooling system	Yes

Description	Conditions and/or Specifications
n. Type of starting device	- A synchronous generator/motor with a thyristor frequency converter or - A squirrel cage motor with a torque converter
o. Compressor on-line and off-line cleaning device	Yes
p. Wet type air compressor cleaning device	Yes
q. Pre-heater of natural gas fuel	As per manufacturer's option
r. Type of inlet air filter	Multi-stage or self-cleaning type with a dust removal efficiency of more than 99.5% for ISO fine dust.
s. Bypass stack	Self-standing type fabricated with steel plates with a height of 45 m
3) HRSG	
a. Application standard	Relevant ASME Pressure Vessel Codes or equivalent
b. Type of configuration	Lateral or vertical gas flow type with evaporation drums and natural circulation
c. Type of cycle	Triple-pressure, reheat
d. Flue gas exit temperature	Not lower than 90°C in consideration of the impact on the environment
e. Type of installation	Outdoor installation
f. Supplementary duct firing	No
g. Flue gas stack	Stand alone type fabricated with steel plates supported by steel structures with a height of 85 m in consideration of the impact on the environment
h. Flue gas velocity at flue gas stack exit	Not more than 25 m/s
4) Steam turbine	
a. Application standard	ISO 14661 or equivalent
b. Type of configuration	Two (2)-casing, three (3)-admission, sliding pressure, full condensing, axial or downward exhaust type
c. Type of cycle	Triple-pressure, reheat
d. Type of pressure control of extraction steam	Internal pressure control type
e. Type of installation	Indoor installation with sound attenuation cover
f. Rotating speed	3,000 rpm
g. Minimum allowable speed variation range on continuous load operation	3,000 rpm ±3%
h. Type of coupling	Directly coupled with generator by integrated solid coupling

Description	Conditions and/or Specifications
i. Shaft strength	To be designed to withstand the transient torque due to short circuit or out-of-phase synchronization, whichever is greater
j. Shaft lateral vibration	As per ISO 7919-Part 2 “Large Land-based Steam Turbine Generator Sets”
k. Steam bypass	Yes
5) Condenser	
a. Type	Shell and tube surface cooling type with vacuum deaeration function
b. Type of cooling water	Seawater
c. Temperature rise across the condenser	7.0°C
d. Tube cleaning system by seawater reverse flow valve system	Yes
e. Mechanical type tube cooling device	Yes
6) Generators	
a. Application standard	IEC 60034-3 or equivalent
b. Type	Horizontally mounted, cylindrical rotor, rotating field, air or hydrogen cooled synchronous type
c. Rated voltage	24 kV (GTG) / 17.5kV (STG)
d. Type of exciter	Static or brushless type
e. Coil temperature rise	IEC B class
f. Insulator temperature limit	IEC F class
7) Main transformer	
a. Type of cooling	Oil natural and air forced type
b. Primary voltage	24 kV (GTG) / 17.5kV (STG)
c. Secondary voltage	220 kV
(3) Operational Requirements	
1) Type of operation	
a. Type of basic operation	Continuous base load operation
b. Anticipated range of plant controllable power load without steam bypass	30 to 100%
c. Speed droop power load operation	Yes
d. Constant power load operation irrespective of heat export demand	Yes
e. Frequency control operation	Yes
f. Constant gas turbine inlet temperature operation	Yes
g. Gas turbine simple cycle operation	Yes
h. Operation manner	LCD operation from remote control room by keyboard and mouse
i. Blackout start	No

Description	Conditions and/or Specifications
j. Isolated operation of gas turbine from network in an emergency	Yes
2) Time required for start-up to full power after pushing start-up button (time for purge and synchronization is not included)	
a. Cold start	At longest 4 hours
b. Warm start	At longest 3 hours
c. Hot start	At longest 2 hours
d. Very hot start	At longest 1 hours
3) Voltage rating of auxiliary equipment power source	
a. AC power	
a) 200 kW≦P	AC 6,300 V
b) 3 kW≦P< 200 kW	AC 400 V
c) P< 3 kW	AC 200 V
b. DC power	DC 220 V
c. Lighting	AC 200 V
d. Instrumentation	AC 200 V
e. Control power	AC 100 V
f. Control signal	DC 24 V
(4) Basal Conditions for Arrangement of Main Equipment	
1) Gas and steam turbine generators	To be installed inside the gas and steam turbine separate buildings with a ventilation system, an overhead travelling crane and laydown bay for carrying bulky components in and out.
2) HRSG	To be installed outside on the same center axis as the gas turbine generator.
3) Arrangement of axes of gas and steam turbine generators	To be arranged in parallel
4) Gas turbine air filter	To be located as highly as possible above ground level
5) Control and monitoring and electrical equipment	To be located in the rooms integrated with the gas turbine building
(5) Emission	
1) Exhaust gas emissions (O_2 15% dry basis) (75 - 100% load of gas turbine over specified all ambient conditions)	Natural Gas / Diesel oil
a. NO_x (ppmv)	< 25 / < 42
b. SO_x (ppmv)	Changeable depending on sulfur content
c. CO (ppmv)	< 15 / < 80

Description	Conditions and/or Specifications
d. PM_{10} (mg/Nm^3)	< 10 < 15
2) Airborne noise emission with steady state conditions without background noise	
a. Sound pressure level at a height of 1 m on the station boundary	< 60 dB(A): Daytime < 50 dB(A): Nighttime
b. Sound pressure level at a height of 1 m and a distance of 1 m from equipment or enclosure	< 85 dB(A)
(6) Properties of Fuel Gas	
a. Temperature	Max. 50 °C, Min.____°C
b. Pressure	Perf. point 5.5 MPa(g)
c. Composition	
	Perf. Point
CH_4	85.76 %
C_2H_6	7.26 %
C_3H_8	1.64 %
i-C_4H_{10}	0.21 %
n-C_4H_{10}	0.33 %
i-C_5H_{12}	0.07 %
n-C_5H_{12}	0.07 %
C_6H_{14}	0.06 %
N_2	4.02 %
CO_2	0.53 %
He	0.04 %
	100.0 %
d. Net specific energy (Lower calorific value)	45,755 kJ/kg
e. Gross specific energy (Higher calorific value) at performance point	50,716 kJ/kg
f. Density at 101.3 kPa, 0 °C	0.82589kg/Nm^3
g. Wobbe Index (Gas Index) defined by ISO 3977-4	47,270 kJ/m^3 N
(7) Make-up Water for Bottoming System	
a. Type of water	Demineralized water
b. Temperature	10 °C to 30 °C
c. Available flow rate	50 m^3/hr
(8) Operation and Maintenance	
1) Gas turbine	Supply of spare parts as per LTSA Contract for one (1) cycle up to the first major inspection inclusive.

Description	Conditions and/or Specifications
2) Other equipment	Supply of spare parts for two (2) years of actual operating hours.
3) Training of O&M staff at EPC contractor's works	Yes
4) Three (3) resident engineers (mechanical, electrical and control) of EPC contractor during defect liability period for operation and maintenance support	Yes
5) Inspection intervals of gas turbine on an EOH basis	
a. Combustion inspection	12,000 hours
b. Turbine inspection	24,000 hours
c. Major inspection	72,000 hours
6) Inspection intervals of other equipment	As per recommendation of manufacturer
7) Replacement intervals of filter elements	More than 8,000 actual operating hours for ISO fine dust
(9) Guarantee Items	
1) Plant net power output	Yes
2) Plant net thermal efficiencies for 100, 75, 50% loads	Yes
3) Exhaust gas emissions at 75 - 100% load of gas turbine over all specified ambient conditions	
a. NO_x	Yes
b. CO	Yes
c. PM_{10}	Yes
4) Airborne noise emissions on steady state conditions under all specified operating conditions	
a. Sound pressure levels at a height of 1 m on the station boundary limit	Yes
b. Sound pressure level at a distance of 1 m and a height of 1 m from equipment or noise attenuation cover	Yes
5) Successful completion of two (2) weeks reliability run	Yes
6) Shaft vibration of gas and steam turbine sets based on related ISO standards during the reliability run	Yes

Source: JICA Study Team

6.1.2 Outline of Plant System

This plant is a combined cycle power plant (CCPP) which produces only power energy. The plant shaft configuration is of multi-shaft type where the gas and steam turbine shafts are separated. The plant is comprised of main components of a gas turbine, a gas turbine generator, a HRSG, a steam turbine, a steam turbine generator, a substation, buildings, and associated ancillary facilities.

The gas turbine is of a large capacity F class type which is available in the world market with a wealth of commercial operating experience to evaluate the operating reliability.

The HRSG is of triple-pressure and reheat cycle outdoor installed type. The gas turbine is commonly coupled with the triple-pressure and reheat cycle HRSG to elevate the plant thermal efficiency.

The steam turbine is of triple-admission and full condensing type with downward or axial exhaust.

6.1.3 Study on Shaft Configuration

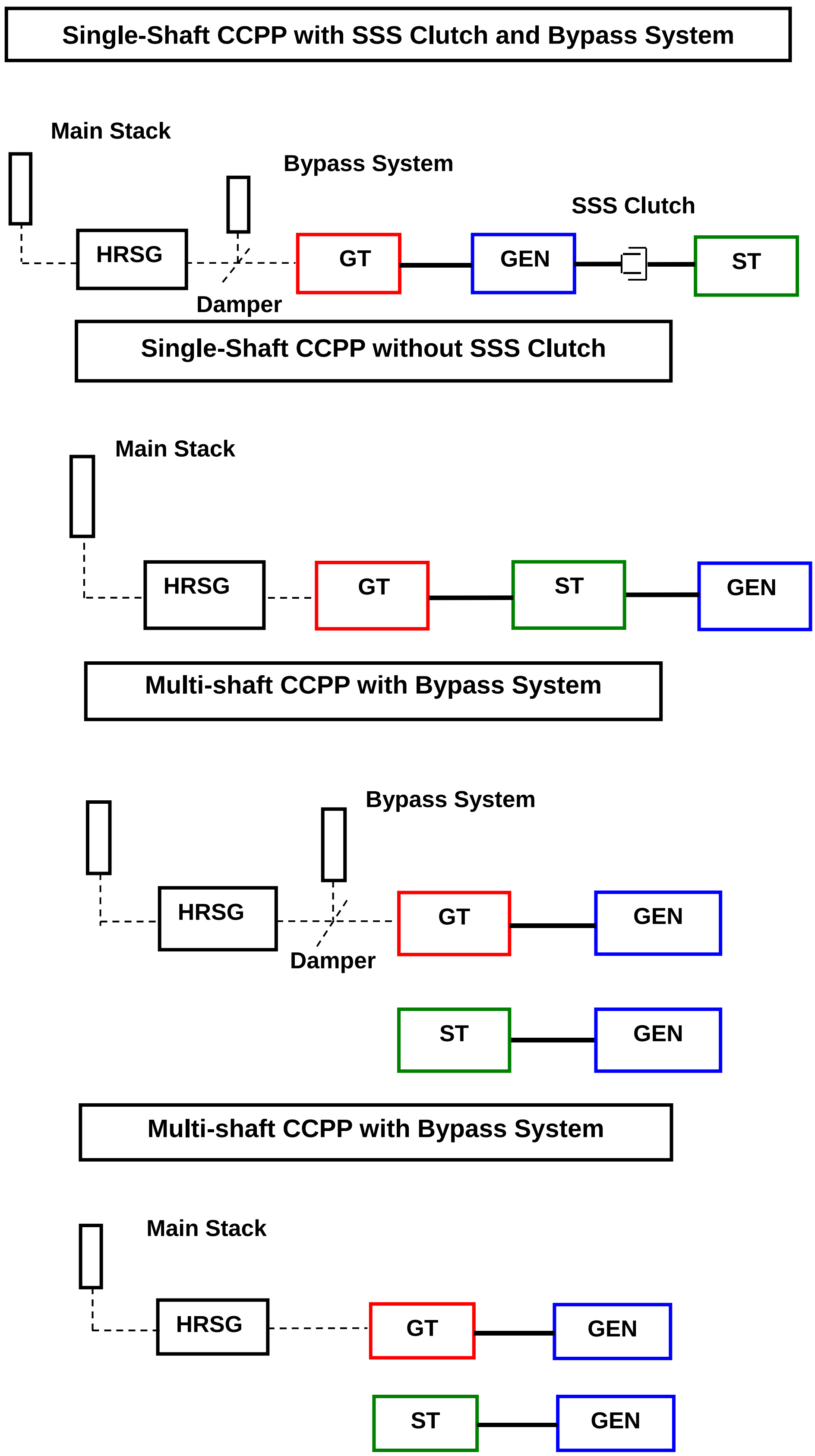
(1) Type of Shaft Configuration

Below is a comparison study on the type of the shaft configuration of the combined cycle power plant (CCPP) comprised of one (1) gas turbine, one (1) unfired type heat recovery steam generator (HRSG), one (1) steam turbine and generator(s).

Basically, there are two (2) types of shaft configurations. One is called single-shaft configuration where the gas turbine, a steam turbine and a generator are connected on the same shaft. The other is called multi-shaft configuration where the gas turbine/generator shaft and the steam turbine/generator are separate.

The single-shaft configuration is classified into two (2) types of configurations depending upon whether it has or does not have a SSS clutch and a bypass system. In case of the former configuration, the power train is arranged in order of the gas turbine, the generator and the steam turbine. The SSS clutch is of auto-engagement and disengagement type and is located between the generator and the steam turbine. In case of the latter configuration, the power train is commonly arranged in order of the gas turbine, the steam turbine and generator.

In case of the multi-shaft type, two (2) types of CCPP configurations with and without the bypass system could be considered. These four (4) types of CCPP shaft configurations are depicted in Figure 6.1.3-2.



Source: JICA Study Team

Figure 6.1.3-1 Shaft Configuration

As shown above, in case of the single-shaft CCPP, one (1) large capacity generator common to both gas and steam turbines is employed. While in the case of a multi-shaft CCPP, two (2) generators are individually employed for the gas and steam turbines. In this case, one is the plant configuration with the bypass system consisting of a bypass stack and a damper, which are installed between the gas turbine and HRSG to allow for the gas turbine/generator to operate as a simple cycle. The other one is the plant configuration without the bypass system.

A comparison study was performed from the viewpoints of thermal efficiency, operational flexibility, operability, start-up steam and auxiliary power requirement, application experiences, operating reliability, maintainability, installation footprint area requirement, construction cost, generation cost and transportation among the above four (4) types of CCPP shaft configurations.

(2) Plant Thermal Efficiency

The single-shaft configuration is equipped with one (1) larger size generator, while two (2) smaller sizes of generators are employed in the multi-shaft configuration. In case of the configuration with the bypass system, the leakage from the bypass system of the exhaust gas will influence plant efficiency. It is reportedly said that the leakage over the lifetime of the plant is 0.5 to 1.5%. This means that the steam turbine efficiency drops by 0.5 to 1.5%. Consequentially, the thermal efficiency of the plant with the bypass system drops by 0.17 to 0.50% compared with the plant without a bypass system. Therefore, the plant thermal efficiencies of the four (4) configurations are as estimated below considering that the efficiency of the larger capacity generator is higher by some 0.1%. The heat loss due to the clutch is considered to be negligibly small.

Type of Configuration	SS CCPP w SSS and BS	SS CCPP w/o SSS and BS	MS CCPP w BS	MS CCPP w/o BS
Plant Thermal Efficiency (%)	Δ0.17~0.50	100	Δ0.27~0.60	Δ0.1

Where,

SS CCPP w SSS and BS	Single-shaft CCPP with Clutch and Bypass System
SS CCPP w/o SSS and BS	Single-shaft CCPP without Clutch and Bypass System
MS CCPP w BS	Multi-shaft CCPP with Bypass System
MS CCPP w/o BS	Multi-shaft CCPP without Bypass System

(3) Operational Flexibility

In case of a single-shaft CCPP without a clutch, the plant could not be operated unless the components of the gas turbine, the heat recovery steam generator, steam turbine and the generator are all functioning well. However, a single-shaft CCPP with a clutch and bypass system could be operated on a simple cycle mode with isolation of the steam turbine by disengaging the clutch even if any components of the bottoming system consisting of a HRSG, a steam turbine and a steam turbine generator are out of order due to any reasons. The exhaust gas from the gas turbine can be discharged into the atmosphere through the bypass system.

In case of a multi-shaft configuration, if the bypass system is equipped, the gas turbine/generator could be operated as a simple cycle similar to a single-shaft configuration

CCPP with a clutch.

Unless the bypass stack is equipped, the plant behaves as if it were of a single-shaft type without a clutch. However, the plant could be operated on a simple cycle mode by dumping the produced steam into the condenser under conditions that the HRSG and the condenser are both in functioning conditions even if the steam turbine is out of service. This is a specific feature of a multi-shaft configuration without a bypass stack.

Thus, a CCPP with a bypass system, whichever the shaft configuration is, will be more flexible in terms of operability than without a bypass system. There is almost no difference in terms of operational flexibility between both types of shaft configurations without a bypass system.

(4) Operability

The CCPP can be operated only by automatic adjustment of the fuel flow into the gas turbine and the operation cycle of start-up, steady operation and shut down can be fully automated irrespective of the type of the shaft configuration. The SSS clutch is of a self-shift and synchronous type. There is, therefore, no essential difference with the operability between both types of shaft configurations. The operational sequence of the multi-shaft CCPP may be slightly more complicated compared to the single-shaft CCPP because of an increased number of components.

(5) Start-up Steam and Auxiliary Power Requirements

In case of a multi-shaft CCPP or a single-shaft CCPP with a clutch, the gas turbine can be started up together with the HRSG separately from the steam turbine/generator. After a certain period of the time, the necessary steam for start-up will be made available from the HRSG and then the steam turbine/generator can be started up with its own steam for flow passage cooling and gland sealing.

In case of a single-shaft configuration without a clutch, however, the steam for the flow passage cooling and gland sealing of the steam turbine which must be started up together with the gas turbine is required from an external source. For the purpose, auxiliary steam from the existing boilers or a standalone auxiliary boiler will be needed.

In case of a single-shaft configuration without a clutch, the power requirement for the starting device is approximately 2.5% of the gas turbine power output, while it is approximately 2.0% in cases of the other three (3) types of CCPPs.

There is no difference with the auxiliary power requirements between the types of CCPPs except for the starting device of the shaft train.

(6) Application Experiences

There are many application experiences with both shaft configuration types of CCPPs. It is understood that both types of shaft configurations are technically feasible without any technical difficulties.

(7) Operating Reliability

The plant operating reliability of each type of CCPP can be evaluated by the plant reliability factor to be calculated with the reliability factors of the main equipment which are assumed as shown below:

Gas turbine:	A1 = 97.5%
Bypass system:	A2 = 97.5%
Heat recovery steam generator:	A3 = 98.0%
Steam turbine:	A4 = 98.5%
Gas turbine generator and transformer:	A5 = 99.0%
Steam turbine generator and transformer:	A6 = 99.0%
SSS clutch:	A7 = 99.0%

The following are the theoretically calculated plant operating reliabilities on an operating hour (PORH) basis of a single-shaft CCPP without a clutch as $PORH_S$ and with a clutch as $PORH_{SS}$, a multi-shaft CCPP without a bypass system as $PORH_M$ and a multi-shaft CCPP with a bypass system as $PORH_{MB}$.

$PORH_S$ = A1×A3×A4×A5 = 0.9318 = 93.18%

$PORH_{SS}$ = A1×A2×A3 ×A4 ×A5 ×A7 + A1×A2×A5×A7×(1-A3×A4) = 0.9317 = 93.17%

$PORH_M$ = A1×A3×A4×A5×A6 = 0.9224 = 92.24%

$PORH_{MB}$ = A1×A2×A3×A4×A5×A6 + A1×A2×A5× (1-A3×A4×A6) = 0.9411 = 94.11%

From the above calculation results, the following relationship could be predicted among operating reliabilities on an hour basis of the four (4) types of CCPPs.

$PORH_{MB}$ (94.11%) > $PORH_S$ (93.18%) = $PORH_{SS}$ (93.17%) > $PORH_M$ (92.24%)

It is found from this relationship that the plant operating reliability of a multi-shaft CCPP with a bypass system ($PORH_{MB}$) is slightly higher compared with other types of CCPPs.

The PORH is the plant operating reliability on the basis of operating hours. However, when the gas turbine is operated on a simple cycle mode, the plant total power output could be reduced by some two thirds. Therefore, the plant operating reliability on the basis of power energy (PORE) has to be evaluated. The PORE of each shaft configuration can be calculated as shown below.

$PORE_S$ = A1×A3×A4×A5 = 0.9317 = 93.17%

$PORE_{SS}$ = A1×A2×A3×A4×A5×A7×(2/3+1/3×0.995) + A1×A2×A5×A7×(1-A3×A4)×2/3
= 0.9194 = 91.94%

$PORE_M$ = A1×A3×A4×A5×A6 = 0.9224 = 92.24%

$PORE_{MB}$ = A1×A2×A3×A4×A5×A6×(2/3+1/3×0.995) + A1×A2×A5×(1-A3×A4×A6)×2/3
= 0.9257 = 92.57%

Therefore, the priority order of the PORE of each shaft configuration can be expressed as shown below:

$PORE_S$ (93.17%) > $PORE_{MB}$ (92.57%) > $PORE_M$ (92.23%) ≥ $PORE_{SS}$ (91.94%)

(8) Maintenance Cost

Compared with a single-shaft CCPP, a multi-shaft CCPP is equipped with additional components such as a generator, a step-up transformer, lubricating and control oil systems, a bypass stack, a bypass stack silencer, and an exhaust gas damper. Therefore, it is envisaged that the maintenance of a multi-shaft CCPP needs more man-hour maintenance and is more expensive.

(9) Footprint Area for Instruction

As mentioned in the previous paragraph, since a multi-shaft CCPP is equipped with more facilities than a single-shaft CCPP, a larger footprint area is needed for its installation. In addition, the space utilization effect is inferior because a gas turbine/generator and steam turbine/generator are severally installed. From our experience, the footprint area for the installation of a multi-shaft CCPP power train is more or less larger by 15 ~ 25% than a single-shaft CCPP depending upon installation of the bypass system.

The larger footprint area for installation of equipment means a larger amount of civil, architectural and construction works, which in turn means higher costs. Figures 6.1.3-2 and 6.1.3-3 attached hereto show typical plan drawings of a single-shaft CCPP power train without a clutch and a multi-shaft CCPP power train with a bypass system using a F-class gas turbine, respectively.

In case of a single-shaft CCPP power train with a clutch and bypass system, the length of the longer side is assumed to be some 20 m longer compared to the layout shown in Figure 6.1.3-1. Therefore, the footprint area for installation comes close to that of a multi-shaft CCPP power train with a bypass system.

(10) Phased Construction

A multi-shaft configuration with a bypass system has the special characteristic of phased construction. The completion time of the gas turbine package is normally faster than the bottoming system, which means that it can be put into commercial operation in advance. This characteristic is advantageous for projects which must cope with steeply increasing power demand.

(11) Construction Cost

A multi-shaft CCPP is composed of more components than a single shaft CCPP as mentioned above. Therefore, it is easily predicted that its construction cost will be higher than a single-shaft CCPP. According to construction estimation results using computer software, the relative cost differences between them can be shown below as referential values for this study.

SS CCPP w/o SSS and BS	100% (Base)
SS CCPP w SSS and BS	Plus 2.2%
MS CCPP w/o BS	Plus 4.2%
MS CCPP w BS	Plus 6.1%

(12) Power Generation Costs

The power generation costs of the other three (3) types of CCPPs against the SS CCPP w/o SSS and BS can be calculated as shown below.

1) Fuel cost

Fuel cost (fuel consumption) is proportional to the plant operating reliability on an hourly basis. Therefore, fuel costs of the other three (3) types of CCPPs against the SS CCPP w/o SSS and BS are estimated as tabulated below:

SS CCPP w SSS and BS	Minus 0.01% (= 93.18 – 93.17)
MS CCPP w/o BS	Minus 0.93% (= 93.17 – 92.24)
MS CCPP w BS	Plus 0.98% (= 93.17 – 94.11)

2) Capital recovery cost
The capital recovery cost proportional to the construction cost can be estimated as shown below referring to the results in the previous sub-section (11). Therefore, the relative values of other shaft configurations against a SS CCPP w/o SSS and BS can be expressed as below:

SS CCPP w SSS and BS	Plus 2.2%
MS CCPP w/o BS	Plus 4.2%
MS CCPP w BS	Plus 6.1%

3) Power energy sales
Power energy sales are proportional to the plant operating reliability on a power energy basis. Therefore, the relative values of other shaft configurations against a SS CCPP w/o SSS and BS can be expressed as below:

SS CCPP w SSS and BS	Minus 1.24% (= 93.18 – 91.94)
MS CCPP w/o BS	Minus 0.94% (= 93.18 – 92.24)
MS CCPP w BS	Minus 0.61% (= 93.18 – 92.57)

Therefore, the power generation cost of a SS CCPP w SSS and BS against a SS CCPP w/o SSS and BS can be calculated to be higher by 2.7% (= ((1–0.0001)×1/(1+2) + (1+ 0.022)×2/(1+2)))/(1 – 0.0124) – 1.0) = 0.027). In this case, the ratio of the fuel cost to the capital recovery cost is assumed to be 1 to 2. The generation costs of the other two (2) types of CCPPs can be similarly calculated. The calculation results are as follows:

MS CCPP w/o BS	Plus 3.5%
MS CCPP w BS	Plus 5.0%

(13) Inland Transportation
The Project site is located on the seaside near Tunis, the capital city of Tunisia. There are two (2) conventional type thermal power plants and one (1) CCPP adjacent to the site. Therefore, there are no differences among types of shaft configurations regarding inland transportation.

(14) Study Summary
The study results described above are summarized in Table 6.1.3-1. The yellow highlighted cells show that the shaft configuration of the cell is preferred in terms of the related comparison item. As shown in this table, as long as the overall priority is judged from the total area of highlighted cells, a single shaft configuration without a clutch and bypass stack is ranked first. A single shaft configuration with a clutch and bypass stack and a multi-shaft configuration with a bypass stack are ranked second. A multi-shaft configuration without a bypass stack is ranked lowest.

However, the priority is changeable depending upon where the weight is placed, the site conditions and requirements for the project. In case of this project, first priority is placed on phased construction where a gas turbine simple cycle operation can be completed. Therefore, a multi-shaft configuration shall be selected for this project. In addition, this configuration is also ranked highest in terms of operating reliability on an hourly operating basis.

For the reasons stated above, a multi-shaft configuration with a bypass stack has been selected for this project.

Table 6.1.3-1 Summary of Comparison Study Results on Shaft Configuration of CCPP

Comparison Item		Single-shaft CCPP		Multi-shaft CCPP	
		Without a SSS clutch	With a SSS clutch and a bypass stack	With a bypass stack	Without a bypass stack
1. Thermal Efficiency		Base (100%)	Δ 0.17 ~Δ 0.50%	Δ 0.27 ~Δ 0.60%	Δ 0.10%
2. Operational Flexibility (Simple Cycle Operation)		Base (No)	More flexible (Yes)	More flexible (Yes)	Slightly flexible (Conditionally yes)
3. Operability		Base	Similar	Slightly complicated due to operation of more equipment	
4. Start-up Requirement	**Steam**	External auxiliary steam	Own steam	Own steam	External auxiliary steam
	Power for Starting device	App. 2.5% of GT capa.	App. 2.0% of GT capa.	App. 2.0% of GT capa.	App. 2.0% of GT capa.
5. Application Experience		Base	Similar	Similar	Similar
6. Operating Reliability	**PORH**	Base (100%)	Δ 0.0%	+ 0.9%	Δ 0.9%
	PORE	Base (100%)	Δ 1.2%	Δ 0.6%	Δ 0.9%
7. Maintenance Cost		Base	Similar	Slightly higher because of more equipment	
8. Footprint Area of Power Train		Base (100%)	+ 15%	+ 25%	+ 10%
9. Phased Construction		No	No	Yes	No
10. Construction Cost		Base (100%)	+ 2.2%	+ 6.1%	+ 4.2%
11. Power Generation Cost		Base (100%)	+ 2.7%	+ 5.0%	+ 3.5%
12. Inland Transportation		Base	Similar	Similar	Similar

Source: JICA Study Team

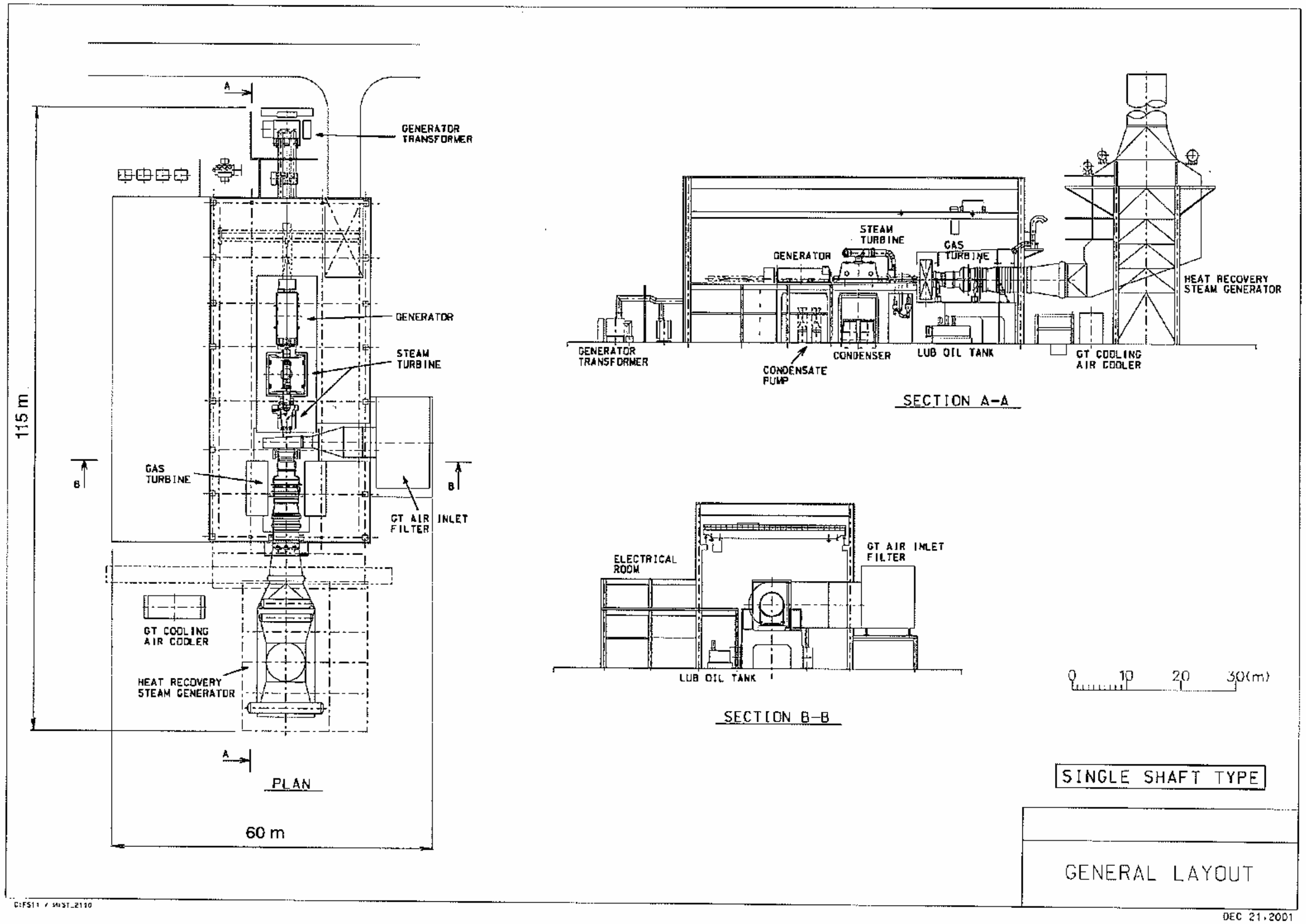


Figure 6.1.3-2 Typical Layout of a Single-shaft Arrangement Combined Cycle Power Plant

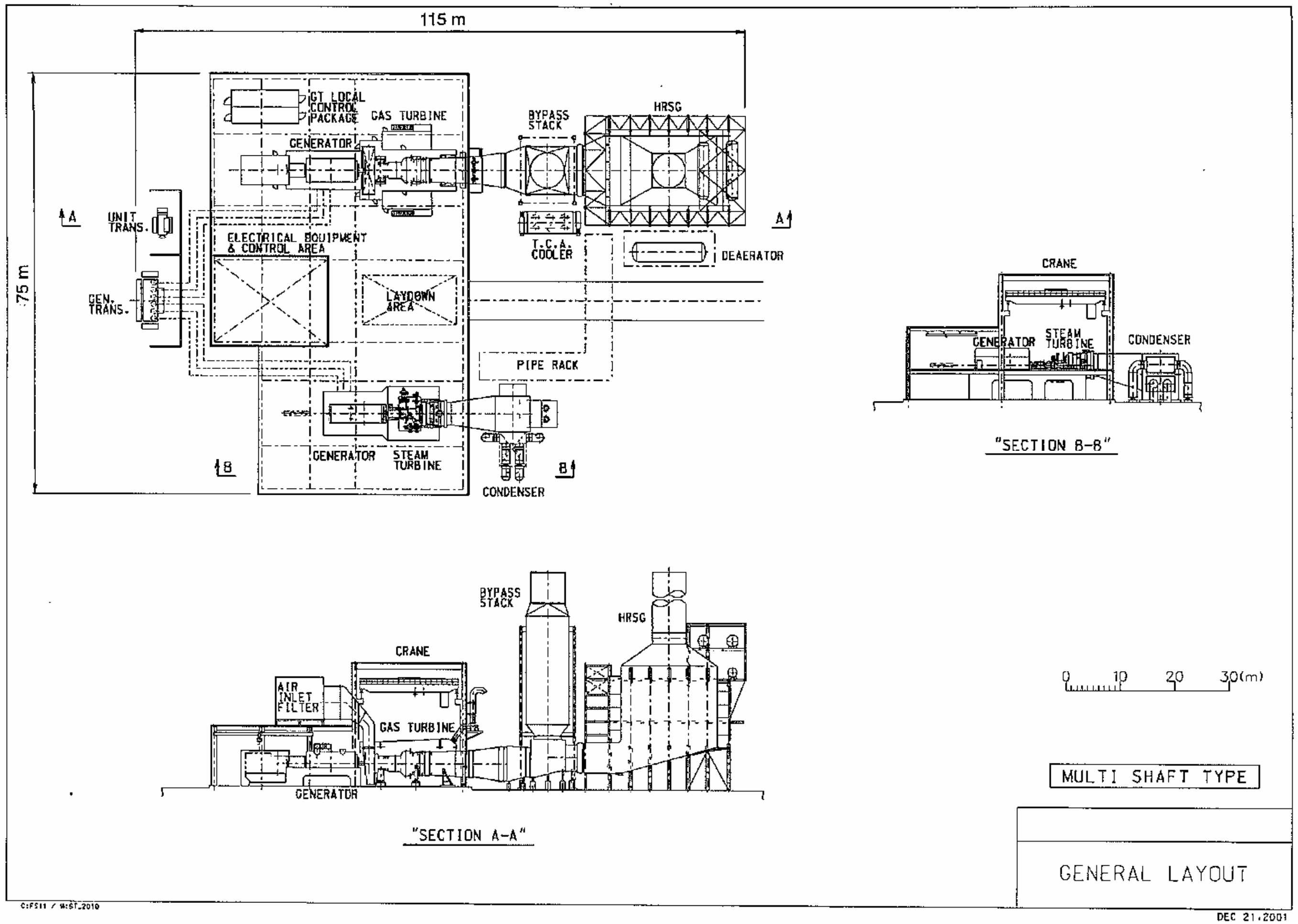


Figure 6.1.3-3 Typical Layout of a Multi-shaft Combined Cycle Power Plant

6.1.4 Candidate Gas Turbine and Performance

(1) Design Codes and Standards

The gas turbine system shall be basically designed as per ISO 3977-3 "Gas turbines-Procurement-Part 3: Design requirements" and ISO 21789 "Gas turbine applications-Safety" or equivalent codes and standards.

(2) Candidate Models

The gas turbine is the most important component to influence the operating reliability of the combined cycle power plant. So it is necessary that it possesses the highest operating reliability. Unlike custom-made steam turbines which are designed every time an order is place, gas turbines are normally of manufacturer's standard design to avoid a long development time before delivery and decrease the cost due to custom design. It is normal practice to select proper gas turbine models to meet the requirements for the project among the standard lineups of gas turbine OEM manufacturers. Here the OEMs are manufacturers who have conducted the full development of the prototype of the proposed type of machine and have performed successive upgrades. The reason for the supply of the machine by an OEM is because the OEM has the full concept of the essential design nature of the machine, which is developed by itself, and it can take new approaches to any problems which may occur.

Gas turbines are always in the process of development and their design parameters are being upgraded year by year. Nowadays, gas turbine models with higher performances than F class of which the turbine inlet temperature is specified to be of approximately 1,300°C are being made public. However, they are not always mature machines with sufficient commercial operating hours. Therefore, it must be confirmed whether the latest version of the same model which the manufacturer may offer has the commercial operating experience sufficient to verify the operating reliability of the model. For the purpose of confirmation of such situation, the proposed gas turbine shall meet certain criteria requirements. The criteria requirements shall be such that the proposed gas turbine shall be a machine technically similar to the reference gas turbines which have commercial operation experience one (1) month before the closing date of the international competitive bidding, as described below:

- The total successful commercial operating hours of at least three (3) reference gas turbines shall be not less than 30,000 actual operating hours.
- One (1) gas turbine at least out of three (3) reference gas turbines shall be in the outside the domicile country of the gas tubine manufacturer.
- The successful commercial operating hours of the unit having the longest operating hours out of the three (3) reference gas turbines shall be more than 16,000 actual operating hours.
- The minimum successful commercial operating hours of each of the three (3) reference gas turbines shall be not less than 6,000 actual operating hours.

In addition, the Bidder shall provide the data and information required by the Table 6.1.4-1 in the Proposal Documents to confirm it that the technical similarity of the proposed gas turbine with the reference gas turbines is reserved.

Table 6.1.4-1 Technical Similarlity Evaluation Sheet of Proposed Gas Turbine

Description		Proposed Gas Turbine	Identification Number of Reference Gas Turbines		
			1	2	3
(1) Performance					
Model No.					
Type of cycle					
No. of shafts					
Power output (MW)					
Thermal efficiency (%)					
Compressor inlet air flowrate (kg/s)					
Pressure ratio (-)					
Reference turbine inlet temp. as per ISO 3977-3 (^{o}C)	HPT				
	LPT				
Turbine outlet temperature (^{o}C)					
(2) Compressor					
Type					
Rotating speed (rpm)					
Inlet guide variable vane		Yes/No	Yes/No	Yes/No	Yes/No
No. of stages					
No. of stages of variable stator vanes					
Material of rotor					
Materials of stationary blades					
Materials of rotating blades					
(3) Combustor					
Type					
No. of combustion chambers for cannular type					
No. of nozzles assemblys for annular type					
Material of combustion chambers					
Material of transition pieces					
(4) Turbine					
Type					
Rotating speed (rpm)					
Material of 1^{st} stage nozzle	HPT				
	LPT				
Material of 1^{st} stage blade	HPT				
	LPT				
Material of 2^{nd} stsge nozzle					
Material of 2^{nd} stage blade					
Material of rotor disc	HPT				
	LPT				
Type of cooling methid of 1^{st} stage nozzle	HPT				
	LPT				
Type of cooling method of 1^{st} stage blade	HPT				
	LPT				
Type of cooling method of 2^{nd} stage nozzle					
Type of cooling method of 2^{nd} stage blade					

All performance parameter values in the above table shall be provided with one (1) figure on ISO conditions at the full open position of the compressor inlet gude vane.

The data and information on the commercial operating experience of the reference gas turbines shall be testified with written confirmation letters signed by the plant owners.

In consideration of the above statements, therefore, the JICA Study Team decided that the models of the gas turbines to be employed for this project shall be of F class as specified in the Gas Turbine Handbook 2010.

In selection of the candidate models of gas turbines, it shall be considered that the proposed gas turbine can be operated in a simple cycle mode taking into account that it may be put into a commercial operation in advance to solve the impending shortage of power supply in Tunisia. For example, Alstom can supply two (2) types of GT26 gas turbines. One is GT26 with an air quench cooler, while the other is GT26 with a once through cooler that uses steam to cool the air extracted from the air compressor for internal cooling of hot parts of the gas turbine. Therefore, the latter type of GT26 gas turbine cannot be operated in a simple cycle mode without a cooling medium of steam from the bottoming system. For such reason, the GT26 gas turbine where ambient air is used as a cooling medium can be chosen as a candidate CCPP for the plant.
General Electric (GE) has two (2) versions of F class gas turbines of 9FA and 9FB to meet the requirements for this project. However, the former is inferior to meet the heat and power capacity specified above. Therefore, the latter model shall be excluded from consideration for this study.

Mitsubishi Heavy Industries (MHI) has two (2) versions of F class gas turbines of M701F4 and M701F5 to meet the requirements for this project. The former model has much experience in the world. However, the latter model doesn't have such operating experience as specified in the previous page at this stage though it has better performance. Therefore, the latter model is not considered as the candidate model for this project.

Consequently, the following four (4) models of gas turbines shall be eventually selected as candidate models for this project with the performance values shown in the Table 6.1.4-1 on ISO conditions as per the said Handbook:

Table 6.1.4-1 Performance Values of Four (4) Candidate Models of Gas Turbines

Model of Gas Turbine	GT26 (AQC)	9FB	M701F4	SGT5-4000F
ISO base rating (MW)	292.1	288.2	312.1	292.0
Efficiency (%)	38.50	37.85	39.30	39.83
Pressure ratio	34.7	18.0	18.0	18.2
Air flow rate (kg/s)	653.2	655.1	702.6	692.2
Exhaust gas temp (°C)	615.0	641.7	596.7	577.2

Source: JICA Study Team

(3) Gas Turbine Manufacturers
According to the said Handbook, the gas turbine manufacturers of the above four (4) models of gas turbines are as tabulated in the following Table 6.1.4-2:

Table 6.1.4-2 OEM Manufacturer of the Four (4) Models of Gas Turbines

Model of Gas Turbine	OEM Manufacturer
GT26 (AQC)	Alstom
9FB	GE
M701F4	Mitsubishi
SGT5-4000F	Siemens

Source: JICA Study Team

6.1.5 Plant Performance by Candidate Gas Turbine

The CCPP shall be comprised of the candidate gas turbine which is available in the present world market and the bottoming system suited to it. Therefore, the plant performance shall be naturally changeable depending upon the type of candidate gas turbine which may be employed for this project. This section describes the plant performance calculated for each candidate gas turbine.

(1) Basic Calculation Conditions
Such basic calculation conditions as ambient conditions and fuel gas compositionare as specified in Table 6.1.1-1 as rated conditions.

(2) Candidate Models of Gas Turbines
The plant performance shall be calculated for the four (4) candidate models of gas turbines of which performance values are shown in Table 6.1.4-1 of the previous section.

(3) Type of the Bottoming System
The combined cycle plant is a combination of a “Topping System” of a gas turbine with Brayton Cycle and a “Bottoming System” of a boiler-steam turbine with Rankine Cycle. The performance and construction cost of the combined cycle plant is changeable due to how the bottoming system is designed for the given topping system of the gas turbine. In general, the more complicated the cycle of the bottoming cycle, the higher the performance and construction cost of the combined cycle plant. In case of employment of the F class gas turbine, the triple-pressure and reheat cycle bottoming system is commonly employed.

(4) Design Parameters of the Bottoming System
The cycle design parameters of the bottoming system may be individual depending upon design concepts to be proposed of the manufacturers of combined cycle power plant. The cycle design parameters of the bottoming system shall be specified in consideration of the expected operating range under the specified range of ambient conditions. For the purpose of calculation of heat and mass balances of the four (4) candidate models of CCPPs, therefore, the cycle design parameters of the bottoming system are preliminarily assumed as tabulated below.

- GT Inlet Air Cooling System — Not considered
- GT Inlet Pressure Loss — 1.0 kPa
- GT Exhaust Back Pressure — 3.5 kPa
- Exhaust Gas Leakage from Bypass Stack — 0.0%
- Cycle Configuration — Triple-pressure, reheat
- HRSG Type — Unfired type

- Steam Conditions at Turbine Throttle Valve Inlet at Rated Site Ambient Conditions
  HP Steam
  - Temperature: 540°C
  - Pressure: 12.7 MPa (130.0 ata)

  IP Steam
  - Temperature: 540°C
  - Pressure: 2.75 MPa (28.0 ata)

  LP Steam
  - Temperature: Mixed temperature of LP SH and IPT outlet steams
  - Pressure: 0.49 MPa (5.0 ata)
- Pre-heater Inlet Temperature: 60°C
- Condenser
  - Terminal temperature difference: 5°C
  - Temperature: 37.0°C
  - Pressure: 6.6 kPa
- Cooling System
  - Type: Once-through type
  - Type of cooling water: Seawater
  - Condenser inlet temperature: 25.0°C
  - Condenser outlet temperature: 32.0°C

(5) Heat and Mass Balance Calculation Results

The heat and mass balances of the combined cycle power plants for the four (4) candidate models of gas turbines are calculated based on the conditions stated in the previous sub-section. The results are summarized as tabulated in Table 6.1.5-1.

Table 6.1.5-1 Expected Performance Values of CCPPs by the Four (4) Models of Gas Turbines

Type of Model of Gas Turbine	GT26	9FB	M701F4	SGT5-4000F
Plant Gross Power Output (MW)	417.0	428.7	443.8	409.9
GT Gross Power Output (MW)	274.1	274.7	297.4	274.4
ST Gross Power Output (MW)	142.9	154.0	146.4	135.5
Plant Gross Thermal Efficiency (%)	57.3	57.7	57.8	57.7
Auxiliary Power Requirement (MW)	8.3	8.6	8.9	8.2
Plant Net Power Output (MW)	408.7	420.1	434.9	401.7
Plant Net Thermal Efficiency (%)	56.1	56.5	56.6	56.5

Source: JICA Study Team

As can be seen in the above table, the plant net power outputs of the four (4) CCPPs are estimated to range from 401.7 MW to 434.9 MW on the specified calculation conditions stated above. The requirement range of the plant net power output to be prescribed in the international competitive bidding documents should be "380 MW ~ 460 MW" in consideration of proper allowance for the calculated power output values. The nominal net power output of the plant should be 420 MW as the mean value of the said power output range.

The plant net thermal efficiencies are predicted to range from 56.1% to 56.6% on the same conditions. Therefore, the requirement of the plant net thermal efficiency should be specified as “not less than 54.0%” in the bidding documents in consideration of proper allowance for the calculated power output values.

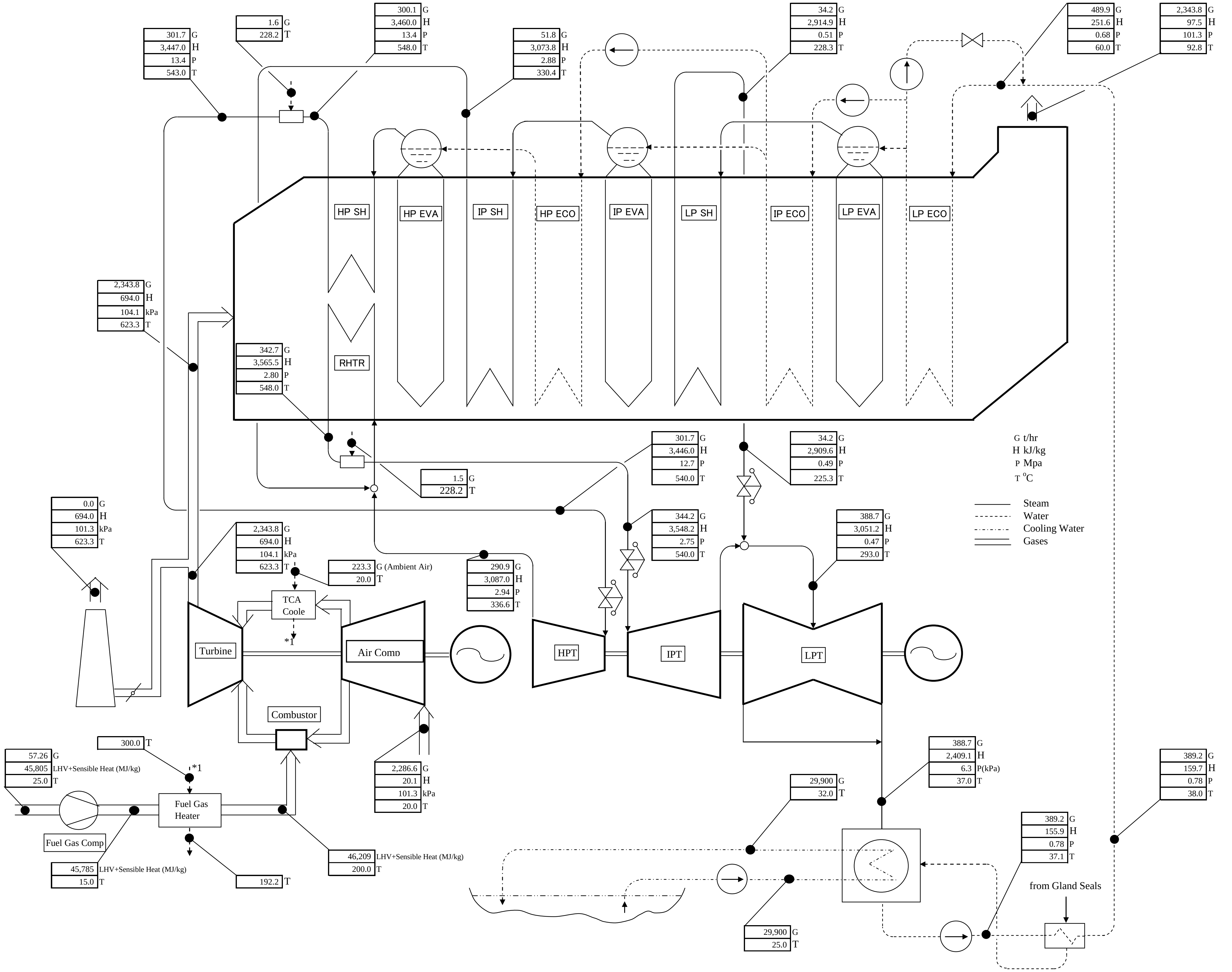
The following heat and mass balance diagrams corresponding to the above heat and mass balance calculation results are shown in the following figures.

Figure 6.1.5-1 Heat and Mass Balance Diagram of CCPP by Alstom GT 26 Gas Turbine

Figure 6.1.5-2 Heat and Mass Balance Diagram of CCPP by GE 9FB Gas Turbine

Figure 6.1.5-3 Heat and Mass Balance Diagram of CCPP by MHI M701F4 Gas Turbine

Figure 6.1.5-4 Heat and Mass Balance Diagram of CCPP by Siemens SGT5-4000F Gas Turbine



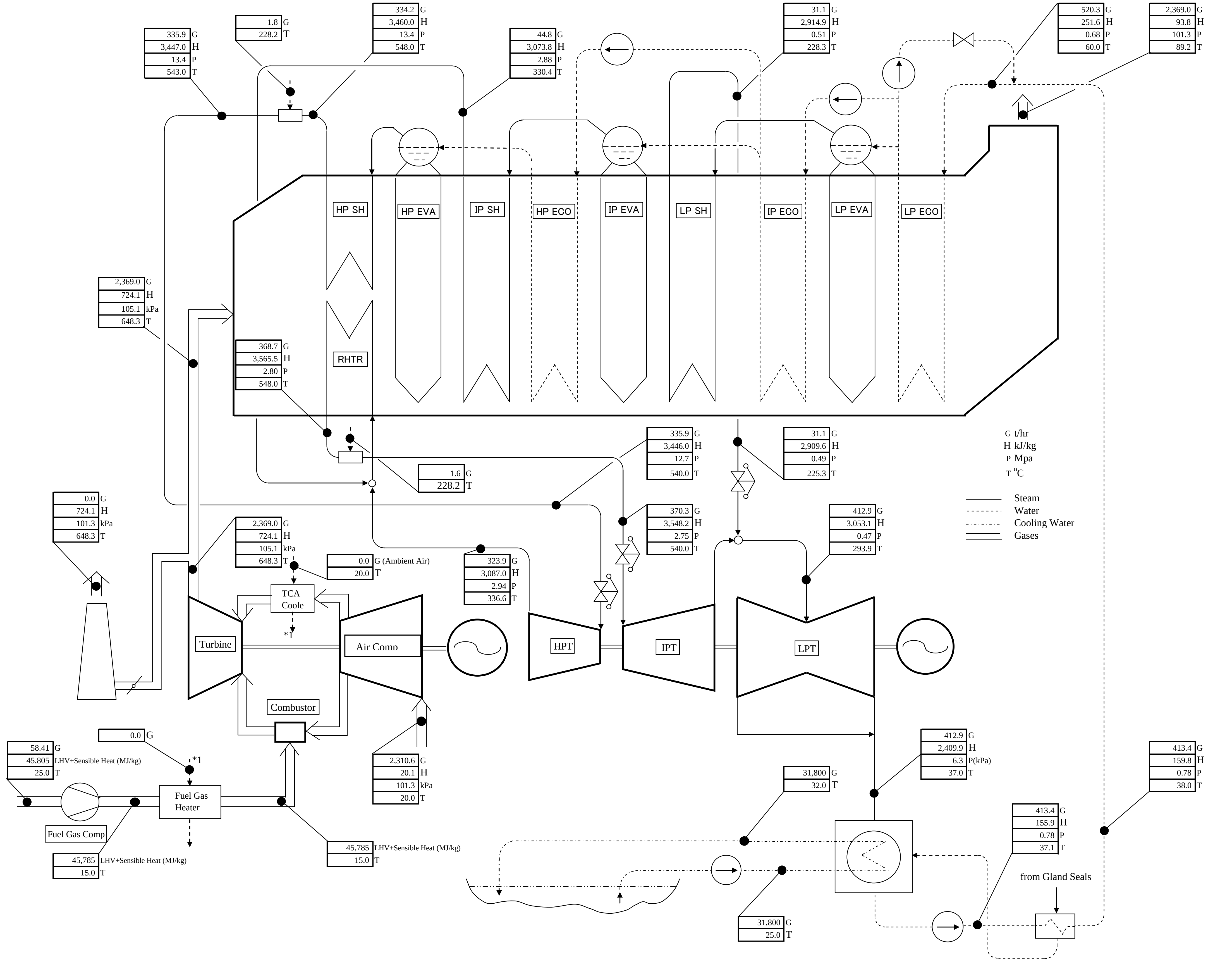
Gross Power Output		
Gas turbine	274,200	kW
Steam turbine	142,900	kW
Total	417,100	kW
Plant Gross Thermal Eff	57.3	%
Auxiliary Power	8,300	kW
Net Power Output	408,800	kW
Net Thermal Efficiency	56.1	%

Operating Conditions		
Dry Bulb Temperature	20.0	oC
Ambient Pressure	101.3	kPa
Relative Humidity	70.0	%
Wet Bulb Temperature	16.5	oC
Type of Fuel	Natural Gas	
Net Specific Energy	45,750	kJ/kg

Heat and Mass Balance Diagram
at Performance Evaluation Point
Type of Gas Turbine Alstom GT26

Source: JICA Study Team

Figure 6.1.5-1 Heat and Mass Balance Diagram of CCPP by Alstom GT26 Gas Turbine



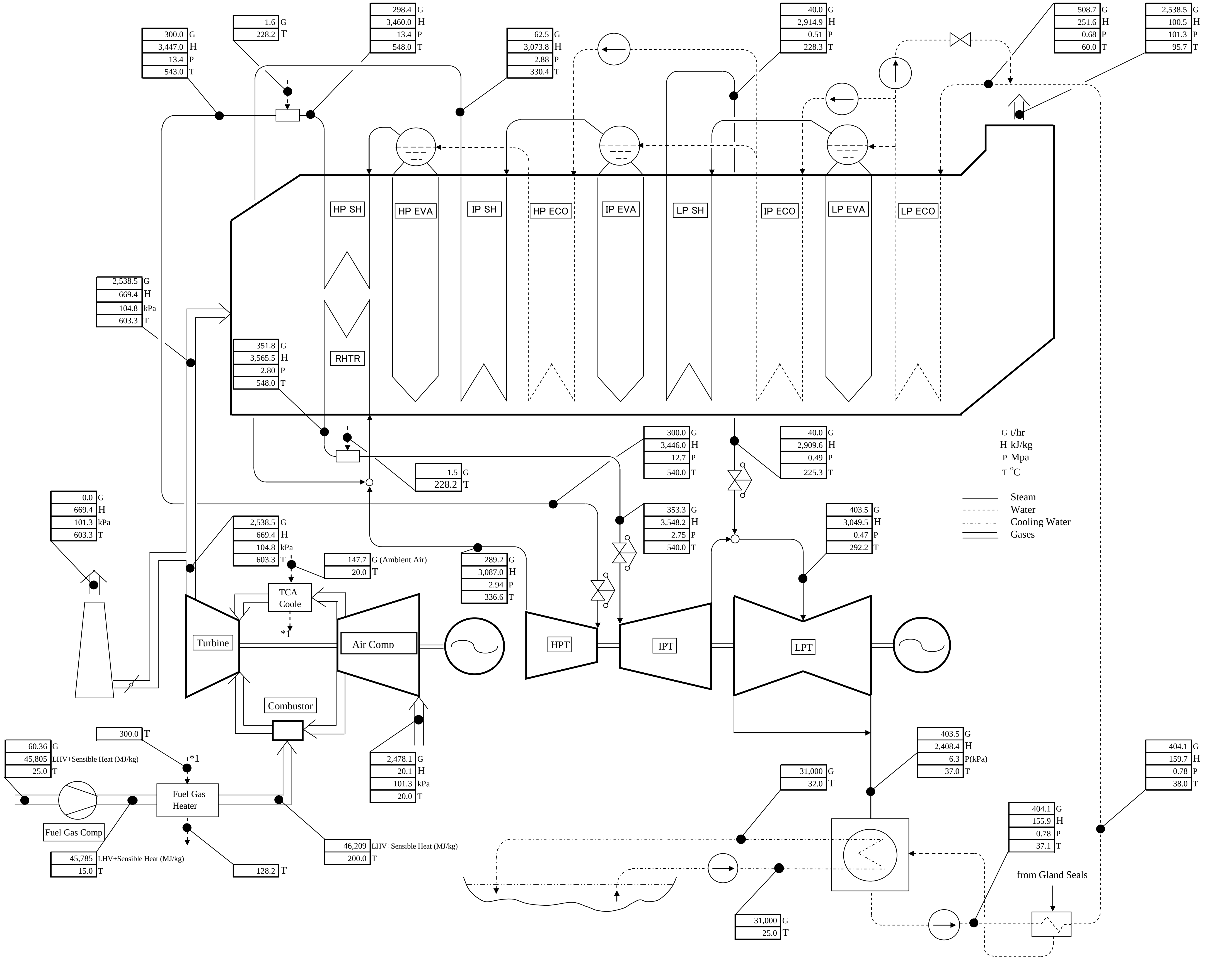
Gross Power Output		
Gas turbine	274,700	kW
Steam turbine	154,100	kW
Total	428,800	kW
Plant Gross Thermal Eff	57.7	%
Auxiliary Power	8,600	kW
Net Power Output	420,200	kW
Net Thermal Efficiency	56.5	%

Operating Conditions		
Dry Bulb Temperature	20.0	oC
Ambient Pressure	101.3	kPa
Relative Humidity	70.0	%
Wet Bulb Temperature	16.5	oC
Type of Fuel	Natural Gas	
Net Specific Energy	45,750	kJ/kg

Heat and Mass Balance Diagram
at Performance Evaluation Point
Type of Gas Turbine GE F9FB

Source: JICA Study Team

Figure 6.1.5-2 Heat and Mass Balance Diagram of CCPP by GE F9B Gas Turbine



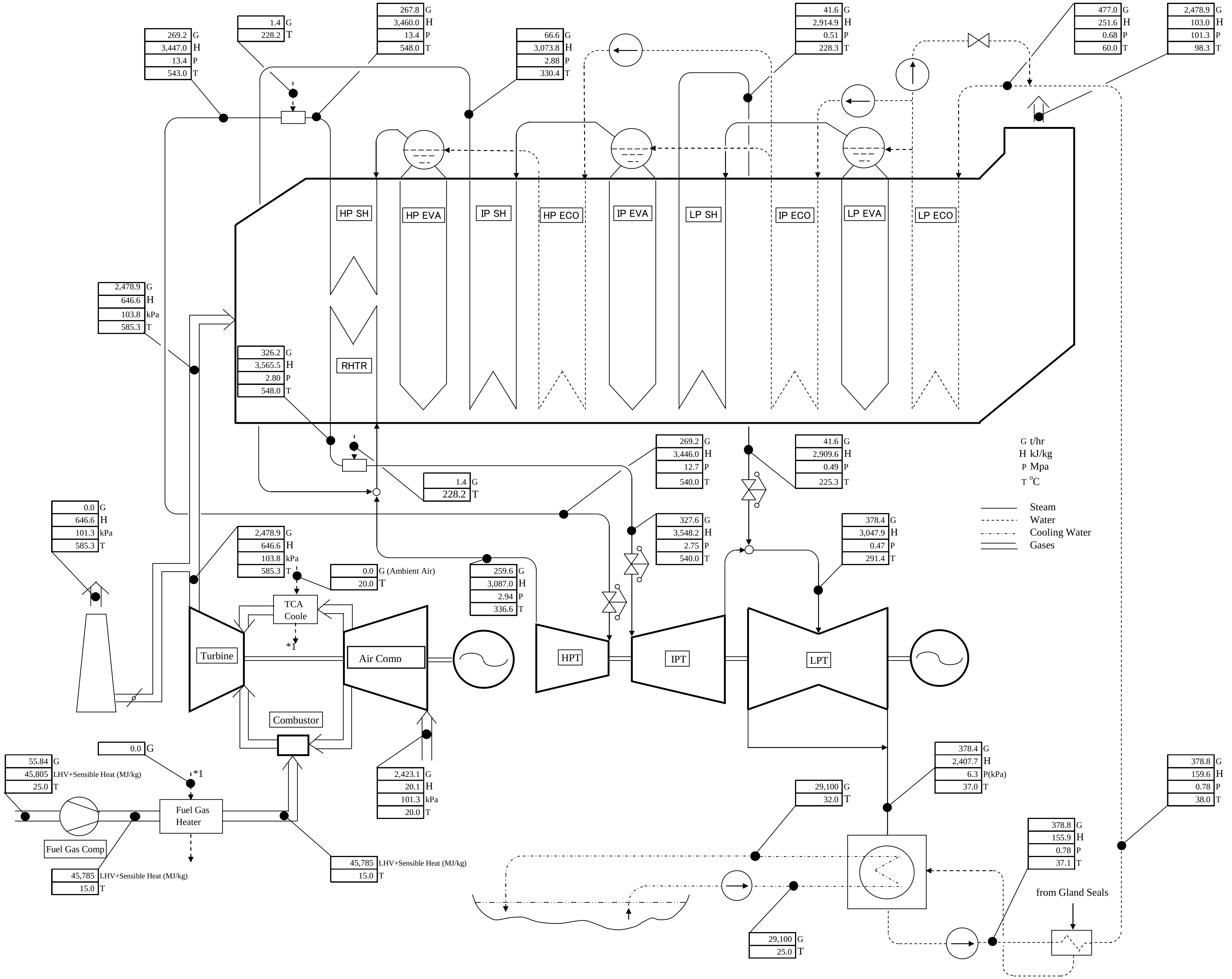
Gross Power Output		
Gas turbine	297,500	kW
Steam turbine	146,400	kW
Total	443,900	kW
Plant Gross Thermal Eff	57.8	%
Auxiliary Power	8,900	kW
Net Power Output	435,000	kW
Net Thermal Efficiency	56.6	%

Operating Conditions		
Dry Bulb Temperature	20.0	oC
Ambient Pressure	101.3	kPa
Relative Humidity	70.0	%
Wet Bulb Temperature	16.5	oC
Type of Fuel	Natural Gas	
Net Specific Energy	45,750	kJ/kg

Heat and Mass Balance Diagram
at Performance Evaluation Point
Type of Gas Turbine MHI M701F4

Source: JICA Study Team

Figure 6.1.5-3 Heat and Mass Balance Diagram of CCPP by MHI M701F4 Gas Turbine



Gross Power Output		
Gas turbine	274,400	kW
Steam turbine	135,500	kW
Total	409,900	kW
Plant Gross Thermal Eff	57.7	%
Auxiliary Power	8,200	kW
Net Power Output	401,700	kW
Net Thermal Efficiency	56.5	%

Operating Conditions		
Dry Bulb Temperature	20.0	oC
Ambient Pressure	101.3	kPa
Relative Humidity	70.0	%
Wet Bulb Temperature	16.5	oC
Type of Fuel	Natural Gas	
Net Specific Energy	45,750	kJ/kg

Heat and Mass Balance Diagram
at Performance Evaluation Point
Type of Gas Turbine SMS SGT5-4000F

Source: JICA Study Team

Figure 6.1.5-4 Heat and Mass Balance Diagram of CCPP by Siemens SGT5-4000F Gas Turbine

6.1.6 Condenser Cooling System

The three (3) types of condenser cooling systems of a once-through cooling system, an induced draft cooling tower cooling system and a forced draft air cooling system should be considered as the cooling systems of the steam turbine condenser for the Project. The merits and demerits of the cooling system are variable depending upon the site conditions, operating conditions and economic conditions, such as the electric power sales price and fuel costs.

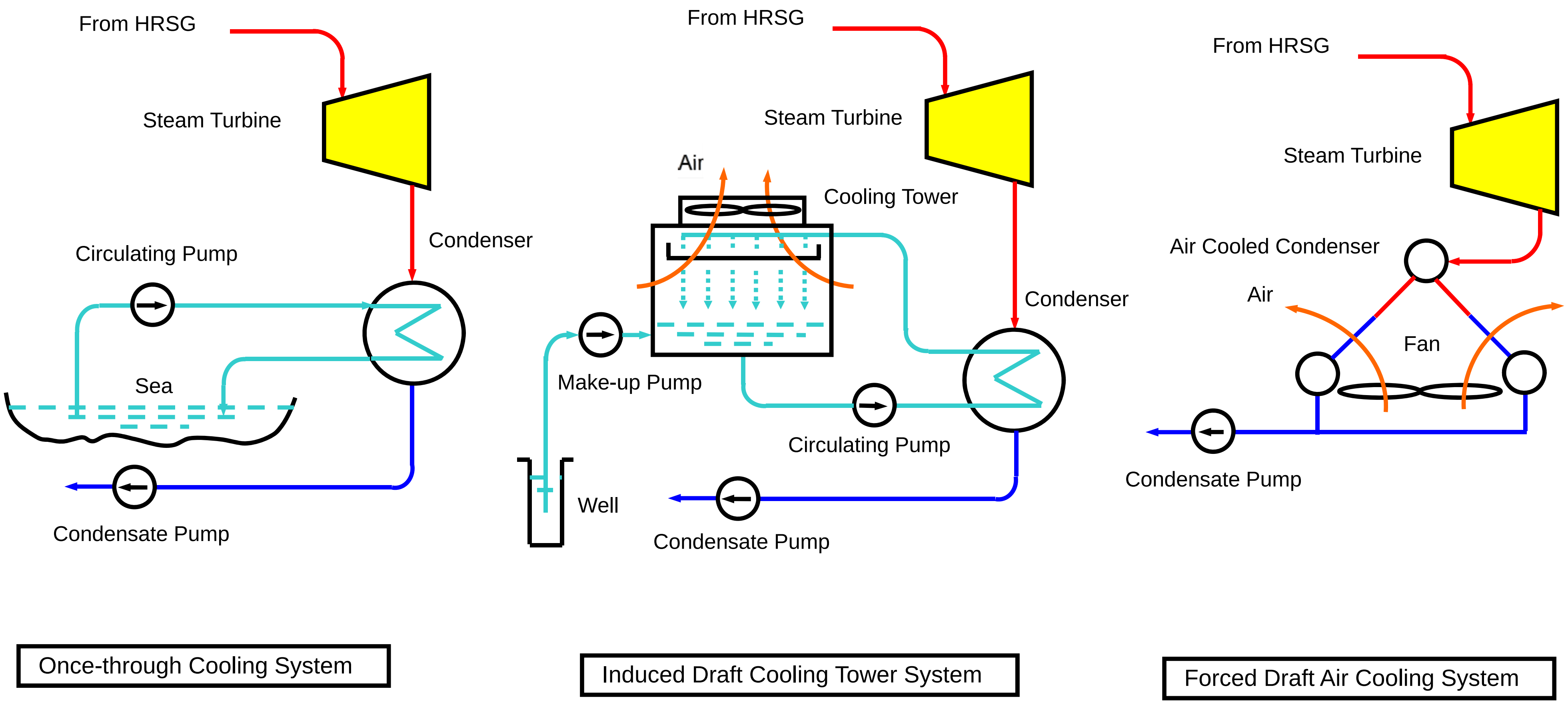
The once-through cooling system type is commonly employed in case that the site is located on a seaside, riverside or lakeside, and that the circulating cooling water flow rate sufficient to cool the condenser is available economically without any environmental impacts. The condenser pressure is normally the lowest among the above three (3) types. Therefore, the steam turbine power output is highest. This system is most economical from the plant performance point of view.

The induced draft cooling tower type is commonly used in case that sufficient circulating cooling water flow rate is not available economically and the water flow rate to compensate for the evaporation and blow-down losses is obtainable.

The forced draft air cooling type is commonly used in case that the site is located in such places as desert and inland areas where water is scarce. The condenser pressure is normally the highest among the above three (3) types. Therefore, the steam turbine power output is lowest. The auxiliary power required to operate the cooling system is highest because many air draft fans must be operated. The instillation footprint area for this system is the largest. However, the system is most friendly to the environment in that no water is used.

The schematic diagrams of the three (3) types of cooling systems are shown on the next page.

The site for this Project is located on the seaside where power plants are already installed and in service. Intake and discharge channels for circulating cooling seawater of this project can be constructed without any economical, technical and environmental difficulties. For such reasons stated above, the once-through cooling system is chosen as a suitable cooling system for this Project.



Source: JICA Study Team

Figure 6.1.6-1 Schematic Diagram of the Three (3) of Cooling Systems

6.1.7 Compressor Inlet Air Cooling System

(1) General

The gas turbine power output drops due to reduction of compressor inlet air weight flow rate which decreases with increase of the ambient air dry bulb temperature. Thereore, the one method to augment the gas turbine power output is to cool the gas turbine compressor inlet air.

The gas turbine compressor inlet air cooling system can be classified into two (2) diferent systems by evaporative and chilling effects.

In the former system, the compressor inlet air is cooled by the evaporation latent heat of the water supplied in the inlet air stream. The cooling effect by means of this system is influenced by the inlet air conditions of temperature and relative humidity and is limited to certain amount of temperature. There exist two (2) types of systems of evaporative and fogging coolers depending upon water supply method. In case of evaporative cooler system, the water is supplied into the inlet air stream in form of water droplets, while in case of fogging cooler system the water is supplied in form of fog which is made by injection of water into the air stream from nozzles on high pressure conditions of 10 to 20 MPa.

In the latter system, the compressor inlet air is indirectly cooled with the medium fluid chilled by the refrigeration system. The cooling effect by this system is not influenced by the inlet air conditions and a large amount of inlet air temperature drop can be expected. However, a large amount of cooling heat energy is required. In case of chiller cooling system, various types of refrigeration systems such as direct and indirect mechanical, absorption and ice storage types can be considered. However, the chiller cooling system with the indirect mechanical refrigeration system by R-134a refrigerant medium which is of less greenhouse gas effect is considered for the purpose of simplified comparison study.

In this section, above three (3) types of inlet air cooling systems are studied from technical and economical points of views and one (1) type of system is recommended for bidding requirement of this project for simplification of the bidding evaluation. In this connection, the study was made for the M701F4 gas turbine where the data and information for study can be prepared more easily.

(2) Type of Inlet Air Cooling System

1) Evaporative cooler system

With evaporative cooler system, water is added to the inlet air of the gas turbine compressor. Part of the water evaporates absorbing latent heat from the air. As the results, the air cools down and the density of the air increases. This means the increase of the mass flow rate of the inlet air and pressure ratio resulting in an increase of output and efficiency of the gas turbine. The temperature drop effect by the evaporative cooler is influenced by not only the atmospheric conditions, but also the cooler design, especially the cooler’s effectiveness. The cooler effectiveness (CE) is defined by the following formula. The CE value is ranging from 75 % to 90 % depending upon the atmospheric conditions and cooler design.

$$\mathrm{CE} = \frac{\mathrm{T_{2DB}} - \mathrm{T_{1DB}}}{\mathrm{T_{2DB}} - \mathrm{T_{WB}}} \times 100\ (\%)$$

Where,
T_{2DB} : Dry bulb temperature of leaving air
T_{1DB} : Dry bulb temperature of entering air
T_{WB} : Wet bulb temperature of air

The evaporative cooler system to be installed on the downstream side of the air filtration system normaly consists of a cooling media, a water supply system, a mist eliminator, a water recirculation facility and a water treatment facility. The simplified schematic diagram is depicted as the Figure 6.1.7-1.

The amount of water to be provided as makeup is the sum of evaporation, carryover and blowdown. The rate of blowdown is determined by the hardness of the make-up water, the evaporation rate, and the degree of concentration to be allowed.

It must be noted that the installation of the evaporative cooler system causes an additional pressure drop in the inlet duct

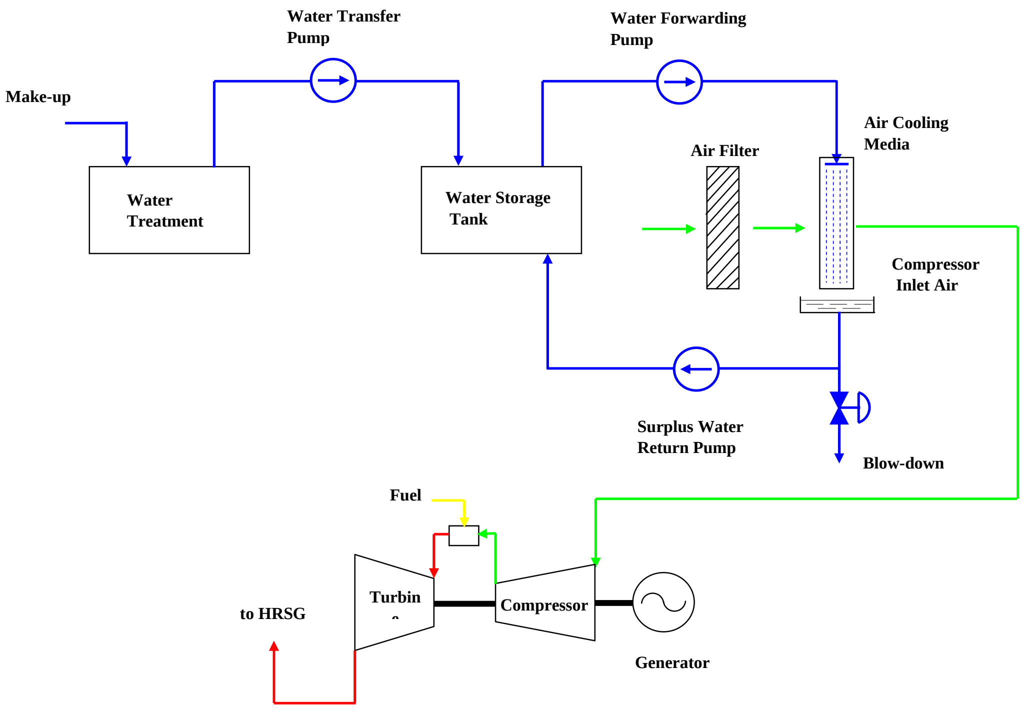


Figure 6.1.7-1 Schematic Diagram of Evaporative Cooler System

2) Fogging cooler system

The fogging cooler system is similar to media-type evaporative cooler system in that it cool the inlet air by evaporating water. But instead of using an evaporative medum, the water is atomized into micro-fine fog droplets so that they can be quickly evaporated.

The demineralized water is atomized from the fog nozzles at the pressure of 140 Bar(g) to 200 Bar(g) to make small fog droprets with an average diameter of 10 microns.

In most cases, the fog nozzle assembly is installed downstream of the air filtration system and immediately upstream of the silencer. The fog nozzle assembly can also located upstream of air filtration system. In this case, it is required to use the fog droplet eliminator to avoid the filter elements are wetted.

In case of the evaporative cooler, the honey-com type madia is utilized to maximize the surface area of water exposed to the air and expidite the evaporation rate of the water. In high pressure fogging, the evaporative surfaces are the fog dtoplets themselves. For this reason, the temperature drop effect of the fogging cooler is higher than the evaporative cooler. Normally, the inlet air dry bulb temperature drops down to the wet bulb temperature of the air. It can be said that the cooling effectiveness is commonly 100 %.

The Figure 6.1.7-2 shows the simplified schematic diagram of the fogging cooler system.

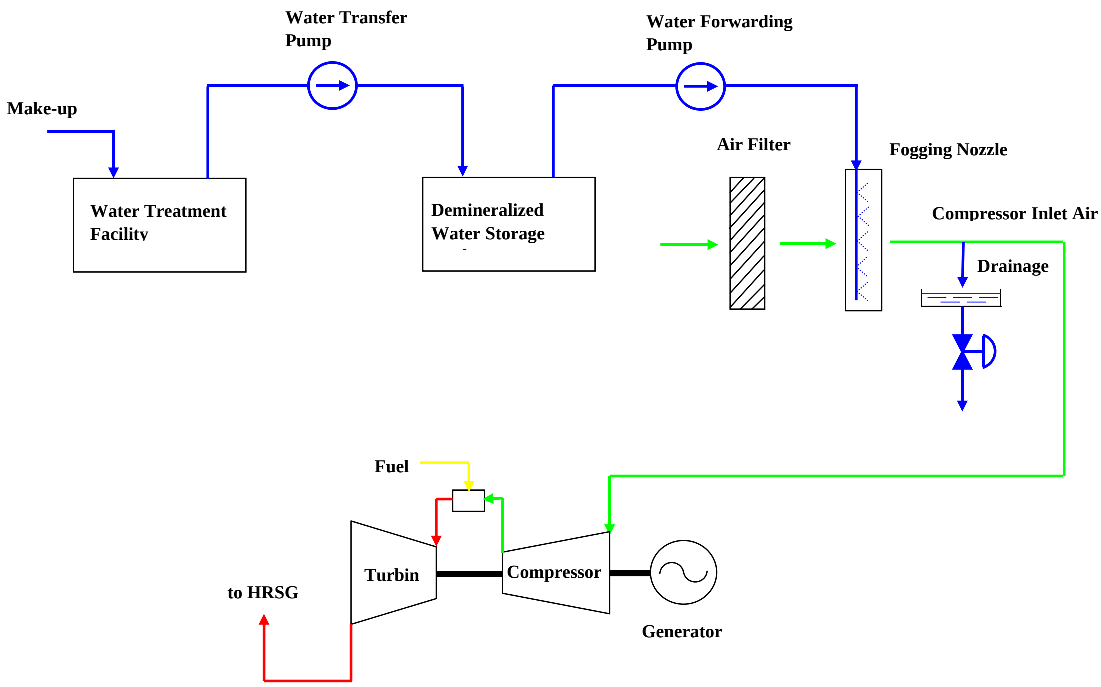


Figure 6.1.7-2 Schematic Diagram of Fogging Cooler System

3) Chilling cooler system

In a chilling cooler system, heat is removed from the inlet air flow through the heat exchanger (chilling coil). In other words, cooling is achieved removing both sebsible heat and latent heat from the air flow by means of use of the heat exchanger. Therefore, the most advantageous merits are that it cools down the inlet air regardless of ambient humidity and that the inlet air temperature drop range is far lager than other systems. The cooling is limited to 8 ^{o}C to avoid the ice formation on the Inlet Gude Vane.

A mixture of water and glycol is usual as a coolant medium used for heat exchange with the inlet air. The proportion of water and glycol is determined depending upon the minimum temperature that the coolant will experience. The coolant supplied to the heat exchanger can be cooled by several methods including mechanical refrigeration cycle, absorption refrigeration cycle and ice storage system.

In a chilling cooler system, the heat exchanger is installed downstream of the inlet air filtration system, where is the clean path location. A mist eliminater is equipped to protect condensed water droplets from entering the compressor. The heat exchanger is usually of the plate-fin type and its materials are usually copper and aluminium respectively. The mist eliminater is commonly of inertial type and almpst of the condensater water droples are captured that may be carried over bu the air stream. Since the the inlet ductwork and plenum after the chiller coil are always exposed to the saturated air, they are usually made of stainless steel.

The Figure 6.1.7-3 shows the simplified schematic diagram of the chilling cooler system.

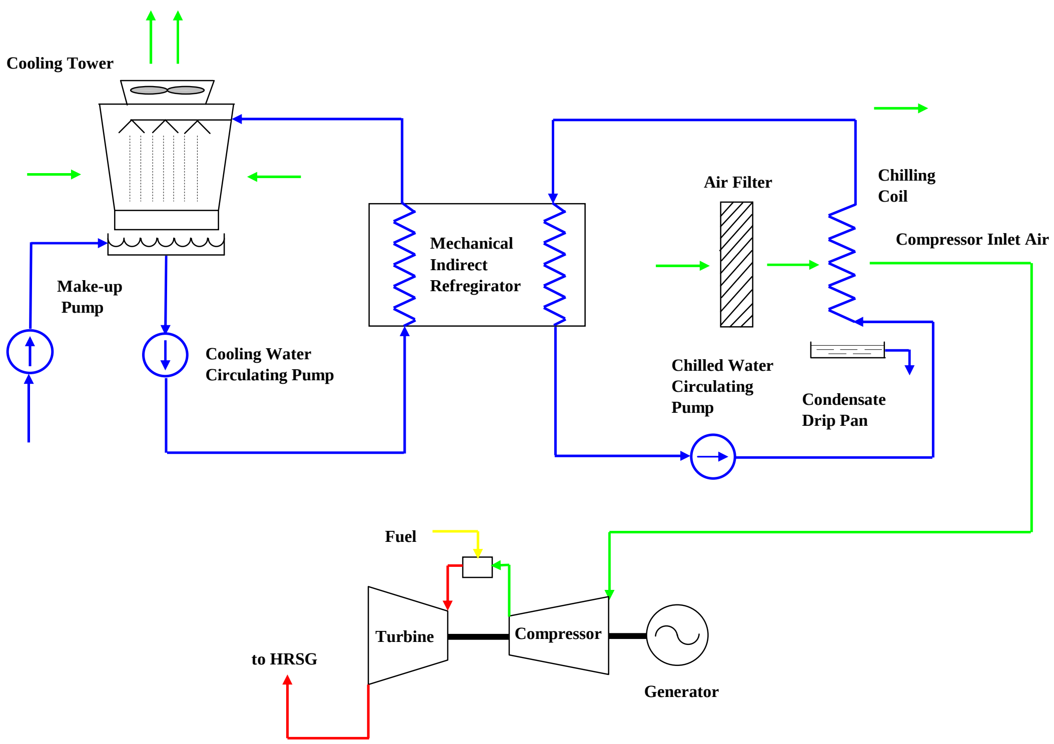


Figure 6.1.7-3 Schematic Diagram of chilling Cooler System

As shown in the above diagram, in this case a mechanical type indirect refregirator (turbo-refregirator) system is considered. The refregirant medium is Freon R-134a. The circulating water from the cooling tower is used as a low temperature heat source of the refregirator system.

(3) Parameter Study

1) Mehod

The net power output will be augmented by introduction of the inlet air cooling system. This net power output augmaentation can be considered as revenue. On the otherhand, the cost and fuel consumption will increase, which is the expenditure. The economical study will be performed comparing the unit power output augmentation cost (US$/kW) which can be obtained by deviding the sum of inlet air cooling system cost and present worth of the total fuel and maintenance costs through the service life by the augmented net power output. The generation cost is also compared.

For the purpose, the augmented net power output, the fuel consumption increase and the cost by introduction of the inlet air cooling system have to be estimated. The power output and fuel consumption increases are estimated by using the thermodynamic engineering sense of manner, and the costs for three (3) cadidates of cooling systems are obtained through the computer software owned by TEPSCO.

2) Conditions

The following conditions are assumed for calculation of the augmented net power output, fuel consumtion increase, and present worth of the total fuel cost through the service life.

a) Ambient and operating conditions

Dry bulb temperature	40.0 ^{o}C
Wet bulb temperature	31.5^{o}C
Relative humidity	55.0 %
Annual operating hour	825 hours (=5×30×5.5)

b) Cooling system condition

Type of candidate system	Evaporative type (ET) Fogging type (FT) Chilling type (CT)
Cooling effectiveness of evaporative type	85 %
Cooling effectiveness of fogging type	100 %
Temperature drop of chilling type	20 ^{o}C

c) Economical conditions

Service years (SY)	30 years
Construction period (CP)	3 years
Discount rate (DR)	0.08 (8 %)
Present fuel unit price	12.1 US$/GJ HHV (18.2 TND/GJ HHV)
Escaration rate (EF) of fuel unit price	0.02 (2 %)/year
Present annual maintenance cost (PM)	0.5 % of capital cost for ET 0.5 % of capital cost for FT 1.5 % of capital cost for CT
Escaration rate (EM) of annual maintenance cost	0.015 (1.5 %)/year

Levelizing factor (LF) of fuel price through the service year can be calculated by the following equation commonly stated in the textbook of engineering economics.

$$\mathrm{LF} = (1+\mathrm{EF})^{\mathrm{CP}} \times \frac{\mathrm{DR}}{(\mathrm{DR}-\mathrm{EF})} \times \frac{(1+\mathrm{DR})^{\mathrm{SY}}-(1+\mathrm{EF})^{\mathrm{SY}}}{(1+\mathrm{DR})^{\mathrm{SY}}-1} = 1.29$$

Similarly, levelizing factor (LM) of maintenance cost through the service year is calculated.

$$\mathrm{LM} = (1+\mathrm{EM})^{\mathrm{CP}} \times \frac{\mathrm{DR}}{(\mathrm{DR}-\mathrm{EM})} \times \frac{(1+\mathrm{DR})^{\mathrm{SY}}-(1+\mathrm{EM})^{\mathrm{SY}}}{(1+\mathrm{DR})^{\mathrm{SY}}-1} = 1.21$$

The factor (PWF) to convert the annual cost to the present worth can be calculated from the following equation commonly known.

$$\mathrm{PWF} = \frac{1}{(1+\mathrm{DR})^{\mathrm{CP}}} \times \frac{1}{\mathrm{DR}} \times \frac{(1+\mathrm{DR})^{\mathrm{SY}}-1}{(1+\mathrm{DR})^{\mathrm{SY}}} = 8.94$$

The generation cost (GC) is the sum of capital recovery cost, fuel cost and maintenance cost and can be calculated by the following equation similar to STEG evaluation formula.

$$GC = \frac{CC \times 10^5}{825 \times AP \times PWF} + \frac{HR \times PF \times LF}{10^4} + \frac{PM \times LM \times 10^5}{825 \times AP} \quad \left(\frac{\text{US Cent}}{\text{kWh}}\right)$$

Where,
CC: Capital cost (1,000 US$)
AP: Augmented net power output (kW)
HR: Heat rate (kJ HHV/kWh)
PF: Present fuel unit price (US $/GJ HHV)
PM: Present annual maintenance cost (1,000 US$)
Other symbols are denoted in the previous page.

3) Parameter study results

The study results of performance and economic parameters based on the above assumed conditions due to employment of three (3) candidate types of inlet cooling systems are described.

a) Performance parameters

The estimation results of performance parameters are as tabulated below:

Table 8.1.7-1 Performance Parameter

Type of System	Evaporative	Fogging	Chilling
Inlet temperature drop (^oC)	7.2	8.5	20.0
Augmented power output (kW)	13,200	15,600	37,600
Additional total auxiliary power (kW)	20	80	11,740
For pumps (kW)	20	80	440
For refrigerator (kW)	-	-	11,100
For cooling tower fan (kW)	-	-	200
Augumented net power output (MW)	13,180	15,520	25,860
Increased fuel consumption (kg/hour)	1,951	2,304	5,429
Heat rate (kJ HHV/kWh)	7,460	7,460	10,580

As shown in the above table, in case of the chilling type of inlet air cooling system, the augmented power output is 37,600 kW, however a huge amount of heat (33,700 kW) has to be removed from the inlet air. For the purpose, a refrigerator system with refrigeration capacity of 9,570 USRT is required and the auxiliary required power is 11,740 kW. Therefore, the effective augmented power output is lessened to 25,860 kW.

b) Economic parameters

The estimation results of economic parameters are as tabulated below:

Table 8.1.7-2 Economic Parameter

Type of System	Evaporative	Fogging	Chilling
Capital cost (1,000 US$)	1,811	1,090	19,800
Levelized annual fuel cost (1,000 US$)	1,263	1,491	3,314
Levelized annual maintenance cost (1,000 US$)	11	7	120
Total present worth (1,000 US$)	13,200	14,500	52,300
Total present worth per kW (US$/kW)	1,000	930	2,020

Type of System	Evaporative	Fogging	Chilling
Generation cost (US Cent/kWh)	13.6	12.6	27.5
Capital recovery cost (US Cent/kWh)	1.9	0.95	10.4
Fuel cost (US Cent/kWh)	11.6	11.6	16.5
Maintenance cost (US Cent/kWh)	0.1	0.05	0.6

As shown in the above table, the total present worth per kW and generation cost of the chilling type inlet air cooling system is almost double other two (2) systems.

4) Study results

The evaporative and fogging cooler systems are similarly functioning and utilized worldwide for cooling of the gas tubine inlet air, especialy for peak load use gas turbines with much operating experiences. Their capital costs and operation maintenance costs are lowest. Their performance improvement is limited and highly influenced by the site humidity. However, the performance improvement of the latter system is slightly higher than the former system. The former system can operate on the treated low water, the latter on the demineralized water.

There are no crucial differences between economic parameters of the both systems. The technical difference consists in the size of water mist leaving the cooling system. The water mist of the former system is large and is almost removed by the mist eliminator. While, that of the latter system is as small as 10 microns and is entrained in the air stream. Consequently, some water mist reaches the compressor inlet and erosion by the water mist may happen to compressor blades. Such erosion broblems are actually reported with some literatures. The conclusion of the literatures is that considerable action has to be taken to avoid the risk of such problem on introduction of fogging cooler system..

The chilling cooler system has the advantages that it is not sensitive to ambient air conditions and that it can increase the performance improvement higher than other systems. Othe otherhand, initial capital and operation and maintenance costs are higher. Expertise is needed to operate and maintain the plant with this system. Another chilled medium cooling system and low temperature source such as a coolin tower are required. The parasitic load of this system is far higher than other two (2) systems. These are disadvangages of the chiiling cooler system.

The chilling cooler system is limited to such special cases with ice storage facility which is functioned during the night time when the electricity tariff is constrained to as low as half of the day time. It is rare case that this system is utirized for electric utility companies. The reason is why such disadvantages exist and the economic parameters are considerably pessimistc as understood from the parameter sdudy results of the previous section.

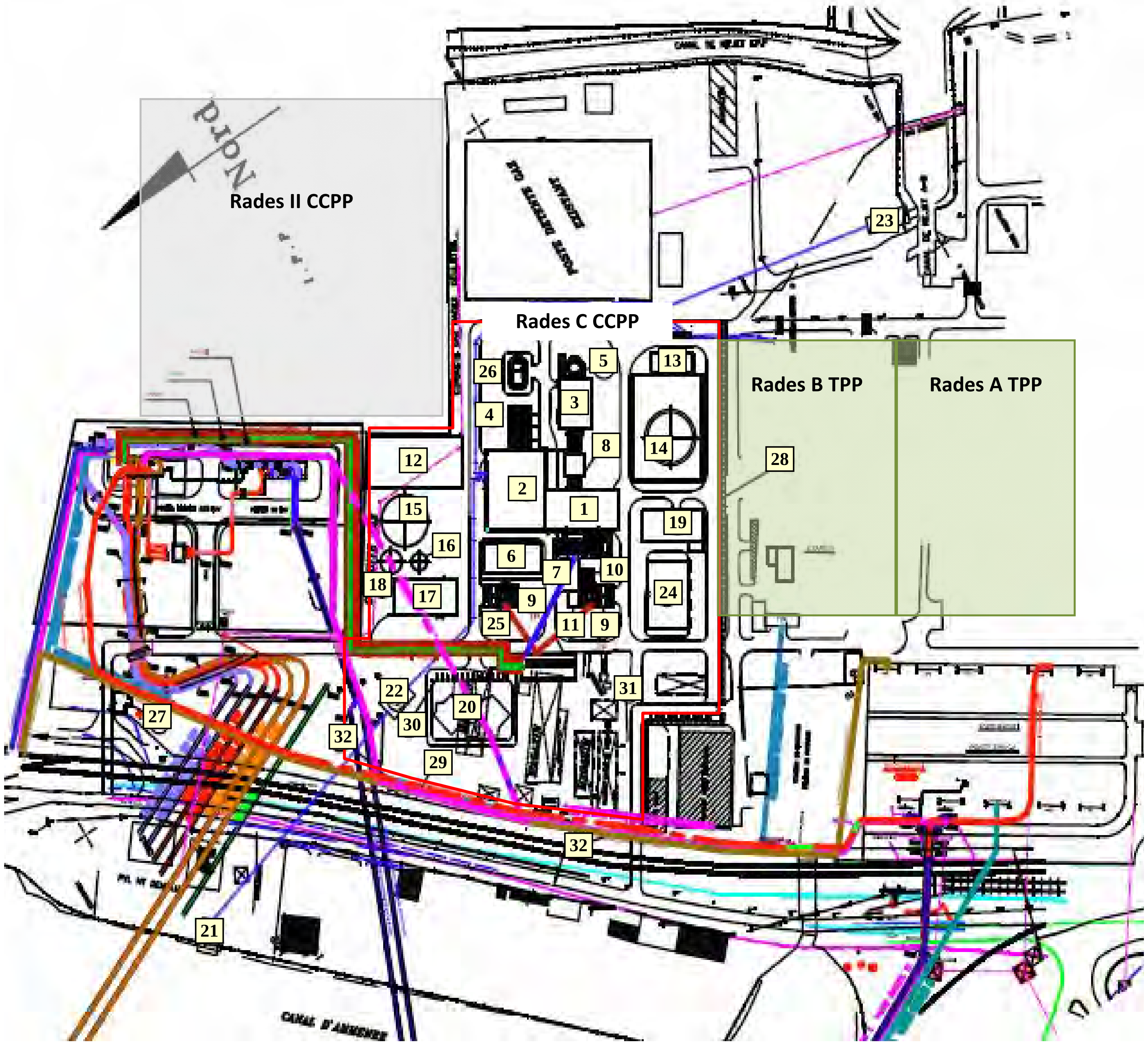
(4) Study Conclusion

It is not possible to find the reasonable reson to employ the chilling cooler system for this project.

Comparing the evaporative cooler system with the fogging cooler system, there is no crucial difference in economic parameters between both systems. It is implied in literatures that in case of the latter system any erosion may happen to the compressor blades.
Consequentially, the Study Team recommends that the evaporative cooler system should be specified in the bidding documents.

6.2 Plot Plan

The candidate site is situated in an area adjacent to the west side of the Rades A&B TPPs. The conceptual arrangement of the Rades C CCPP is shown in Figure 6.2-1.



LEGEND:

1 Gas Turbine (GT) Machinery Room
2 Steam Turbine (ST) Machinery Room
3 Heat Recovery Steam Generator (HRSG)
4 Boiler Water Feed Pumps
5 Main Stack
6 Electrical Equipment Building
7 GT Air Filter
8 Diverter Damper and Bypass Stack
9 Main Transformer
10 Auxiliary Transformer
11 Power Generator
12 Gas Discharge Post
13 Diesel Oil Storage/Transfer Station
14 Diesel Oil Storage Tank
15 Desalinated Water Storage Tank
16 Demineralised Water Storage Tank
17 Water Treatment Facilities
18 Raw Water Storage Tank for Fire Protection
19 Technical Building/Central Control Room
20 Administration Building
21 Circulating Water Intake Mouth
22 Circulating Water Pumping Station
23 Circulating Water Discharge Mouth
24 Workshop
25 Energy Discharge Consolidated Post (to be made by STEG)
26 Car Washing Garage
27 Guarding and Reception House
28 Fence
29 Existing Fence (to be rebuilt)
30 Roofed Car Park
31 Open Car Park
32 Guard Tower

Source: STEG

Figure 6.2-1 Plot Plan

6.3 Basic Systems for Plant Design

6.3.1 Gas Turbine System

(1) Design Codes and Standards

The gas turbine system shall be basically designed as per ISO 3977-3 “Gas turbines-Procurement-Part 3: Design requirements” and ISO 21789 “Gas turbine applications-Safety.”

(2) Gas Turbine

The gas turbine shall be of single shaft configuration, open cycle, heavy duty F class temperature level type with dry low NOx design suitable for the specified natural gas.

The gas turbine design shall be with a minimum number of bearings, and shall be located on a steel frame or on adequate steel structures and concrete foundation, so sized as to withstand the transient torque imposed on the shaft in case of short circuit of the generator or out-of-phase synchronization, whichever is larger. The power output shall be taken out at the cold end of the shaft.

An evaporative cooling system of the inlet air shall be considered to augument the power output on higher ambient temperature conditions.

The gas turbine shall be complete with all auxiliary systems such as starting system, lube oil supply system, inlet air filtration system, fuel gas supply system, turning device, control and monitoring equipment necessary for safe, reliable and efficient operation with the fuel specified. The gas turbine shall be designed for indoor installation in an enclosure suitable for specified noise requirements.

The gas turbine shall be designed for continuous base load operation according to the manufacturer’s standard, burning natural gas with the specified composition range. The gas turbine shall be capable of start-up, loading and shut down using the specified natural gas.

The gas turbine shall be provided with an automatic start-up and control system capable of being operated from the central control room of the plant.

The control system of the gas turbine shall be such that it is capable of performing the following operations as a simple and combined cycle:

- Constant load operation at all loads between the minimum and full loads
- Governor free (droop) operation
- Turbine inlet temperature constant operation
- No load operation for certain periods of time without being not synchronised as a simple cycle
- Minimum load operation not more than 30% of the full load as a combined cycle on the full power of the steam turbine keeping all the bypass valves closed.
- Automatic purging cycle to ensure that specified natural gas is removed from the gas turbine and entire exhaust system up to the exit of the stacks. Purging time shall be adjustable.
- The load rejection from the full load without tripping for easy re-synchronization.

The gas turbine shall be of horizontally split case construction for convenience for maintenance and shall permit easy access to stationary and moving blades without undue difficulties.

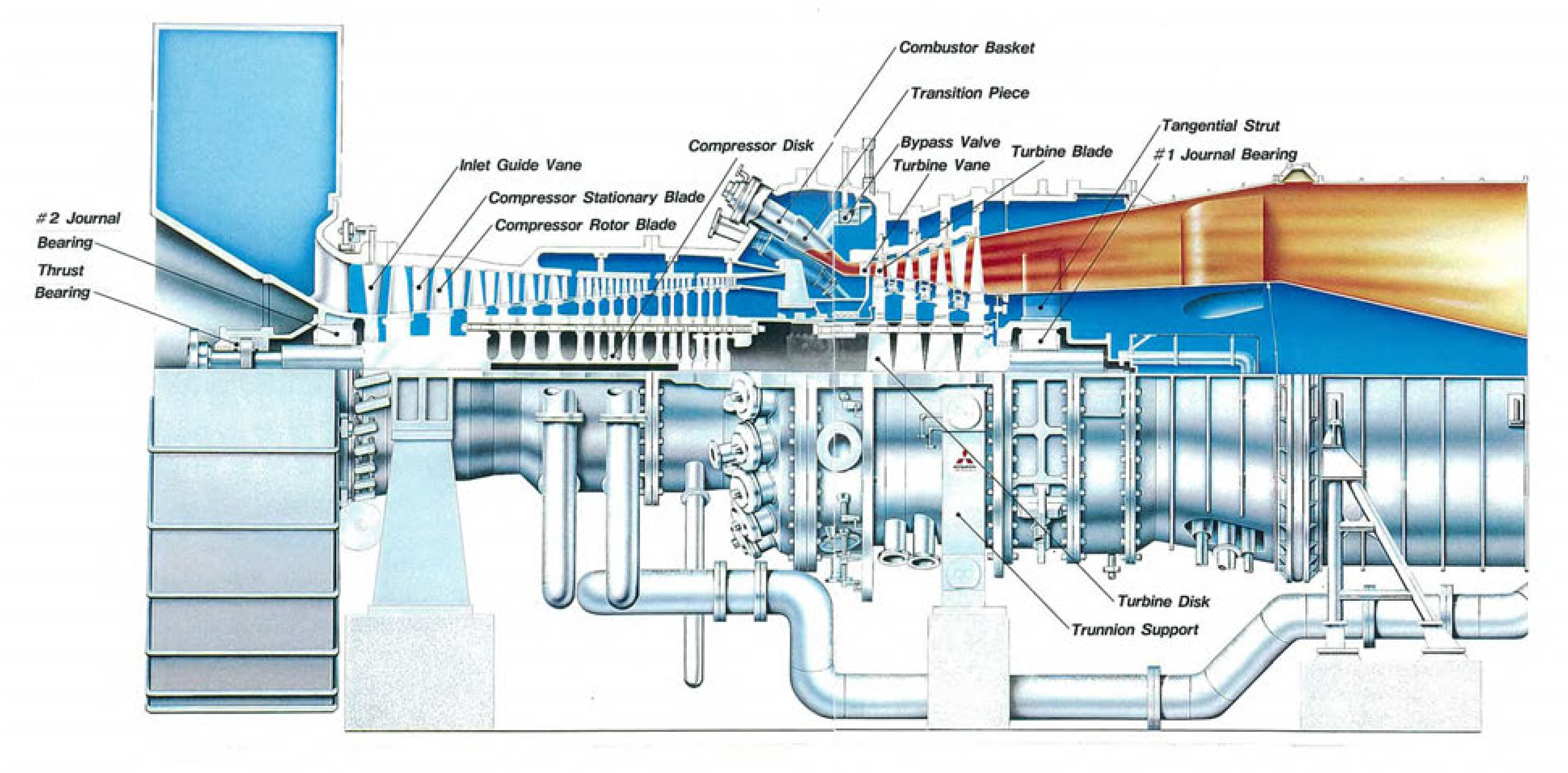
The entire gas turbine casing shall be heat and sound insulated in such a manner as to allow easy removal and replacement for overhaul and inspection. The insulation material shall be of asbestos free non-combustion and chemically inert material and shall be covered by sheet metal. The design of the heat and sound insulation shall be in a manner to avoid the lube oil soaking in.

Around the gas turbine there shall be working space of at least 0.8 m width without any interference by piping, cabling, walls, etc.

The journal bearings shall be of sleeve bearing type. The axial thrust force shall be oriented in one direction during all steady state operating conditions and shall be absorbed by an adjusted axial thrust bearing. All main bearings of hydrodynamic type shall be equipped with bearing oil outlet temperature indicators and monitors and vibration indicators and monitors. The monitors shall be capable to actuate alarm and/or trip as per manufacturers' practices.

Borescope parts for inspection of all critical inner parts shall be provided.

Figure 6.3.1-1 shows the longitudinal cross section of the typical F-class gas turbine which is one of the candidate gas turbines applicable for this Project.



Source: MHI Catalogue

Figure 6.3.1-1 Longitudinal Cross Section Drawing of Typical F-class Gas Turbine

(3) Starting System

The starting device and associated power supply equipment shall be suitable for the acceleration of the gas turbine/generator and the extended operation during purge and compressor cleaning cycles. The rating of the starting device shall be determined so as to produce the starting and acceleration torque with a proper margin to allow for the gas turbine/generator to accelerate to the rated speed from standstill within 25 minutes (excluding the purge and synchronization time) on all machine state conditions without any difficulties throughout the specified ambient temperature range. The starting device and starting power supply capacity shall be minimized as long as the train will be accelerated within the specified time.

The following two (2) types of starting devices are conceivable for such a large capacity gas turbine and generator of the separate shaft type CCPP as required for this plant.

- A synchronous generator/motor with a static frequency converter
- A squirrel cage type motor with a torque converter

The starting system should preferably be rated without limit on the number of starts attempted in succession and without restricting the rate of starting.

Interlocks shall be provided to prevent the gas turbine/generator from starting in case the lube oil pressure is not sufficient to rotate the gas turbine/generator rotor.

Any starting device shall disengage automatically and shut down before it reaches the maximum allowable speed. The starting device is normally disengaged at the self-sustaining speed or idle speed and is at rest during operation. Failure of the disengagement shall automatically abort the starting sequence.

The gas turbine/generator shall be capable of starting instantaneously from any standstill conditions as long as it is on reserve condition.

The starting control system, including any pre-start actions such as turning, shall be of manual and automatic as defined below:

Manual start:	The start-up sequence shall be held and advanced at the events such as cranking, purging, firing and at the minimum governor setting speed.
Automatic start:	The start-up sequence shall be automatically advanced to the minimum governor setting speed or the readiness to synchronizing or to the pre-set load.

The starting control system shall be provided with an automatic purge function to ensure safe operation.

(4) Lube Oil Supply System

The lube oil supply system shall be basically designed as per the requirements of the latest version of API 614. A complete lube oil system shall be provided and shall be fully integrated with jacking oil system (if applicable), oil purification system and dirty oil drains for the gas turbine/generator. The lube oil system shall have sufficient capacity to accommodate the requirements of the systems that will be supplied with the lube oil.

The system shall include sufficient standby equipment to allow any items of equipment within the lube oil system to be taken out of service for maintenance without restricting the operation of the plant.

The lube oil system shall be preferably separated from that of the steam turbine/generator.

The retention time of the oil reservoir shall not be less than eight (8) minutes based on the normal flow rate of oil and the retention capacity which is the total volume below the minimum operating level.

Alarms shall be at least made on the occurrence of the following situations:

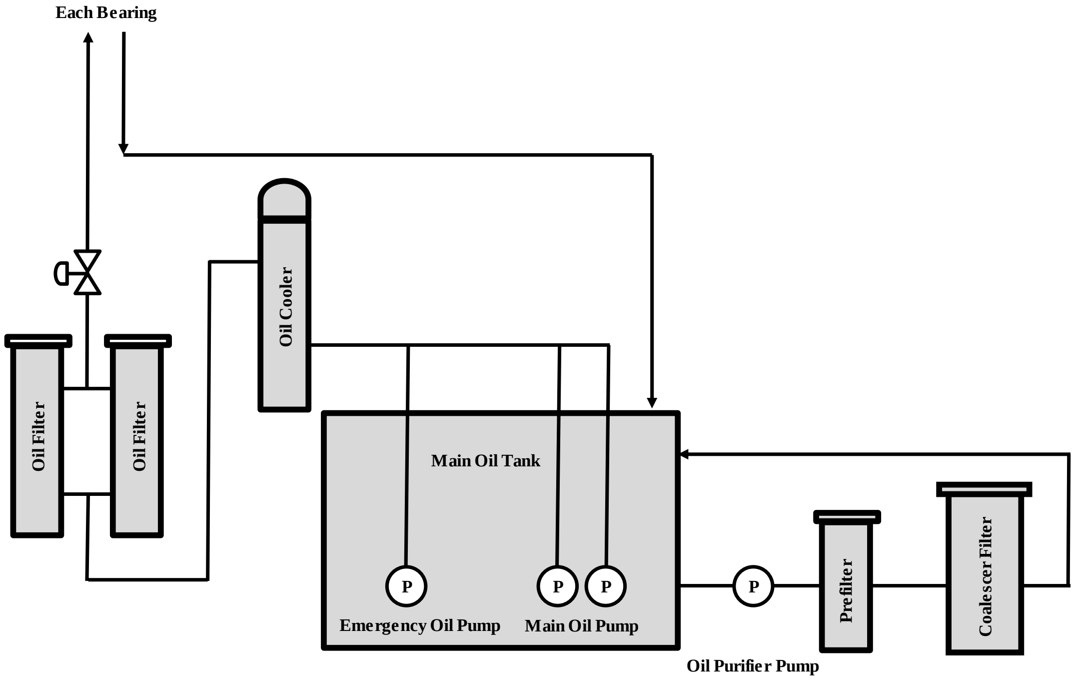
- Lube oil supply pressure low
- Lube oil reservoir level low
- Lube oil discharge temperature high
- Lube oil supply temperature high
- Lube oil filter differential pressure high

All bearing drain lines and oil wells are to be provided with visual indicators capable of being observed from a local platform or operating floor level.

The outlets of relief valves shall be routed to the oil reservoir tank.

In the event of AC power failure, the emergency DC oil pump to be operated for rundown of the rotating shafts and bearing cool-down shall be automatically put into operation. A combined AC/DC tandem motors-driven pump shall not be accepted.

Where oil is supplied from a common system to two (2) or more machines, the characteristics of the oil shall be specified by the Contractor. The Contractor shall ensure that the specified oil meets the requirements of the different machines and is locally procurable.



Source: JICA Study Team

Figure 6.3.1-2 Flow Diagram of Lube Oil Supply System

(5) Fuel Supply System

The gas turbine combustion system shall be of a dual-fuel design so that the specified natural gas indigenous in Tunisia can be fired as a main fuel without any difficulties. The gas turbine shall have such a function that the diesel oil can be fired as a standby fuel.

The natural gas pipeline terminal point is located outside the boundary fence adjacent to the plant site. The pressure at the terminal point is specified from 3.3 to 7.6 MPa (g). The dust particle distribution data necessary for design of the pre-treatment facility will be examined in due course of time.

The fuel gas supply system shall be such that it can supply the gas turbine with the specified natural gas under normal conditions with a proper pre-treatment, and the necessary booster compressor station as per required under worst supply conditions.

The fuel gas supply system shall cover all the equipment required for the start-up, shut down and continuous operation of the gas turbine. A flow metering valve, pressure-regulating valve, shut-off valve, flow meter, fine filter and distributing manifold, but not limited to such equipment, shall also be included in the scope.

Any fuel gas heating facility where the fuel gas may be heated with hot air extracted from the gas turbine compressor as a turbine cooling media for improvement of the thermal efficiency of the plant may be provided depending upon the gas turbine manufacturer.

The gas turbine shall be designed so that the diesel oil can be fired without any difficulties for one (1) week when the supply of the fuel gas is interrupted due to any reasons. Any equipment necessary for the purpose, including the storage oil tanks, shall be in the scope.

Any other conditions necessary for the design of the gas turbine shall be examined at the detailed design stage.

(6) Air Intake System

1) General

The air supply for a gas turbine shall be taken from a high-level atmospheric air inlet external to the gas and steam turbine building. The air intake shall also be positioned to avoid the ingress of any exhaust gases from the main stack of the heat recovery steam generator.

The design of the hood shall permit ready access to the air filtration system. After filtration, the air shall be directed to the inlet flange of the gas turbine compressor.

The intake system shall be complete with inlet screen and louvers, filters, airtight duct from filters to compressor inlet, foreign object damage protection screen, sound attenuators and all controls and instrumentation necessary for safe control.

The number of access points and penetrations into the air inlet system for maintenance and inspection shall be minimized. Any door or hatch shall be capable of being securely locked, and interlocks shall be provided to prevent any attempted start with any door or hatch not properly closed.

2) Air Filtration System

The air intake filtration system shall be accomplished by a multi-stage dry system. The filter elements shall be preferably of washable reuse type to minimize industrial waste. The air filtration system shall be so designed that its dust collection efficiency will not fall below 99.5% in the weighing method for ISO fine dust while in service and shall be such that particles remaining in the filtered air shall not exceed 5 microns diameter.

The replacement interval of filter elements shall not be shorter than 6,000 operating hours for use of ISO fine dust.

The air intake shall be equipped with a silencer downstream of the filtration system and the whole of the ducting shall be sealed to avoid ingress of unfiltered air.

The air filters chosen shall be suitable to reduce the sand, dust and salt content of the atmospheric air to a level which is not detrimental to the life of the gas turbine unit and under the most adverse atmospheric conditions of the site.

A self-cleaning type air filtration system shall be acceptable as an alternative. The filter system shall be composed of high efficiency media filter cartridges, which can be cleaned automatically by reverse pulses of compressed air taken from the intermediate stage of the gas turbine air compressor. The sound pressure level during the reverse cleaning operation shall not exceed 85 dB (A) at the distance of 1 m from the system.

The design shall minimize the inlet system pressure drop. The instrumentation and control equipment shall also be kept to a minimum but must include a differential pressure monitor across every stage of the filtration system.

3) Air Inlet Ductwork

The ductwork shall be complete with all the necessary expansion joints, guide vanes, supports and supporting steelwork, vibration isolators, flanges, silencing equipment, cladding and any other items necessary to complete the system.

The expansion joint shall be such that no loads or forces are transmitted to the gas turbine inlet flange.

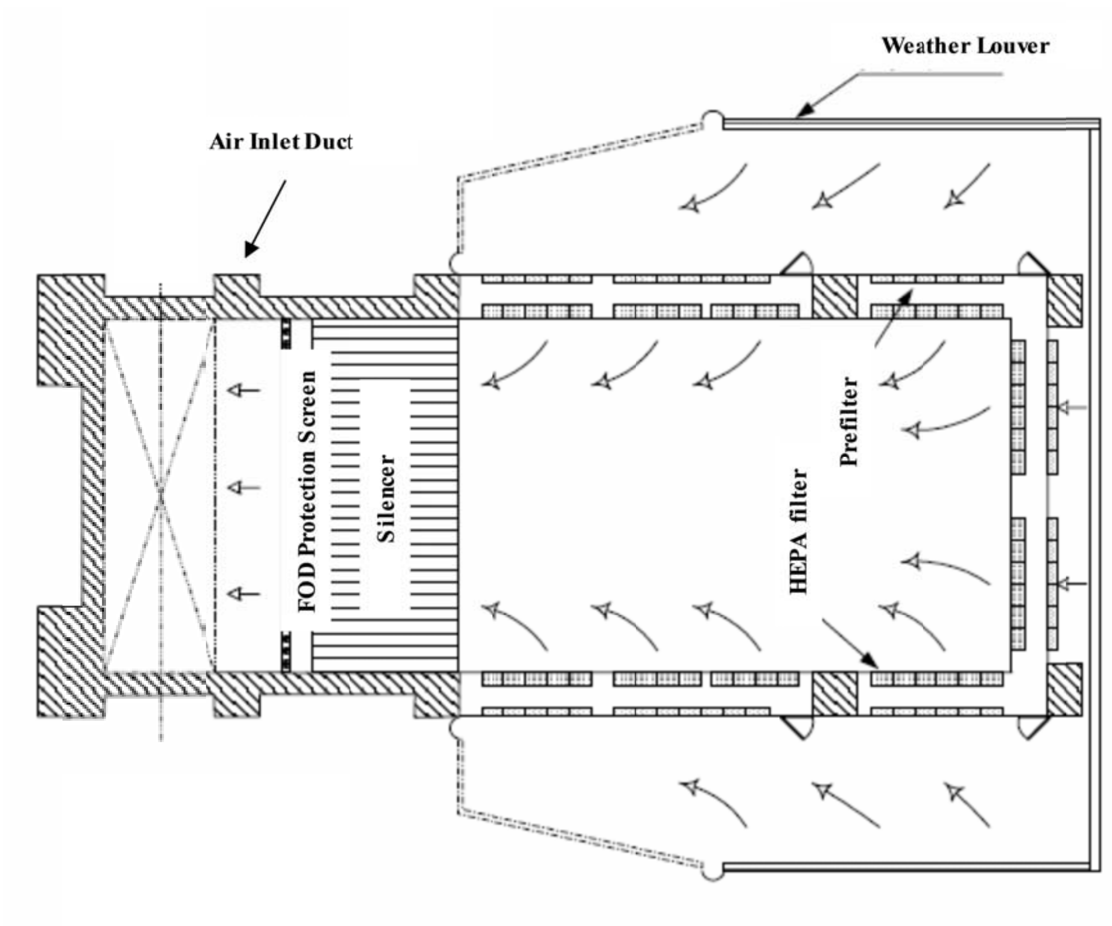
Sliding joints shall not be used in the ductwork. All expansion joints shall be flanged for removal without disturbing the main sections of the ductwork.

No entrapped nuts, bolts or rivets shall be used inside the ductwork downstream of the filtration system.

Bypass doors shall be provided in the ductwork to allow the air filtration system to be bypassed in the event of excessive differential pressure across the filtration system. The construction of the bypass door shall be preferably of a counter weight type. An alarm in the control room shall be initiated on high filter differential pressure. On further increase in differential pressure, a further alarm shall be initiated together with automatic opening of the bypass doors.

4) Silencer
A silencer shall be provided to control the noise from the air compressor to the specified level. The silencer acoustic panels shall be designed for the service life of thirty (30) years at the full load condition of the gas turbine. The silencer shall be capable of being removed from the ductwork without dismantling or removing any other ductwork than that containing the silencer. The silencer acoustic panels shall be constructed from stainless steel. The infill and panels shall be fully resistant to the worst atmospheric conditions anticipated on the site. Precautions shall be taken to prevent settling or packing of the infill material. The infill material shall be vermin proof.

5) Foreign Object Damage (FOD) Protection Screen
Since there is a possibility of foreign objects entering the gas turbine and causing damage of rotating parts, the FOD protection screen shall be installed at the compressor inlet to reduce the size of objects that can enter to a size that is not liable to cause such damage. The location of the screen shall be sufficiently upstream to avoid the potential for large objects to cause significant localized flow blockage that may induce blade failure.



Source: JICA Study Team

Figure 6.3.1-3 Air Intake System

6.3.2 Steam Turbine System

(1) Design Codes and Standards

The steam turbine system shall be basically designed as per the latest version of ISO 14661 "Thermal turbines for industrial applications" or equivalent codes and standards.

(2) Steam Turbine

The steam turbine shall be of a reheat, three (3)-admission, two (2)-casing, full condensing type directly connected to the generator. The steam shall be downward exhausted to a surface condenser which is cooled by circulating seawater of a once through type cooling system.

The steam turbine shall be of a three (3) pressure-level turbine with HP, IP and LP sections.

The steam turbine and ancillary systems shall be designed to run continuously under all specified conditions over the specified lifetime of the plant.

The steam turbine maximum capability shall be defined so as to cope with such parameters as steam pressure, temperature and flow rate to be developed by the HRSG under conditions where the gas turbine is operated at the maximum capability ambient temperature.

The steam turbine shall be complete with all auxiliary systems such as a steam condenser, lube oil supply system, control oil supply system, admission steam stop and throttling valves, governing system, steam bypass system, turning device, and control and monitoring equipment necessary for safe, reliable and efficient operation. The steam turbine shall be designed for indoor installation in an enclosure suitable for specified noise level requirements.

The steam turbine design shall be with a minimum number of bearings, and shall be located on a steel frame or on adequate steel structures and concrete foundation, so sized as to withstand the transient torque imposed on the shaft in case of short circuit of the generator or out-of-phase synchronization, whichever is larger. The power output shall be taken out at the LP turbine section side.

The turbine blading shall be designed so that it withstands the continuous operation under any loads at any network frequency from 48.5 to 51.5 Hz with any allowable time limitation for frequency less than 48.5 Hz.

Blades shall be thoroughly protected against erosion from moisture. The last stage blades shall be protected against erosion by flame hardening or by erosion shields of stellite or other suitable material. Other erosion protection provisions, such as drain grooves on the last few stator blades and turbine casing, will also be considered if such provisions are proven to be effective.

The steam turbine shall be designed so that the expected life expenditure of the main components shall not exceed 75% of their expected lives through the specified service hours when it will be operated under specified conditions.

The turbine shall be provided with the necessary number of borescope parts to inspect the conditions of the blades at periodical intervals.

The steam turbine shall be designed with proven materials having a wealth of commercial operating experiences under similar operating conditions. In particular, special attention shall be paid to the material of the integrated single rotor where operating conditions are different in the front and rear parts.

As for the design of the casing and its pipe connections, it shall be taken into account that the most severe conditions of pressure and temperature may simultaneously be applied to them. In addition to the calculated minimum thickness of the casing, allowance shall be made for corrosion if the casing is not of a corrosion-resistant material.

The rotor shall be designed to be safe against the speed of at least 10% above the momentary speed which may be liable to occur when the full load is shed under the maximum capability ambient conditions. If the rotor is of built-up construction, the disc shall remain secure at the speed mentioned above.

Figure 6.3.2-1 is a longitudinal cross section of a typical steam turbine which may be applicable for this project.

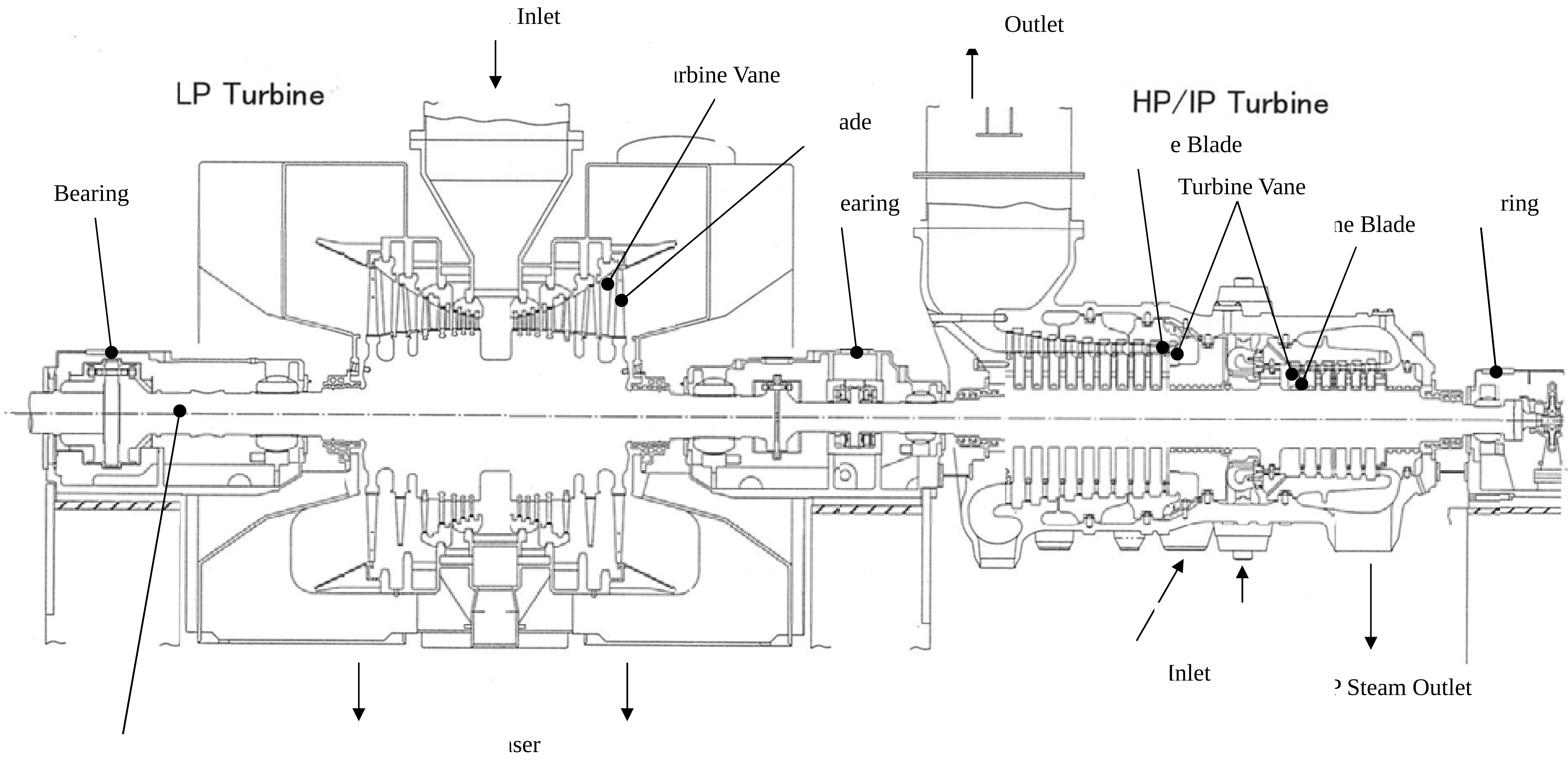


Figure 6.3.2-1 Longitudinal Cross Section of a Typical Steam Turbine

6.3.3 Heat Recovery Steam Generator (HRSG) System

(1) Introduction and Scope

This part of the specification covers the one (1) Heat Recovery Steam Generator (HRSG) complete with ducting, mountings, integral valves and pipes, and other specified items associated with the one (1) gas turbine generator of the combined cycle block.

The HRSG shall be of triple-pressure, natural or forced circulation, reheat type of proven design in accordance with the requirements of the ASME B&PV Code or equivalent, where applicable. It shall be designed to accept the maximum exhaust gas mass flow from a gas turbine at base continuous output with minimum specified ambient temperature, and the heating surfaces shall be designed to take into account the variation on the temperature/flow profile which will occur in the gases leaving the gas turbine under differing loads and ambient conditions.

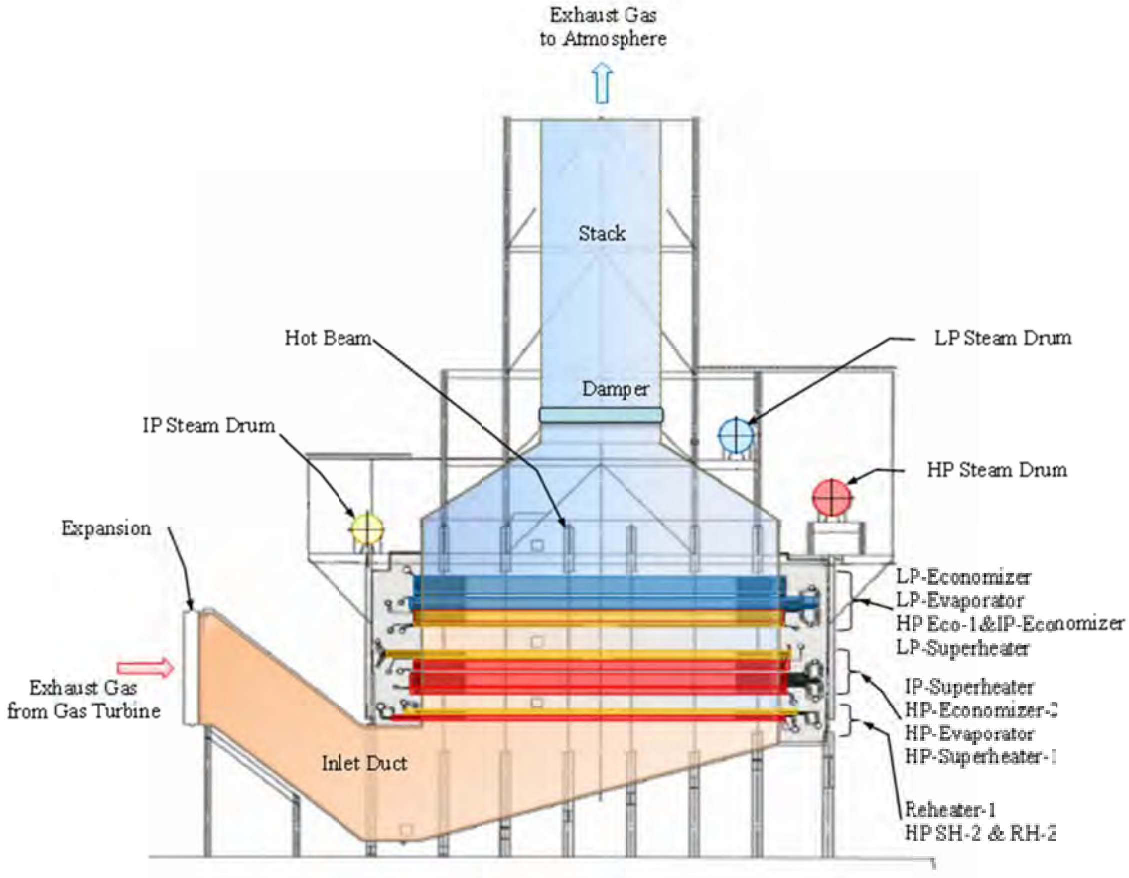
The HRSG shall be capable of following, with use of the modulating control damper, the inherent rapid start-up and shut down of the gas turbine without undue thermal stress. It shall be designed to operate on the exhaust gas of the gas turbine when fired with either gas fuel or distillate oil.

An exhaust gas bypass system with bypass stack shall be incorporated to improve flexibility of the combined cycle operation.

The HRSG design shall be such as to minimize the back-pressure on the gas turbine while maintaining the rated output and steam conditions. It should be constructed of large, factory-tested, shippable modules to reduce installation time.

The following heat transfer modules shall be considered, as applicable, for the HRSG design:

- High Pressure Superheater Section
- High Pressure Evaporator Section
- High Pressure Economizer Section
- Reheater Section
- Intermediate Pressure Superheater Section
- Intermediate Pressure Evaporator Section
- Intermediate Pressure Economizer Section
- Low Pressure Superheater Section
- Low Pressure Evaporator Section
- Low Pressure Economizer Section
- Condensate Preheater (if required)



Source: JICA Study Team

Figure 6.3.3-1 HRSG of Vertical Gas Flow Type

To minimize the outage time for inspection and maintenance, provision shall be made to allow ready access to the flue gas path, tubing, and other pressure parts. Access doors with integral seals to prevent gas leakage into the atmosphere shall be provided.

The HRSG shall be designed for outdoor installation and shall be entirely weatherproof. Canopies shall be provided to protect both personnel and equipment (drum fittings, valve and circulating pumps) from the external environment.

The steam drums shall be sized sufficiently large to accommodate water level variations during start-up and during operating transient conditions without resorting to wasteful water dumping or risk of carry over. The drum capacity shall also be sufficient such that tripping of any one (1) operating boiler feed water pump shall not cause the HRSG to trip prior to standby boiler feed water pump reaching its operating load. Particulars of the general layout of the water circulating system, including the number and internal diameters of the feeders and mains for each circuit, shall be provided.

The HRSG shall be arranged with the total pressure parts comprising steam drums, superheaters, reheaters, evaporators, economizers, headers, down comers and integral pipe work in the form of a self-contained unit supported by its own steel structure. This structure is to be quite independent of any building except for normal points of interconnection with access galleries, platforms, or stairways.

The design of the HRSG and associated ancillary and auxiliary systems shall have been developed for both base load and cycling service in particular where component material stress and structural design are concerned. Any special features for the HRSG necessary to permit both constant and variable pressure operation for the turbine steam temperature matching shall be incorporated.

(2) Design and Operating Conditions

The HRSG shall be suitable under normal and abnormal operating conditions to match the proven combined cycle plant design as per the Heat Balance Diagrams. The gas side of the HRSG passages shall be designed for the maximum temperature, pressure and mass flow that can be anticipated under all operating conditions (including a trip situation). The maximum values will not necessarily be concurrent.

The HRSG shall be able to meet the requirements of a sustained base load as well as two (2) shift operation.

The HRSG shall be capable of automatic variable pressure operation both for sustained base load as well as two (2) cycling regimes, to minimize the turbine thermal stress levels and obtain the desired flexibility and efficiency. The manufacturer shall define the variable pressure characteristics of the HRSG including the minimum load at which variable pressure operation can be sustained.

Under conditions of total load rejection, the thermal load on the HRSG shall be rapidly reduced to the capacity of the steam bypass system by means of the exhaust gas bypass modulating control dampers.

The starting and loading to full load of the gas turbine shall not be restricted in combined cycle operation. It is intended that the diverter damper shall be capable of being operated in a number of pre-fixed intermediate positions to cater for hot, warm and cold starts of the HRSG with the gas turbine operating at full load as well as during HP/LP bypass operation.

The HRSG is to be designed such that it can be started-up in the following two (2) operating modes:

- Start-up together with GT; and
- Start-up of HRSG when the GT is already operating at full load. Flue gas regulation shall be achieved by regulating the diverter damper.

The HRSG design shall be optimized for continuous efficient operation over the entire operating range of the gas turbine. The efficiency between 70% and 100% MCR shall be maximized.

The feed water quality shall meet the requirements of the HRSG and steam turbine as per the applicable codes.

(3) Design Standards and Codes of Practice

All materials, designs, manufacture, construction, and inspection and testing shall conform to criteria and recommendations of the relevant codes and standards.

All pressure parts, mountings, fittings and sub-assemblies shall be designed, constructed, and tested to conform to the requirements of the approved Inspection Authority.

(4) Design and Construction of HRSG

1) HRSG Gas Path

The gas turbine exhaust gas path through the HRSG shall be horizontal or vertical with water and steam tubing located horizontally/vertically across the gas stream to suit the plant layout and as per the manufacturer's standard design.

The heating surfaces of various modules in the gas stream shall reduce the gas temperature to the lowest value practicable, with each of the fuels available to the gas turbine, without risk of damage from corrosive sulfur products at the economizer outlet or within the stack. Control of the feed water temperature to ensure that metal temperatures in any part of the economizer remain above the dew point shall be achieved via the deaerator.

The tubes and headers in each plenum shall be completely drainable and provision shall be provided to gain access to the tubing for inspection and maintenance.

2) Tubes

The tubes shall be of solid drawn or electrical resistant welding (EWR) steel as per the manufacturer's experience. The design, manufacture and testing of the tubes shall be in accordance with the relevant standard specification.

Adequate circulation ratio shall be provided to minimize circulation upsets that may occur during rapid start-up or load change. Fins added to the heat exchanger tubing to improve the heat transfer characteristics must be continuously welded to the outside surface of the tubes. All welds and tube connections to headers shall be outside the gas passage and readily accessible for inspection and maintenance.

3) Superheaters and Reheaters

The HP superheater tubing shall be designed and located in the HRSG unit such that the steam temperature at delivery to the steam turbine will not exceed the HP steam chest and rotor stated limits, with the gas turbine at base continuous output with the highest anticipated ambient temperature, without recourse to desuperheating the steam.

The design will be compatible with the requirements of constant and variable pressure operation and the variable characteristics of the gas turbine exhaust gas flow.

The design of the HP, IP and LP superheaters within the HRSG units shall ensure even distribution of steam through the tubes at all loads. Superheaters and reheaters shall be in the form of fully drainable elements. Superheater and reheater tubes are to be designed with no steam flow in the tubes during start-up. Material selection shall conform to the same.

Austenitic stainless steel shall not be used anywhere in the superheater.

4) Evaporators

The HP, IP and LP evaporator plenums will be designed to achieve a steam generation rate such that the gas leaving the zones is not more than 17.5ºC above the steam saturation temperature in that zone (i.e., temperature difference at the pinch point: maximum 17.5ºC).

The evaporator shall be designed to operate over the full load range of the HRSG without drumming or vibration and the design will ensure an even distribution of water through the tubes. The evaporator elements shall be drainable completely.

5) Economizers
The HP, IP and LP economizers shall be designed to ensure stable non-steaming operation/single phase flow throughout the full operating range of the HRSG. Connections shall be arranged between the steam drum and the economizer inlet to enable circulation of water to be maintained through the economizer during start-up. Should recirculation of water through the economizer be necessary during start-up or low load conditions, the connections shall be arranged complete with a pump to allow this.

The economizer elements shall be completely drainable.

6) Condensate Preheater (if applicable)
A condensate preheater for the HRSG as the last heat recovery module shall be provided, if necessary for maximum heat recovery. The condensate preheater shall be designed for the condensate extraction pump shut off head. Material selection for the preheater shall be suitable for undeaerated condensate water.

7) Steam Temperature Control
The steam temperature at the outlet of the superheaters and reheaters shall be controlled using direct spray type desuperheaters. The capacity of each desuperheater shall be selected taking all operating conditions, especially operations with the duct firing system, into consideration.

The spray water control station shall have a motorized isolation valve in the common line, interlocked to close automatically when the steam temperature reaches below a set point and to prevent water induction into the steam turbine.

8) Safety Valves
Safety valves of the approved number, design, and capacity shall be mounted in approved locations in accordance with the requirements laid down by the relevant regulations. The safety valves at the superheater outlet shall be sized to have a discharge capacity equal to at least 20% of the maximum steam quantity generated by the HRSG. The safety valves at the steam drum shall have total discharge capacity equal to at least the remaining of the maximum steam quantity required for the protection of the HRSG.

Safety valves on the reheater must be sized to pass the maximum reheater flow without a rise in reheater inlet pressure of more than 10% of the highest set pressure.

9) HRSG Insulation and Cladding
The whole of the HRSG shall be insulated internally and/or externally and all external insulation shall be cladded in accordance with the specification to provide an entirely weatherproof unit suitable for outdoor operation.

The insulation shall be of proven material and suitable for continuous service at the maximum operating temperature.

10) Access and Inspection Doors
Adequate access and inspection doors of an approved type and size shall be provided to

allow free entry for maintenance and cleaning of the HRSG gas-path and pressure parts.

11) Blowdowns and Drains

The steam drum shall be provided with a continuous drum water blowdown connection, located to ensure preferential discharge of concentrated drum water, complete with parallel slide isolating and regulating valves in accessible positions adjacent to the drum connection, capable of controlling the rate from 0.05% minimum to 4% maximum of the HRSG steam rating.

Intermittent blowdown and drain piping shall be included where necessary from all drainable sections of the HRSG down to the intermittent blow down tanks. And the HRSG shall be provided with continuous and intermittent blowdown tanks.

An adequate number of electrically operated blowdown valves and superheater and reheater drain valves shall be provided for automatic operations during start-up, load operation, and shut down of the HRSG.

12) Economizer/Condensate Preheater Recirculation System (if applicable)

Economizer/condensate preheater recirculation pumps shall be provided if the overall plant design demands such an arrangement for the safe and efficient operation with the desired flexibility and reliability of the plant as specified in the Design Consideration under start-up and low load operation.

(5) HRSG Control & Instrumentation Requirements

1) General

The control and protection requirements for the HRSG are principally bounded by the following:

- On the gas side, by the gas turbine exhaust and HRSG diverter damper position
- On the feed/steam side, by the HP/IP and LP feed pumps discharge and the HRSG HP/IP and LP steam stop valves.

The control system for the HRSG shall be implemented in the Distributed Control System (DCS). All necessary control functions and interlocks required for safe and efficient operation of the HRSG shall be incorporated within the DCS. Separate DCS Field Control Stations/Remote I/O Stations shall be provided for interlock and protection related parameters and signals meant for control and monitoring purposes.
The control functions of the HRSG shall comprise of the following as a minimum:

- HP, IP and LP feed water control
- Start-up/load rate control
- Superheated steam temperature control
- Reheated steam temperature control, etc.

The main protection/interlock associated with the HRSG shall be implemented by utilizing the signals associated with the following as a minimum:

- Gas Turbine Trip
- High-High and Low-Low Drum Levels
- Steam Turbine Trip
- Steam Turbine steam bypass failure

- Local and Remote Emergency Trip, etc.

The start-up, operation within the normal load range and shut down of the HRSG shall be fully automated up to the functional group level. However, the initial HRSG filling operation and the establishment of the initial HRSG drum level shall be manually controlled and supervised from the Central Control Room and only local control may be provided for minor drain and vent valves, where these are not automatic and which are not required during normal steam rating.

The HRSG shall be capable of constant pressure operation up to a 60% load and thereafter on variable pressure operation.

In the incidence of a steam turbine trip (at any load), an excessive rate of increase of the HP/IP superheater temperature within the HRSG or a HRSG trip due to say a loss of feed water supply shall initiate the appropriate interlocks to move the diverter flap to the blast stack position and not trip the gas turbine unless the diverter flap fails to move to the correct position within a preset time. HRSG permissive signals shall be required for moving the diverter flap from the bypass stack position to the HRSG position.

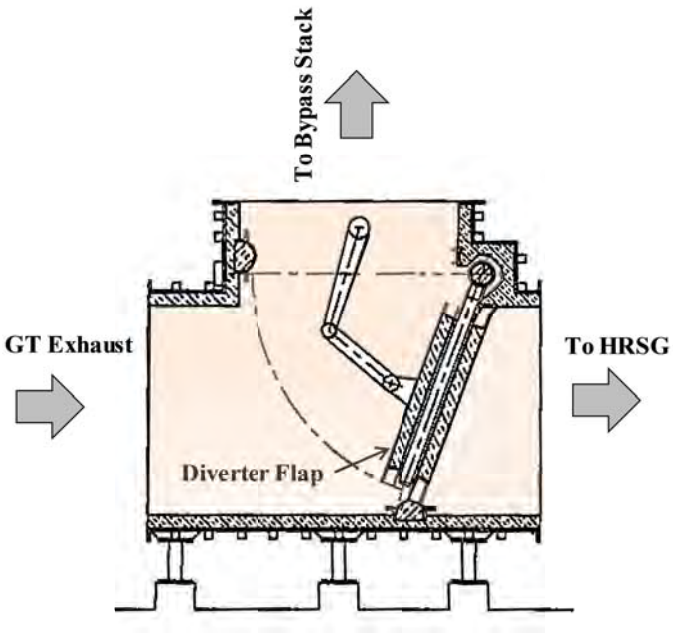
The following, as a minimum, shall move the diverter flap to the bypass stack position:

- Gas Turbine Trip
- Low-Low Drum Level
- Steam Turbine steam bypass failure
- Local and Remote Emergency Trip
- In the case of a steam turbine trip, the diverter flap shall be moved to a predetermined intermediate position to maintain the HRSG in a ready condition for reloading.

In the case of a steam turbine trip, the steam turbine bypass system shall be functioned to maintain the HRSG in a ready condition MTBF (Mean Time Between Failure) of the HRSG control and protection system, except for the transmitter, detecting elements and regulating devices, shall be more than one hundred thousand (100,000) hours of design.

The manufacturer shall supply the following instrumentation, control and protection system with all necessary components and accessories, but not limited to:

- HRSG modulating control system
- HRSG system sequence control
- HRSG autonomous control system
- HRSG instrumentation, etc.



Source: JICA Study Team

Figure 6.3.3-2 Diverter Damper

2) Turbine Exhaust Gas Control Requirements

All control and instrumentation systems required for the regulation and supervision of the heat input to the HRSG shall include the controls for the turbine exhaust gas (TEG) diverter flap position for the direct regulation of TEG flow through the HRSG, as well as all temperature and pressure measurement both on the gas and feed/steam sides.

The control system shall regulate the TEG flow into the HRSG to achieve the maximum rate of initial steam raising, steam load and delivery temperature variation compatible with the design thermal stress limitations associated with the critical HRSG and steam turbine components. Automatic HRSG start-up shall be possible under the full spectrum of operating conditions which shall include the following:

- The run up and loading of the gas turbine generator and HRSG
- The start-up of the HRSG from any initial temperature condition (i.e., cold to full load temperature) with the associated gas turbine generator operating under part or full load conditions.

To control the temperature and pressure rise of the HRSG and steam piping during start -up, the diverter flap shall be set to predetermined positions based on the gas turbine load as well as the condition of the HRSG at start-up. This function may not be necessary if the HRSG can accommodate the full exhaust gas flow for all conditions of start-up and during transient operating conditions without the need to set the diverter flap to intermediate positions.

In addition to the start-up requirements, the control system shall meet the following disturbance conditions:

- It shall maintain maximum steam generation compatible with the turbine bypass capacity in the event of the steam turbine tripping to permit the reloading of the latter with the minimum of delay.

- It shall minimize the effect of a partial or total block load rejection and maintain the HRSG in a state which shall minimize the delay in the subsequent re-connection and loading of the steam turbine.

The control and supervisory functions of the following plant items shall be considered:

- The TEG diverter flap
- The gas passage between the inlet diverter flap and the HRSG exhaust
- The HRSG LP economizer, drum, evaporator and superheat sections
- The HRSG HP/IP economizer, drum, evaporator and superheater sections

The principal sequence and protection control functions shall include the following as a minimum:

- The start-up and HRSG Loading Control

The requirement for these control functions is sequential in nature. In addition to the TEG diverter flap, the sequence controls of HRSG stop valves and associated bypass valves, including all necessary state monitoring, shall be controlled by these control functions.

A check to ensure that the diverter flap is fully closed in the bypass stack position shall form a pre-check in the HRSG start-up sequence. Only local controls are considered necessary for the operation of the diverter flap, to be restricted by a Permit-to-Work system.

- Shut down

This function shall be capable of being initiated both manually and automatically from the central control system. The shut down function shall initiate coordinated closing of the TEG inlet and closing of HRSG stop valves after an appropriate delay. The stopping of HRSG feed pumps and circulation pumps may be regarded as a manual action.

This sequence function shall initiate the tripping of the gas turbine if the diverter flap fails to move to the bypass stack position within a preset time after the HRSG is tripped and the operation of the diverter flap is initiated.

The HRSG supervision shall not exercise any direct control functions but shall comprise all measurement hardware required for the monitoring of the operational state of the HRSG.

3) Feed Control Requirement

The control and instrumentation system required to regulate feed water supply to the HRSG shall include feed water regulation valves, instrumentation associated with drums, main steam and feed water together with the feed water pumps.

The feed control system shall comprise of a single element drum level control operating on a low load feed water control valve and three element control operating on the full load feed water control valve nominally rated for 0% to 100% MCR feed water flow. Differential pressure across the feed water control station shall be maintained at a constant value by varying the scoop position of the feed water pumps.

The system shall be designed to maintain the drum level within acceptable limits under all anticipated HRSG load changes and disturbances, such as transfers from the duty feed water pump to the standby feed water pump, etc.
The principal modulating control functions to be associated are:
a. Start-up feed water control
b. Normal load feed water control

4) Drum Level/Feed Water Control
The control system shall comprise of a single element drum level control operating on a low load feed water control valve and a three element control operating on a full load control valve (in case of HP & IP on one of the full load control valve). A low load feed water control valve is envisaged for controlling the drum level during plant start-up and low load operation up to 30% MCR. For normal load up to 100% MCR, a full load control valve is envisaged to maintain the drum level. A stand-by full load feed water control valve (in HP & IP feed water control stations) shall be provided for improving the availability during on-line maintenance of the main valve. The facility shall be provided for both a manual and automatic changeover from single element to three element control and vice versa.

The three element function shall consist of the steam flow, feed water flow and drum level. Steam flow measurements shall be pressure and temperature compensated and the drum level measurements shall be pressure compensated.

The feed water control shall develop the flow control signal for matching between feed water flow and steam flow using drum level deviations from the drum level set-point.

5) Main Steam Temperature Control
The steam temperature shall be designed to maintain the main steam temperature at the turbine inlet by means of the spray control valves. One or more stages spray control based on the HRSG design shall be used for the control of superheater temperature.

The spray desuperheater shall be provided with shut-off valves. The feed forward circuit shall be used for sufficient control response.

6) HRSG Autonomous Control System
The HRSG autonomous control system (ACS) shall interface with the data highway of the Distributed Control System (DCS) through process I/O interface devices. The process I/O system shall have duplicated system architecture. The interface type shall be of either the conventional hardwired I/O interface (I/O) or the remote I/O interface (R-I/O).

The following ACS of the HRSG auxiliaries shall be interfaced to the data highway through I/O interface devices but not limited to:

- HRSG metal temperature measurement system
- Environmental measurement system
- Water/steam sampling system
- Instrument air compressor system
- Service air compressor system

7) Instrumentation

The manufacturer shall provide all necessary instruments for the HRSG and auxiliaries to allow centralized control and monitoring facilities from the operators' consoles in the Central Control Room, through a microprocessor based Distributed Control System (DCS).

The following field control and instrument devices shall be provided:

- Gauges, Transmitters, etc.
- Detecting elements such as flow elements, thermocouples, pressure switches and temperature switches, etc.
- Regulating devices such as control valves, vanes, dampers, and drives, etc.
- Local instrument panels (if necessary)
- All piping, tubing and wiring necessary for satisfactory operation shall be provided.

This shall include instruments for measuring the following minimum process parameters:

a. Feed water
b. Drum
c. Steam
d. HRSG metal temperature, drum level viewing system including indicator (optical fiber system) and all other necessary pertinent items.

The manufacturer shall provide all local instruments.

- Pressure gauges
- Thermometers
- Flow indicator
- Level gauges
- Limit switches, etc.

6.3.4 Water Treatment Plant

(1) General

The source for service water and demineralized water shall be seawater for this project, even though the existing TPPs have utilized the city water as source water.

A complete water treatment system comprising seawater supply facility, pretreatment facility, desalination plant, and demineralized water plant, shall supply service water and make-up water required for Rades C CCPP. The seawater desalination plant shall also supply 720t/day service water for the existing Rades A and B TPPs.

Potable water (drinking water) required for Rades C CCPP shall be drawn from an existing raw water storage tank. Water supply to the raw water tank is provided through the city water supply system in Rades city. Potable water supply system from the raw water tank is included in the scope of works.

The provisional analysis of seawater and city water are as shown in the Table in Chapter 8 of this report.

(2) Scope of Work

The scope of work shall include design, manufacturing, supply, delivery to site, installation at site, commissioning and testing of complete water treatment system comprising the following equipment as major system components.

1) Seawater supply and pre-treatment (filtration) facilities:
- Seawater supply pumps (2 x 100%)
- Media filter (2 x 100%)
- Filtered water tank (1tank)
- Hypochlorite dosing equipment (1 set)
- Coagulant dosing equipment (1 set)

2) Desalination Plant:
- Cartridge filter feed pumps (2 x 100%)
- Cartridge filter (2 x 100%)
- Reverse osmosis feed pumps (2 x 100%)
- Reverse osmosis membranes (2 x 100%)
- Anti-scalant dosing equipment or pH adjustment equipment (1 set)
- Sodium bisulfite dosing equipment

3) Service water supply facilities:
- Service water tank (1tank x minimum 3 days storage capacity)
- Service water pumps (2 x 100%)
- Fire fighting water pumps (1 x 100% diesel driven, 2 x 100% electric motor driven, and 1 x 100% jockey pump)
- Service water transfer pumps (2 x 200%) and pipes and valves connecting with the existing service tanks of Rades A and B TPPs

4) Demineralization Plant:
- Activated carbon filters with 10 micron cartridge filter (2 x 100%)
- Demineralizers including resins (2 trains x 100%)
- Demineralized water storage tank (1 x minimum 3 days storage)
- Demineralized water transfer pumps (2 x 100%)
- Chemical regeneration system including storage tanks, regeneration pumps, backwash tower and measuring equipment

5) Make-up water supply facilities:
- Condensate storage tank (1tank x minimum 3 days storage)
- Make-up water supply pumps (2 x 100%)
- Make-up water transfer pumps (2 x 100%) and pipes and valves connecting with the existing deminerarized water tanks of Rades A and B TPPs

6) Potable water facilities:
- Potable water storage tank (1tank x 3 days storage)
- Potable water distribution pumps (2 x 100%)
- Hypochlorite tank (1 tank)
- Hypochlorite metering pumps (2 x 100%)

7) Pipe work and valves, supports, fittings and interconnections

8) Electrical equipment

9) Instrumentation and control system

10) Spare parts

11) Special tools and standard tools set

(3) Applicable Codes and Standards

The water treatment plant shall be designed and constructed in accordance with the requirements of international codes and standards.

(4) Design and Performance Requirements

1) Water Balance

The main water demand for the desalination and demineralization plant is described below:

a. Demand for Demineralized Water

The demand of demineralized water is estimated as shown in Table 6.3.4-1 "Water Balance of Rades C CCPP".

The demand of demineralized water for Rades C CCPP is estimated 242 t/day. The plant will consist of two (2) 100% trains. The capacity of each train has to be 272 t/day including regeneration water. Two (2) trains x 300 t/day deminerarization plant is proposed.

The capacity of deminerarized water tank will be at least 3 days of water production demmand: that is (299 t/day x 3 days =) 900 m^3 (effective capacity)

Demand of demineralized water at Diesel Oil Firing

Considering water injection during diesel oil firing to reach the lowest NOx emissions, the same amount of demineralized water as fuel oil supply (approximately 66t/h) has to be injected to the gas turbine. This will lead to a mighty increasing of the demineralized water production and respectively storage. Since fuel oil will be used as a back up fuel only, the power plant will be sized to ensure a water injection for 5 days at the full load continuous operation.

The increase of the demineralized water demand will be (66 t/h x 24 h/day x 5 days =) 7,920 tons.

By putting to practical use the above one standby demineralized water train with the capacity of 300 t/day (effective capacity: 242 t/day) and the storage tanks with a capacity of 900 m^3, it is confirmed that the full load operation can be continued for only a half day. In order to satisfy 5 days of oil firing operation, net storage capacity of 6.710 m^3 is required.

900 tons x 1 /(66t/h x 24h/day -242 t/day) =0.67 days
6740 tons x 1 /(66t/h x 24h/day -242 t/day) =5 days

Table 6.3.4-1 Demand of Demineralized Water

Item	Unit	Value	Remark
Demi. water for Rades C CCPP			
Make-up for condencer	t/day	237	2.2% of total steam flow
Make-up for closed cooling water	t/day	4	
Make-up for aux. steam to Demi. Plant	t/day	1	
Subtotal	t/day	242	
Water for Regeneration	t/day	30	
Margin of 10%	t/day	27	
Capacity of Demi. Plant (per train)	t/day	299	Say 300 t/day/train

Source: JICA Study Team

b. Demand for Service Water (Desalinated Seawater)

The demmand of service water (desalinated seawater) is summerized in Table 6.3.4-2).

Table 6.3.4-2 Demand of Service Water (Desalinated Seawater)

Item	Unit	Value	Remark
Demineralized water	t/day	272	From item a) above.
General service	t/day	20	Washing water in Building
Sealing water for pumps	t/day	51	For seawater pumps and chemical dosing pumps
HRSG blowdown drain cooling	t/day	428	
	t/day	720	30t/h x 24h/day
Total demmand of service water	t/day	1,492	
Margin of 10%	t/day	149	
Required capacity of desalination plant per train	t/day	1,641	1650 t/day

Source: JICA Study Team

c. Operation Time and Capacity of Water Treatment Plant

The capacity of Demineralized Water Plant shall be determined based on the operating time of twenty (20) hours a day excluding regenerating or cleaning time of four (4) hours a day.

Table 6.3.4-3 Operation Hour and Capacity of Water Treatment Plant

Item	Unit	Desalination plant	Demineralizer	Remark
Demmand	t/day	1641	300	
Operating hour	h/day	24	20	
Required capacity	t/h	69	15	

Source: JICA Study Team

d. Capacity of Treated Water Tank

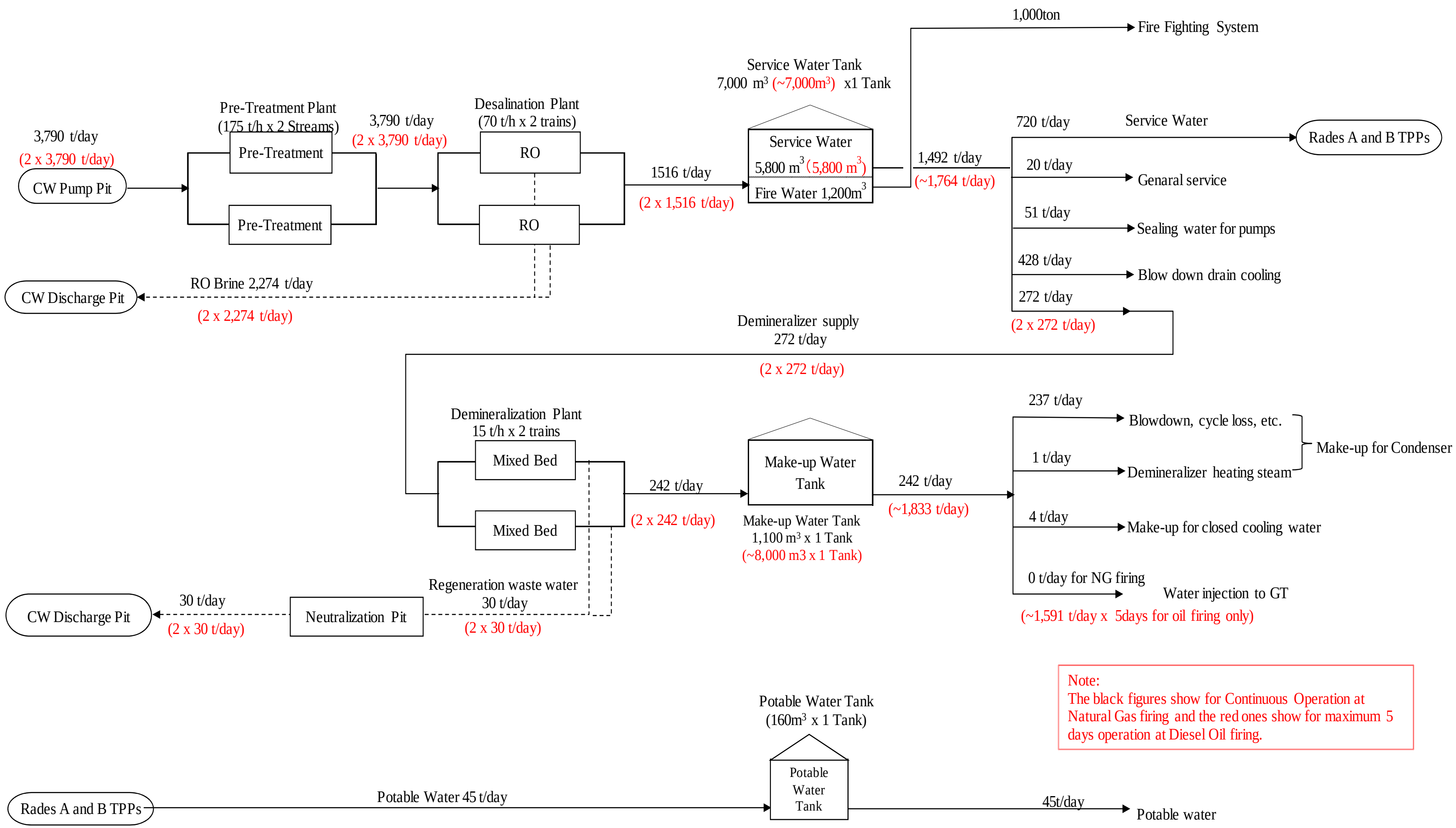
The capacity of each water storage tank shall be determined taking account of three days storage and effectiveness factor of 0.85.

Table 6.3.4-4 Capacity of water storage tank

Item	Unit	Service water tank	Make-up water tank	Potable water tank	Fire Tank
Water Flow Rate	t/day	1,641	300	45	-
Storage day	day	3	3	3	-
Effective storage capacity	m^3	4,922	900→6,740 for oil firing	135	1000
Effectiveness factor	-	0.85	0.85	0.85	0.85
Required storage capacity	m^3/tank	5,791	7,940	159	1,176
No. of tanks	tank	1	1	1	1
Selected storage capacity	m^3/tank	5,800	8,000	160	1,200

Source: JICA Study Team

Water balance of Rades C CCPP is as shown in Figure-6.3.4-1 attached hereinafter.



Source: JICA Study Team

Figure 6.3.4-1 Water Balance of Rades C CCPP

2) Seawater supply and pre-treatment (Filtration) facilitues

The seawater supply facilities consist of two (2) 100% seawater supply pumps located in the circulating water pump area. Hypochlorite shall be dosed to kill micro organism in the supplied seawater.

The water filtration system consists of a rapid filtering device, various pumps, blowers, pipes and valves. This system shall be capable of removing non-reactive (colloidal) silica effectively from the raw water.

Due to the presence of free chlorine in the raw water, the chlorine scavenging chemical dosing equipment shall be provided, which is capable of treating raw-water with a maximum chlorine level less than 0.1 mg/l.

The water pre-treatment plant components shall include provision for the following:

- The clarity of water treated by the filtered water plant shall be below 1 mg/l.
- Two (2) sets of 100% duty each raw water pumps shall be installed. The capacity of each pump shall have a margin to keep the pre-treatment plant capacity of two (2) streams x 175 t/h.
- The type of the filter shall be cylindrical, vertical, mild steel (designed per ASME standard), rubber coating inside, gravity or pressure dual media sand-anthracite filters.
- Two (2) sets of filter air blowers (each 100% duty) shall be equipped for filter air scouring.
- Puddle pipes and fittings for filtered water sump shall be constructed in reinforced concrete.
- Two (2) sets of 100% duty each filter backwash pumps shall be installed.
- Filtered water tank with appropriate capacity shall be installed for backwashing of filters.

3) Desalination Plant

The service water for Rades C CCPP is produced from seawater by desalination process and will be stored to the service water tank.

The type of desalination system will be the seawater reverse osmosis type. The process has proven records of reliability in current operating installations, however special attention must be paid to avoid frequent replacement of the membrane which will increase the operating and maintenance costs.

Since the number of pumps, especially high pressure pumps are used in the RO plant, operation and maintenance works are also important to keep the reliability.

Consideration must be given to the following:

- Pretreatment of the seawater before transfer into the RO plant is very important for the membrane life time and reliability of the plant.
- The membrane provided shall be suitable for the seawater quality at Rades.
- A comparison of the water quality produced by the RO plant shall be investigated and the impact on the demineralized plant has to be evaluated.

The desalination plant will be sized to supply water for the demineralized water plant, service water system, waste water treatment plant, firefighting system, others. The required amount of service water will be designed to be 70 t/h.

Under all operating conditions the plant shall produce water equal to or better than the specified quality for the demineralizer feedwater, which shall be as follows:

Table 6.3.4-5 Quality of Desalinated Water

Item	Unit	Desalinated Water
Total dissolved solid	mg/l	Less than 10 mg/l
Total ion	mg/l	Less than 0.2 mg/l
pH (@ 25ºC)	-	6.5~7.0

Source: JICA Study Team

Design data for the desalination plant will be as following:

a. Installation: Indoor
b. Type: Seawater reverse osmosis
c. Number: Two trains
d. Capacity: 70 t/h
e. Number of stage: To be defined by the contractor

Quality of desalinated water: see Table 6.3.4-5

4) Demineralized Water Plant

The demineralized water stream will consist of mixed bed polishing system (MBP) (or cation tower, anion tower, mixed bed polisher, vacuum degasifier, regeneration system), pumps, tanks, and pipes.
The demineralized water plant shall have two (2) streams with each production capacity of 15 t/h.

The period between regenerations shall not be less than twenty (20) hours, and the regeneration period shall be less than four (4) hours.
The raw water quality shall be taken into account in the design of the Demineralizer plant.
Under all operating conditions the plant shall produce water equal to or better than the specified quality for the boiler feedwater, which shall be as follows:

Table 6.3.4-6 Quality of demineralized water

Item	Unit	Demineralized Water
Conductivity(@ 25ºC)	μS/cm	Max. 0.2
Total Silica	mg/l	Max 0.02
pH (@ 25ºC)	-	-
Suspended Solids	mg/l	-
Turbidity	Degree	-
Total Fe	mg/l	Max 0.01
Total Cu	mg/l	Max 0.005
CO_2	mg/l	Max 2
Cl^-	mg $CaCO_3$/l	-
SO_4^{-2}	-	-
TDS	mg/l	-
Residual C1	mg/l	-
Sodium and Potassium	mg/l	Max 0.01

Source: JICA Study Team

Design data for the demineralization plant will be as following:

a. Installation: Steel structure (sheltered type)
b. Type: Mixed Bed Ion-Exchange Resin
c. Number: Two (2) trains
d. Capacity: 15 t/h

e. Number of stage: To be defined by the contractor
f. Quality of service water: see Table 6.3.4-5
g. Quality of treated water: see Table 6.3.4-6

6.3.5 Fuel Gas Supply System

(1) Fuel Gas Supply System

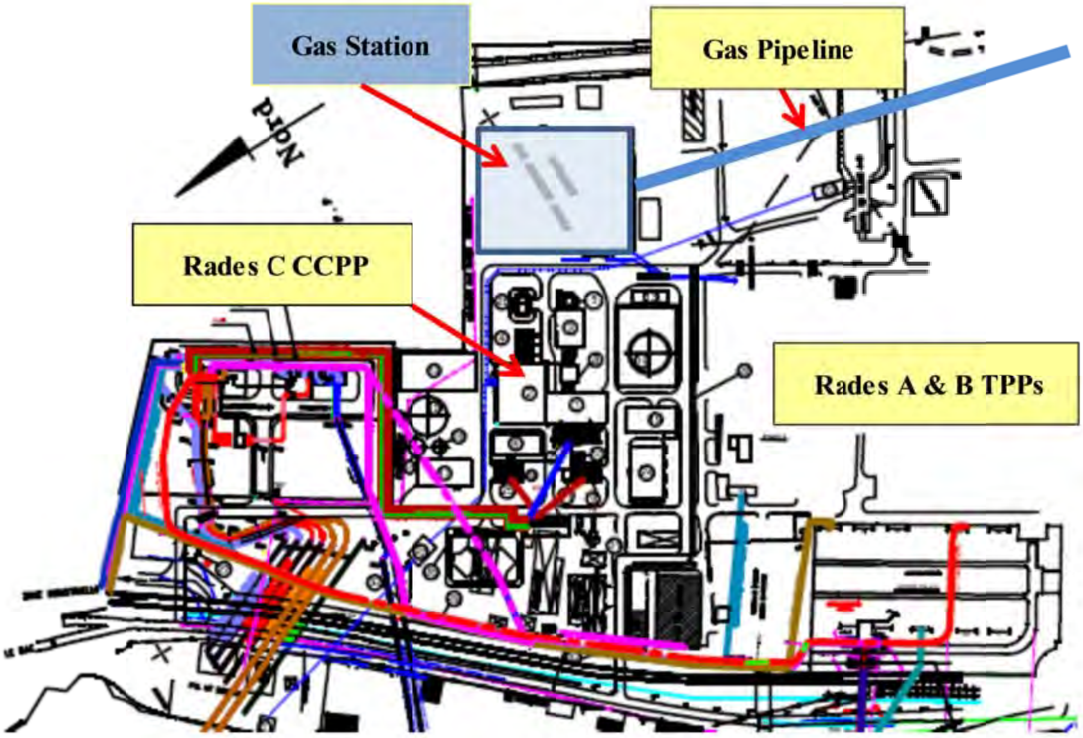
Natural gas will be used as the fuel for Rades C CCPP as well as for Rades A&B TPPs. The gas turbine shall be designed to operate on the specified natural gas. The typical specifications are as shown in Table 6.3.5-1. The fuel gas supply system shall cover all the equipment required for the start-up, shut down and continuous operation of the gas turbine. A gas compressor and gas pressure-regulating device shall be also included.

Table 6.3.5-1 Specifications of Natural Gas

Composition	Unit	Value
Methane	mol%	85.76
Ethane	mol%	7.26
Propane	mol%	1.64
i-Butane	mol%	0.21
n-Butane	mol%	0.33
i-Pentane	mol%	0.07
n-Pentane	mol%	0.07
Hexane	mol%	0.06
Nitrogen	mol%	4.02
Carbon dioxide	mol%	0.53
Helium	mol%	0.05
Total	mol%	100
Heating Value (LHV)	kcal/m^3N	9,057.23
Specific Gravity	kg/m^3N	0.829
Maximum content of H_2S	mg/m^3N	7
Temperature	^oC	Max. 50
Pressure	MPa	3.3 ~ 7.6

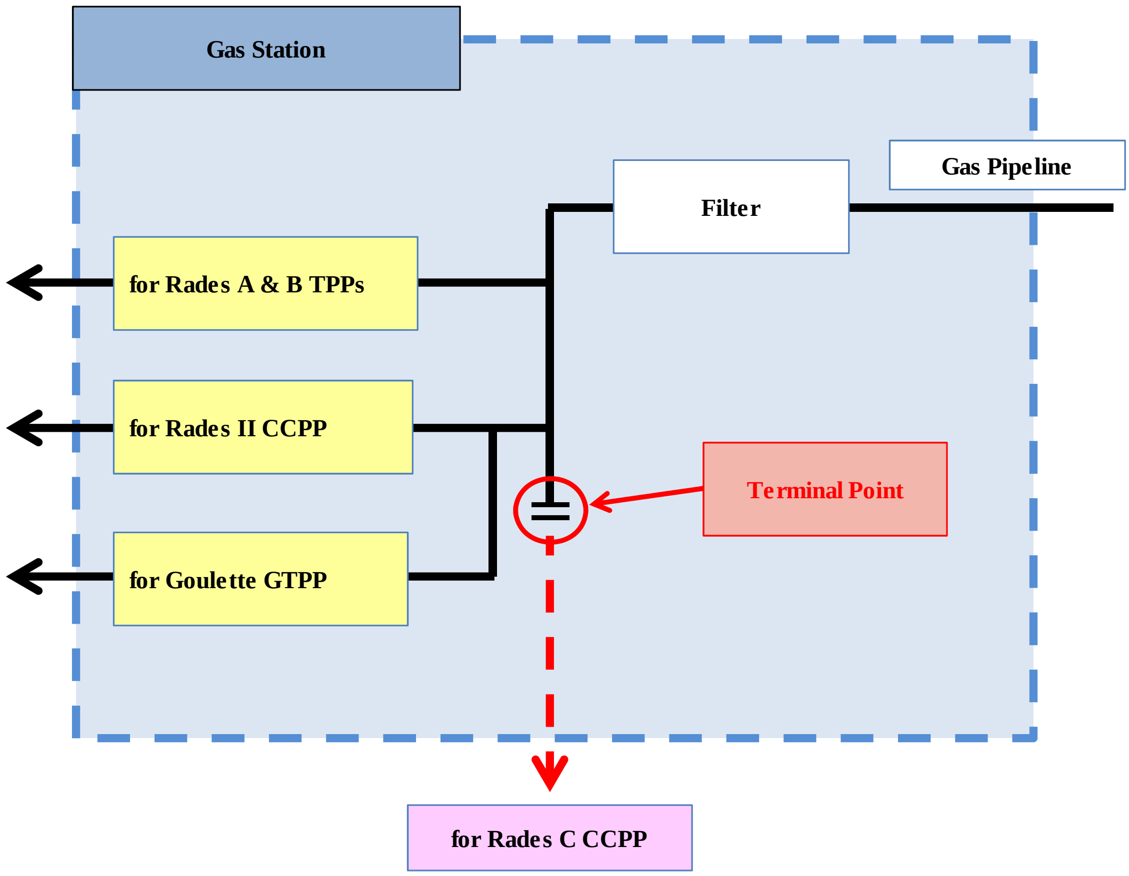
Source: STEG

A gas pipeline with a 16 inch diameter is connected separately with the existing gas station. And the following figure below describes the natural gas terminal point.



Source: STEG

Figure 6.3.5-1 Location of the Existing Gas Station



Source: JICA Study Team

Figure 6.3.5-2 Location of the Terminal Point

Natural gas is separated at the above-mentioned terminal point and will be supplied to Rades C CCPP. After that, the natural gas will be connected to a fuel gas compressor so that the pressure can be adjusted to the level required at the inlet of the gas turbine. This required pressure level is approximately 3 through 5 MPa, although this value differs according to each gas turbine manufacturer. Therefore, the necessity of the gas compressor is dependent on the manufacturer.

(2) Fuel Oil Supply System

The new plant shall be operated on diesel oil in an emergency. The specification is as shown in Table 6.3.5-2. The fuel oil supply system shall cover all the equipment required for the start-up, shut down and continuous operation of the gas turbine, the same as the fuel gas supply system. The diesel oil tank which has a capacity of 10,000kl, filter system, pump and oil pressure-regulating device shall be also included.

Table 6.3.5-2 Specifications of Diesel Oil

Composition	Unit	Value
Heating Value (LHV)	kcal/kg	10,110
Sulfur Content	%	1.0
Specific Gravity	kg/l	0.81-0.89

Source: STEG

The results of the calculations for the amount of diesel oil for an emergency and the capacity of the diesel oil storage tank are shown as follows.

Assumption

Type of Model	M701F
Net Output (ISO)	312,100 kW
Heat Rate	8,683 Btu/kWh
LHV of Diesel Oil	10,110 kcal/kg (18,198 Btu/lb)
Specific Gravity (ave.)	0.85 kg/l

Results of the calculation:

312,100 kW x 8,683 Btu/kWh / 18,198 Btu/lb x 0.453592 kg/lb = 67,547 kg/h

67,547 kg/h x 24 hours / 0.85 kg/l = 1,907 kl/day, Say 2,000 kl/day

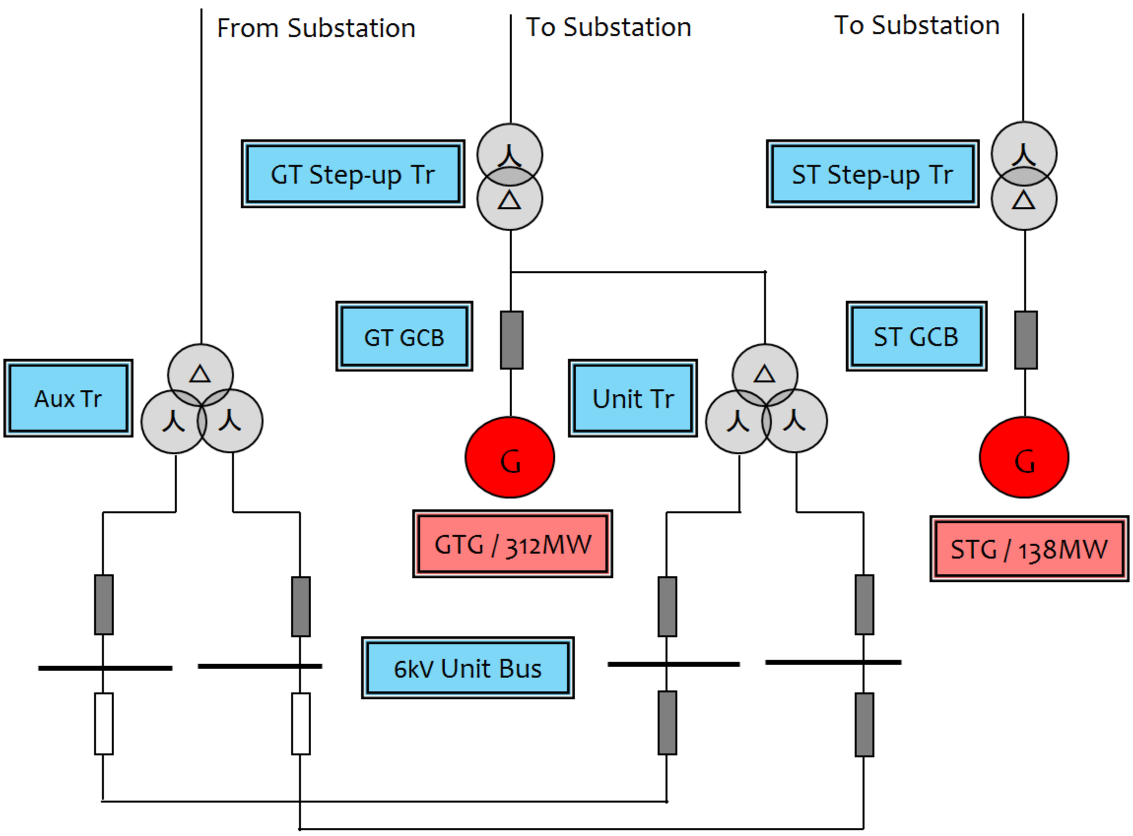
As a result of studying the amount of diesel oil for emergencies that must be stored at Rades C, it is necessary to install a diesel oil tank capable of storing diesel oil for emergency use, from the time it is out of order for five (5) days to restore the service of gas supply facilities (2,000 kl/day x 5 days = 10,000 kl).

6.3.6 Electrical Equipment

(1) Electrical System

1) Evacuation of Generating Power

Figure 6.3.6-1 shows the of generator main circuit.



Source: JICA Study Team

Figure 6.3.6-1 Scheme of Generator Main Circuit

The electrical system will be designed on the basis of a multi shaft configuration having two (2) generators, a gas turbine generator (GTG) and a steam turbine generator (STG), and two (2) transformers, a gas turbine step-up transformer (GT transformer) and a steam turbine step-up transformer (ST transformer). The voltage of the power output from the GTG and STG will be stepped up to 220 kV via GT and ST transformers. The output from these two transformers is merged and transmitted to the 220 kV substation.

During the unit operations, the power source to the unit auxiliary loads under 6.3 kV unit bus will be fed from the GTG via a unit transformer and 220 kV substation via an auxiliary transformer. During the unit shut down and the unit start-up, the power source to the unit auxiliary loads will be fed from the 220 kV substation via a unit transformer and auxiliary transformer. The unit transformer shall be connected to the 6.3 kV unit bus via the circuit breakers. On the other hand, the auxiliary transformer shall be connected to the 6.3 kV unit bus via the circuit breakers. Power will be distributed to the auxiliary loads from the 6.3 kV unit buses.

The auxiliary system and associated equipment shall be designed with flexibility and adequate redundancy to provide a reliable source of power for all auxiliaries that will be required for the new plant.

GTG shall be synchronized by a GTG circuit breaker when GTG is attained at rated speed and voltage. Next, STG shall be synchronized by a STG circuit breaker when STG is attained at rated speed and voltage. Also, GTG and STG can be synchronized at a 220 kV power system breaker as an alternative.

(2) Generators

1) GT and ST Generators

An overview of the specifications of the generators is shown below.

Table 6.3.6-1 Overview of the Specifications of the Generators

Generator	GTG	STG
Type	Three Phase Synchronous	Three Phase Synchronous
Number of Poles	2	2
Number of Phases	3	3
Net Power	312 MW	138 MW
Rated Capacity	368 MVA	163 MVA
Frequency	50 Hz	50 Hz
Rated Speed	3,000 rpm	3,000 rpm
Terminal Voltage	24.0 kV	17.5 kV
Power Factor	0.85 (Lagging)	0.85 (Lagging)
Rotor Cooling Method	Hydrogen or Water Cooled	Hydrogen, Water or Air Cooled
Stator Cooling Method	Hydrogen or Water Cooled	Hydrogen, Water or Air Cooled

Source: JICA Study Team

2) Type of Generators Cooling System

The generators cooling system shall be adopted of hydrogen gas, water or air cooled type. As a result of recent technological advances of cooling performance and windage loss reduction, an air-cooled system will be adopted in generators of the 300 MVA class. It is not possible to select air cooled types for GTG because of the capacity shortage (GTG rated capacity: 368 MVA > Maximum air cooled generator capacity: 300 MVA). A hydrogen supply system for generator cooling is necessary and shall be included in the

Scope of Works by the Contractor.

However, it is possible to select the air cooled type for STG (STG rated capacity: 163 MVA < Maximum air cooled generator capacity: 300 MVA). The air-cooled system has made some advances over the hydrogen gas-cooled system, such as it's a simpler system, with easy operation and maintenance, allowing for cost savings.

(3) Excitation Method

1) Excitation System

Each generator will be provided with a thyristor static excitation system which makes it possible to provide a full ceiling voltage, either positive or negative, almost instantaneously under conditions of system disturbances. The system shall include a transformer, automatic voltage regulator system (AVR) cubicle, thyristor, convertor cubicle and field circuit breaker. A current transformer for control, regulation, protection and metering of the generator would be either provided in the generator stator terminal bushing both on the lines as well as neutral sides, or would be housed in the isolated phase bus (IPB).

2) Automatic Voltage Regulator System

The generator manufacturer shall have AVR. AVR detects generator voltage and controls the reactive power to control the generator voltage.

(4) GT Start-up Method

The GT start-up method shall be selected from the thyristor or motor driven torque converter start-up method.

(5) Transformers

1) GT Transformer

The GT Transformer shall step up from GTG voltage (24.0 kV) to transmission line voltage (220 kV).

The GT Transformer shall have tap changing mechanism, oil insulation three (3) phase transformers. The cooling type shall be the oil natural air forced (ONAF) type. The phase connection shall be the Delta-Star (Δ-Y) type.

2) ST Transformer

The ST Transformer shall step up from STG voltage (17.5 kV) to transmission line voltage (220 kV).

The ST Transformer shall have tap changing mechanism, oil insulation three (3) phase transformers. The cooling type shall be the ONAF type. The phase connection shall be the Δ-Y type.

3) Unit Transformer

The Unit Transformer shall step down from GTG voltage (24.0 kV) to Unit Bus (6.3 kV).

The Unit Transformer shall have tap changing mechanism, oil insulation three (3) phase transformers or four (4) single phase transformer (one (1) for spare). The cooling type shall be the oil natural air natural (ONAN) type. The phase connection shall be Star-Delta-Delta with Stabilizing Winding (Δ-Y-Y) type.

4) Auxiliary Transformer
The auxiliary transformer shall step down from transmission line voltage (220 kV) to Unit Bus (6.3 kV).

The auxiliary transformer shall be oil insulation three (3) phase transformers. The cooling type shall be ONAN. And the phase connection shall be Δ-Y-Y type.

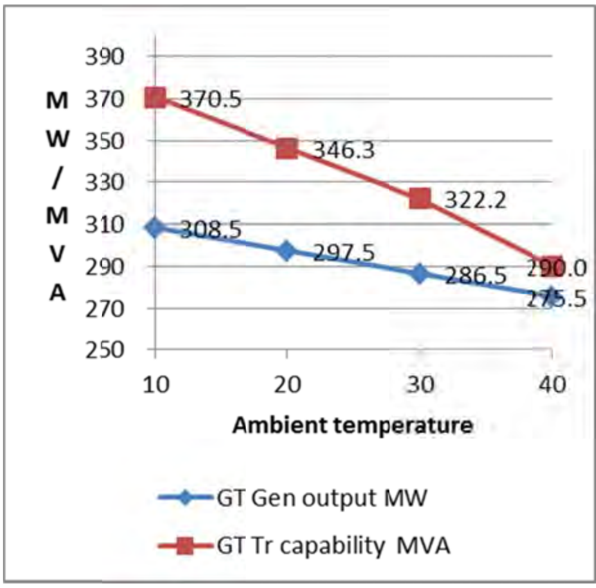
An overview of the specifications of the transformers is shown below.

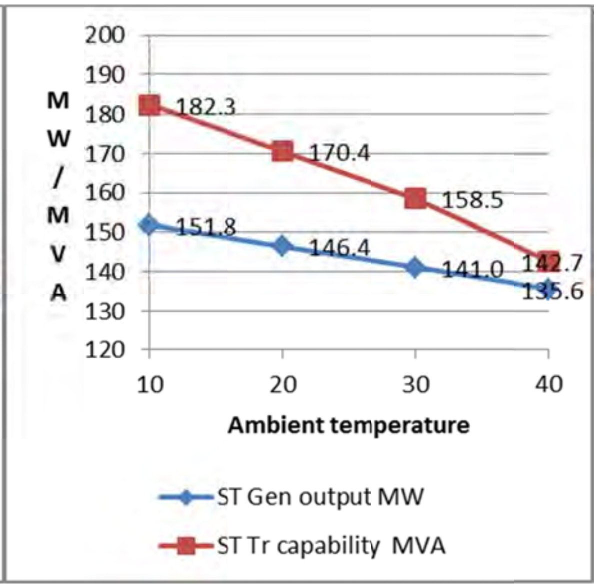
Table 6.3.6- 2 Overview of the Specifications of the Transformers

Transformer		GT Transformer	ST Transformer	Unit Transformer	Auxiliary Transformer
Rated Voltage	1st	24.0 kV	17.5 kV	24.0 kV	220.0 kV
	2nd	220.0 kV	220.0 kV	6.3 kV	6.3 kV
Rated Capacity	1st	350 MVA	175 MVA	25 MVA	40 MVA
	2nd	350 MVA	175 MVA	12.5/12.5 MVA	20/20 MVA
Phase Connection		Δ-Y	Δ-Y	Δ-Y-Y	Δ-Y-Y
Cooling Type		ONAF	ONAF	ONAN	ONAN

Source: JICA Study Team

Figure 6.3.6-2 shows generator output and the necessary transformer capacity.





GT Generator and transformer ST Generator and transformer

Figure 6.3.6-2 Generator output and the necessary transformer capacity

Each generator output depends on the ambient temperature because of the characteristic of CCPP. Also load capability of transformer depends on the ambient temperature since the temperature rises for any load must be added to the ambient to determine operating temperature. Therefore each transfoemer depends on the each generator output. It is necessary to be over 346.3 MVA for GT transformer and 170.4 MVA for ST transformer at 20 °C. As the result, GT transformer capacity is supposed to be 350 MVA and ST transformer capacity is supposed to be 175 MVA.

(6) Generator Circuit Breaker and Disconnecting Switch

The GT/ST circuit breaker and GT/ST disconnecting switch will be set at the primary side of the GT and ST transformers for synchronization.

GTG will be synchronized at 220 kV power system via the GT circuit breaker when GTG is attained at rated speed and voltage. Next, STG will be synchronized at 220 kV power system via the ST circuit breaker when STG is attained at rated speed and voltage. GTG and STG can be synchronized at the 220 kV power system breaker which is formed by a double bus and one (1) circuit breaker with a transfer bus scheme.

(7) Isolated Phase Bus

The isolated phase bus (IPB) duct shall be forced-air cooled and shall deliver the generator output to the GT/ST step-up transformer with GT/ST circuit breaker, potential transformers, generator surge protection equipment, unit transformer, auxiliary transformer and excitation transformer.

(8) Seal Oil Equipment

Seal oil equipment is necessary if the hydrogen cooling method is adopted. The generator seal oil system shall be designed to minimize leakages. The system shall be designed single sided or double sided depending on the manufacturer’s standard. It shall consist of AC motor driven seal oil pumps with a 100% capacity emergency backup DC motor driven seal oil pump.

(9) Unit Electric Supply

The unit electric supply shall be configured from the unit transformer and auxiliary transformer. The equipment used for power plant operation shall be powered from the unit transformer. The equipment used for common equipment (water handling, waste water handling, etc.) shall be powered from the auxiliary transformer system.
Table 6.3.6-4 shows house load apportion.

Table 6.3.6-4 House Load Apportion

Type	Power supply voltage [V]	Power supply board classification	Usage classification
Three (3) phase AC	6,300	6.3 kV Medium Voltage switchgear	Load > 200 kW
	400	400 V Low Voltage switchgear	90kW < Load < 200 kW
		Motor Control Center	3kW < Load < 90 kW
	200	Motor Control Center	Load < 3 kW
	100	Motor Control Center	Valve < 1 kW
One (1) phase AC	100	AC distribution board	
DC	220	DC Motor Control Center DC distribution board	DC load

Source: JICA Study Team

1) 6.3 kV Unit Bus

6.3 kV unit bus shall supply necessary auxiliary power for plant operation.

The design of the 6.3kV power supply system shall be based on the four (4) buses configurations. The unit transformer shall step down from GTG voltage (24.0 kV) to unit bus. The auxiliary transformer shall step down from transmission line voltage (220 kV) to unit bus.

Unit buses shall be connected via a bus-tie circuit breaker and disconnecting switch. Basically, the bus-tie circuit breaker shall be opened. The bus-tie circuit breaker and disconnecting switch shall be closed in case of unit or auxiliary transformer accidents. In that case, the unit bus will evacuate the electric power to unit bus. Also, in the case of an accidental trip at the plant, unit bus will evacuate electric power to unit bus.

The 6.3 kV unit bus shall supply major auxiliary equipment and 400 V unit bus.

2) 400 V Unit Bus
The 400 V unit bus shall supply medium motors and auxiliary power for switching.

3) 220 V DC Supply System
The 220 V DC supply system shall have battery equipment and the DC load shall be supplied by the power from the DC distribution board. The plant can stop safely using DC power from the battery under blackout conditions.

4) Uninterruptible Power System
The uninterruptible power system (UPS) shall be able to supply continuous AC power to the essential AC bus. The UPS shall be supplied with an AC supply source and 220 V DC supply system.

5) Site grounding
IEEE-80 recommendations shall be used to determine grounding system requirements for this plant. The entire ground grid system shall exclusively utilize copper conductors with exothermic connections for in-ground connections.

(10) Generator Main Circuit Protection
The typical protection for GTG, STG, and GT and ST transformers are shown in the following table.

Table 6.3.6-5 Generator Main Circuit Protection

Name	Factor
GTG differential	87 G_{GT}
GT transformer differential	87 T_{GT}
STG differential	87 G_{ST}
ST transformer differential	87 T_{ST}
Current unbalance	46
Loss of excitation	40
Reverse power	67
Stator ground detection	51 GN
Generator overexcitation	24
Generator overvoltage	59
Generator undervoltage	27 G
Generator over/under frequency	81

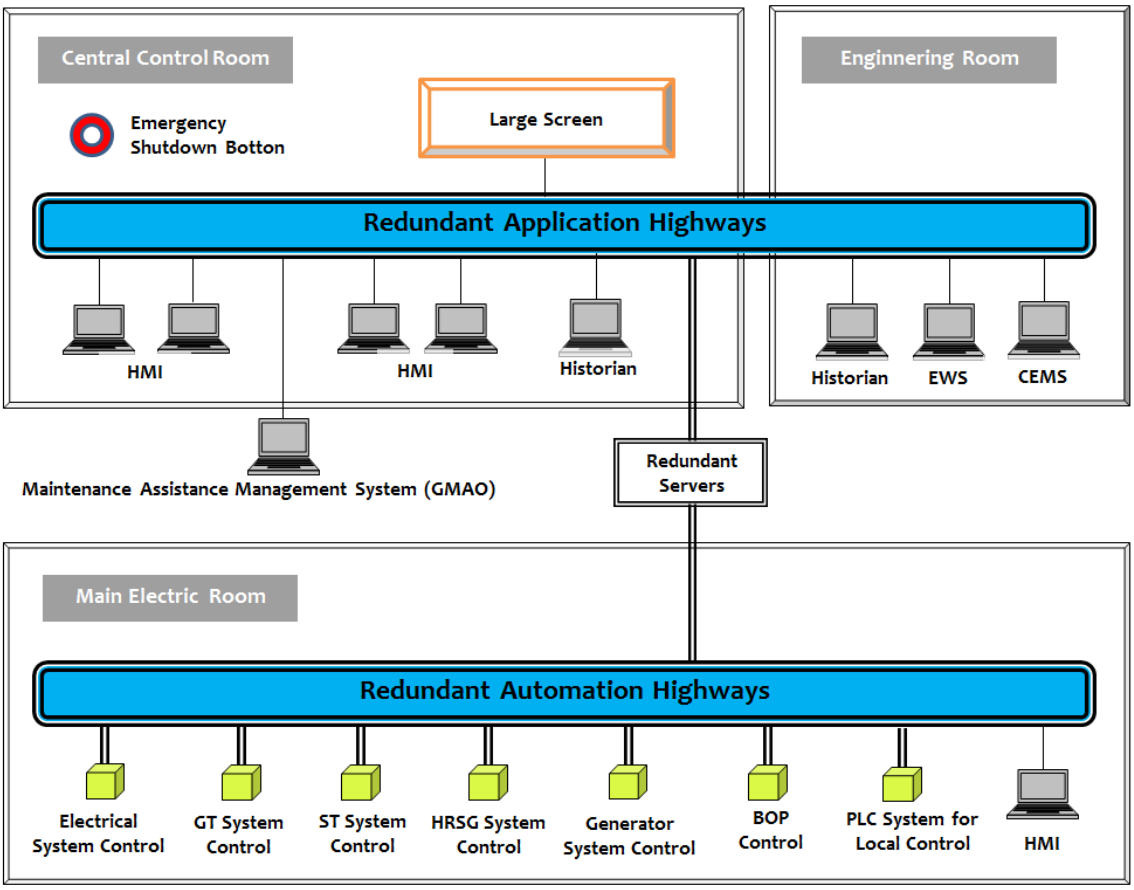
Source: JICA Study Team

Generators and transformers shall be protected by 87 G and 87 T. As a back-up protection for generators, restricted earth fault relay as well as voltage type ground fault relay have also been proposed.

6.3.7 C&I Equipment

(1) Control Philosophy
The control system shall control and monitor the status of equipment and process variables associated with the CCPP to ensure safe and efficient operation with the applicable specifications and performance requirements. All control and monitoring functions necessary for start-up, normal operation and shut down of the CCPP shall be provided in the Central Control Room (CCR). The CCR will normally be manned.

(2) System Configuration of the Control and Monitoring System
Figure 6.3.7-1 shows the configuration for CCPP control.



Source: JICA Study Team

Figure 6.3.7-1 Configuration for CCPP Control

The design of all instrumentation and control systems shall provide maximum security for plant personnel and equipment, while safely and efficiently operating the new plant under all conditions with the highest possible availability.

An Operator Workstation with Human Machine Interface (HMI) and a microprocessor based Distributed Control System (DCS), including redundant controllers using a plant-wide redundant communication highway, shall be provided to allow the operators to control CCPP and to receive monitoring and alarm information.

- The computing and electric power section shall be duplex and the input and output of the DCS will be single.
- Power supply shall be duplex with both AC and DC (butted method).
- Operation during normal times will be through the use of a mouse while confirming the Liquid Crystal Display (LCD) screen.

The operating and monitoring system of the power station are configured by DCS, the information management system, maintenance and repair system, network system and related equipment. The DCS is comprised of the LCD operation system, turbine control system, data assembly system, sequence control system, process I/O system and peripheral equipment. Each independent system is interfaced with DCS.

(3) Control Functions

The design of the control system for the new plant shall utilize state-of-the-art DCS with data logging system in combination with proprietary controls furnished with the gas turbine/ generator, steam turbine/ generator, HRSG and Balance of Plant (BOP), gas compressor system and so on.

The operator console of the plant installed in the CCR shall be used for the primary operator interface and shall contain LCD with keyboards and mouse. The CCR shall be equipped with a shift operator’s room, locker room, WC & shower room, etc., in order to create better environment condition for operators.

The gas turbine control system, steam turbine control system, HRSG and BOP control system shall be tied into the DCS with redundant communications networks and hardwired signals for critical control signals. The remaining control and monitoring signals for the gas compressor control system, heat sources supply control system and so on shall be brought directly or via Remote I/O into the DCS I/O cabinets.

The LCD graphics shall provide the operator with control, monitoring, recording/trending, status, and alarms of equipment and process conditions. The detectors/instruments for protection/control of gas turbines, steam turbines and HRSG shall be a redundancy/triple configuration to enhance the reliability of the new plant.

The control system shall be designed to operate and control the new plant fully automatically, and shall give information of conditions of the new plant and guidance of operation/trouble shootings during start-up, steady state operation and shut down to the operators. The configuration of control logic and graphic display of the control system shall be designed for maintenance engineers to be able to easily and correctly modify and change them on site.

DCS shall have the following functions.

1) Turbine automatic operation control system

- Gas turbine operation, control and protection including gas turbine supervisory instruments
- Steam turbine control and protection including turbine supervisory instruments
- HRSG control and protection
- Generator protection, excitation, voltage regulation and synchronization systems

- Electrical equipment control and protection including supervisory instruments
- Balance of plant control

2) Data collection equipment
- Scan and alert
- Process computation (including performance computation)
- Data log function and data display

3) Common equipment in DCS function
- Gas Booster Compressor System (if necessary)
- Water treatment system
- Waste water treatment system
- Substation System, etc.

(4) Maintenance function

Maintenance tools (Engineering Work Station) for the maintenance of DCS shall be installed and these tools shall have the following functions.
- Control system setting/modification function
- System diagram setting/modification function

These systems have independent monitoring and control. In the event of a defect in the devices, the impact on the power station will be large. For this reason, the calculation system, power supply system, etc., are multiplexed in order to contribute to the reliable operation of system.

The operator can select each mode to correspond to the plant condition. The typical control modes are shown in the following table.

Table 6.3.7-1 Control Mode by DCS

Control Mode	Event
Full-Automatic	In the “Full-Automatic” mode, the start-up or shut down shall be done by a one-push button. The main master sequence is connected to each master sequence and operation status on the unit side, e.g., boiler start preparation to absorber system start-up, and absorber system start-up completed to limestone system start-up. As a result, start-up is automatically executed from boiler preparation to full load under normal operation via CCPP start-up process.
Semi-Automatic	In the “Semi-Automatic” mode, the start-up or shut down shall be done step by step. The operator can proceed to the CCPP startup and shut down process to recognize each breakpoint accomplishment by master sequence.
Manual	In the “Individual” mode, the start-up or shut down shall be manually done.

Source: JICA Study Team

(5) Field Instrumentation

Field instrumentation for CCPP such as pressure/ level/ flow/ temperature – transmitters/ switches/ instruments, flue gas analyzers, vibration detector, etc., will be provided for monitoring the status of equipment and the process variables associated with the CCPP to ensure safe, efficient operation and performance requirements.

All units are established according to the International System of Units (SI).

The main field instrumentations are as follows:

- Pressure/Differential pressure measurements
- Level indicating measurements
- Flow measurements
- Temperature measurements
- Density measurements
- Chemical measurements (pH, conductivity, etc.)
- Vibration measurements
- Position indicators of dampers/valves
- Continuous Emission Monitoring System (CEMS)

All outdoor mounted instruments shall be designed to withstand outdoor ambient temperatures. Adequate freeze protection system installations shall be set up in case of the instrument line freezing.

(6) C&I Equipment Power Supply

C&I equipment power supply will be from the following switchboards:

- 3 x 400/ 200 V, 50 Hz network supply
- 200 V, 50 Hz Safe AC
- 220 V Battery DC

DC supply system for CCPP shall not rely on existing units and shall be independent.

Other I&C equipment power shall be supplied, as follows:

- 24 VDC redundant
- 48 VDC redundant (if necessary)

(7) Telecommunication System

Telecommunication shall be included in the following systems:

- CCTV System by IP cameras, Video server and IP Network
- IP telephone system
- Master Clock System
- Uninterruptible power supply (UPS) system

6.3.8 Civil Engineering and Architectural Facilities

The following table lists up the planned Rades C structures and buildings:

Table 6.3.8-1 List of Planned Rades C Structures and Buildings

No.	Names of buildings and structures
1	Main building consisting of:
2	- gas turbine unit room
3	- steam turbine room
4	- insertion for general control panel (GCP) and electrical devices
5	- electrical building and stack of electrical devices

No.	Names of buildings and structures
6	- area for steam boiler-utilizer - chimney - tank farm of chemical water treatment (CWT)
7	- diesel oil tank
8	- boiler room
9	Open installation of transformers with rerolling ways
10	- oil collector (underground based) for collecting accident-related oil from the transformers
11	- Tank having capacity of accidental discharge of oil turbine
12	ODU(Open Distribution Unit)-220kV
13	Bus-bar assembly
14	HV(High Voltage)-220kV from bus-bar assembly CCGT with installation for gas switch in cell of existing ODU
16	Cable tunnels and channels
17	Electrical container
18	Gas separator pump unit (GSPU) with armature
19	Gas processing facility (GPF)
20	System of purge and dump gas pipelines of CCGT and GSPU
21	Compressor room for compressed air with receivers
Technical supply at the site	
22	Circulation pump station - above-ground part - underground part
23	Circulation water lines
24	Pumping installation for drainage of main building - above-ground part - underground part
25	Circular drainage of main building
26	Pressure water passage of drainage of main building
27	Local fire pump
28	Technical and administrative Bat

Source: JICA Study Team

6.4 Construction Program

The construction plan is made based on the results of the investigation for the present situation of the plant construction site, the surrounding area, and the conceptual design for the facilities for the project.

The construction schedule is planned through the examination of the results of the investigation, and indicated hereafter using a bar chart on a monthly basis, in accordance with the JICA form. Milestones of the key construction items are as shown in the construction schedule. The appropriateness of the construction schedule has been examined considering the schedule of the commissioning.

The commissioning date is set to be in March 2017 for the gas turbine system and April 2018 for the combined cycle, respectively.

6.4.1 Material/Equipment Procurement Program

6.4.1.1 Material/Equipment Procurement

Materials and equipment will be procured from Tunisia, Japan and other countries.

While the main equipment will be procured from abroad, other equipment can be procured in Tunisia.

Civil and architecture works will be executed by national contractors.

Table 6.4.1.1-1 Procurement Program

Categories	Item	Procurement Countries		
		Tunisia	Other Countries	Japan
Equipment	1. Gas Turbine		○	○
	2. Heat Recovery Steam Generator		○	○
	3. Steam Turbine		○	○
	4. Fuel Supply System	○	○	○
	5. Wastewater System	○	○	○
	6. Fire Fighting System	○	○	○
	7. Electrical System	○	○	○
	8. Protection and Control System		○	○
	9. Substation	○	○	○
	10. Transmission Line	○	○	○
	11. Water desalination system	△	○	○
	12. Ancillary	○	○	○
Civil and Architecture Works		○		

Source: JICA Study Team
Remarks: ○ Available, △ Partially available

Table 6.4.1.1-2 Available Materials in Tunisia

Item	Available Materials in Tunisia
Fuel Supply System	Steel plates, valves, etc., for fuel tank construction
Wastewater System	Steel plates, valves, etc., for wastewater treatment tank construction, and some chemicals for operation
Fire Fighting System	Fire extinguishers, hoses, etc.
Electrical System	Cables, transformers, electric panels, cabinets, battery systems, etc.

Source: JICA Study Team

6.4.1.2 Material for Civil and Architecture Works

Main materials like cement, re-bars, H-beams, aggregate, RC-pipes and GRP (Glass-fibered reinforced pipes) for the project are manufactured in Tunisia, and materials like bituminous can be bought in the market in Tunisia.

Table 6.4.1.2-1 Purchase of Main Materials for Civil/Architecture Works

Item	Description	Procurement Plan		
		Tunisia	Other countries	Japan (reference)
Bituminous		○		
Cement		○		
Sand		○		
Aggregate		○		
Re-Bars		○		
H-beams		○		
RC pipes & GRP		○		

Source: JICA Study Team

6.4.1.3 Equipment for Erection of Heavy Equipment and Civil/Architecture Works

Cranes and other machines for the erection of heavy equipment with sufficient hanging and/or jacking up capacity are owned by contractors in Tunisia. They have the experience in the execution of the erection of heavy equipment in similar projects in the past in Tunisia.

Common construction equipment for civil/architecture works are available in Tunisia. Ready mixed concrete and asphalt concrete can be purchased in Tunisia.

Table 6.4.1.3-1 Procurement of Main Equipment

Item	Description	Procurement plan		
		Tunisia	Other countries	Japan (reference)
Piling Driving Machines	RC-pile, L = 20-25 m	○		
Jacking Pipe Machines	Inlet Tunnel, D = 2 m	○		
Bulldozers	15 - 20 ton	○		

Item	Description	Procurement plan		
		Tunisia	Other countries	Japan (reference)
Backhoes	0.8 m^3	○		
Dump Trucks	10 ton	○		
Trucks	10 ton	○		
Cranes	10-100 ton	○		
Cranes for heavy equipment erection	400-600 ton	○		

Source: JICA Study Team

6.4.2 Material/Equipment Transportation Program

For the main heavy equipment, custom clearance procedures and unloading from ships at Rades port were researched, and inland transportation was also investigated. As for the overall equipment transportation plan, transportation experience in past power plant projects with similar size were investigated. It was concluded that the width of the access route from the port to the site is sufficiently wide for the heavy equipment. There are no obstacles for transportation along the route.

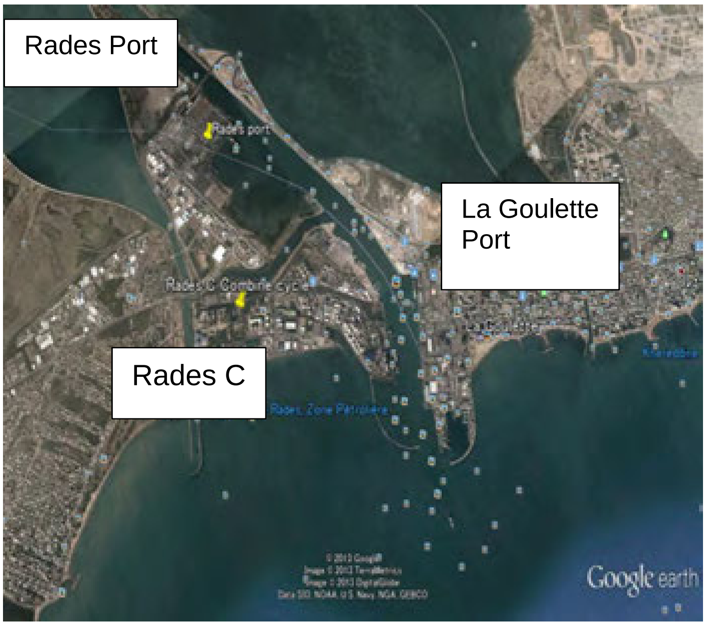
The plant site is located in the industrial zone in Rades city, Ben Arous Governorate. For common materials transportation, the entrance of the Tunis-Sousse-Sfax highway is located near the site. In addition, Rades-La Goluette port is located adjacent to the site. Therefore the site is conveniently located from the aspect of transportation of materials and equipment.

There are transportation companies in Tunisia that have cranes and transporters for heavy equipment of weight up to 150 ton. They have experience in transportation of heavy equipment for similar projects in the past.

For heavy equipment of weight over 150 ton, transporters may be arranged from abroad.

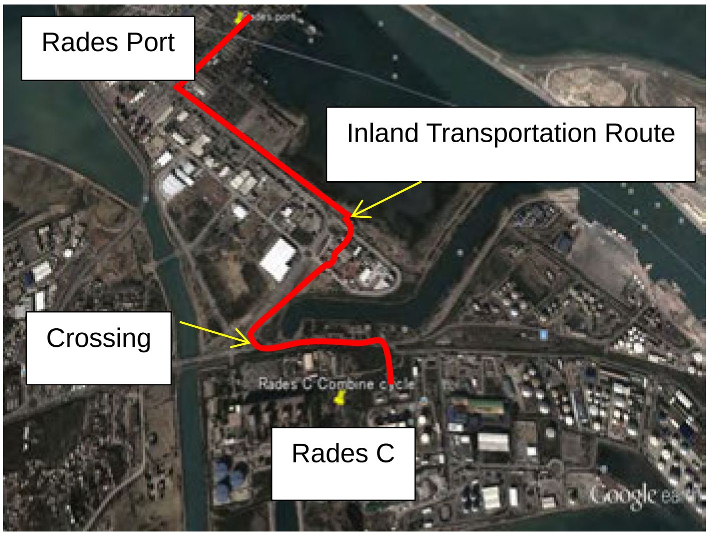
The present conditions of the transportation of heavy equipment are as follows.

Port:
The Tunis port is divided into two ports. One is La Goulette port and the other is Rades port.
Rades port is more convenient for the transportation to Rades C.



Transportation Route:
The inland transportation route is indicated by the red color line. The length of the route is approximately 2 km. The width of the road is 16 m from the port to the crossing, and then 7 m to the prospective carry-in entrance for the heavy equipment of the site.

The distance between light poles and electric poles is 14 m. There are no obstacle utilities for transportation above the road. Also, there is a railway along the road.



A temporary access road connecting the road to the prospective carry-in entrance of the site shall be constructed crossing the railway. As the elevation of the railway is almost the same elevation of the road, the railroad crossing can be constructed at grade. For construction of the carry-in entrance of the site, the existing wall along the railway shall be partially removed.

Road Conditions:

A 16 m wide, four lanes road from the Rades port to the crossing.

A 7 m wide, two lanes road from the crossing to the prospective carry-in entrance of the site. The distance between light poles and electric poles is 14 m.

The elevation of the railway is almost the same as the elevation of the road. There is a wall running alongside the railway.

There is a small drain of 1 m width and 0.7 m depth along the road.

6.4.3 Present Condition of the Site

Several ruined buildings which served as the office of the contractor of Rades A&B remain on the site. In addition, several RC piles and base concrete of RC piles have been left at the site. These shall be demolished and removed to the disposal area at Borj Chakir located at 15 km from the Rades C site. Also, many steel racks of the plant building of Rades A&B have been placed on the ground of the Rades C site. This material shall be transferred to places other than the site of Rades C before the commencement of the Project.

6.4.3.1 Borrow Pits and Disposal Area

Two borrow pits are available near the site of Rades C. One is located at Khlidia, and another is located at Borj Hafaiedh.

There is also an available disposal area at Borj Chakir on the outskirts of Sidi Hsine.

- Borrow Pits

1. Khlidia
2. Borj Hafaiedh

Direct distance:

From Rades C to Khlidia: 17 km

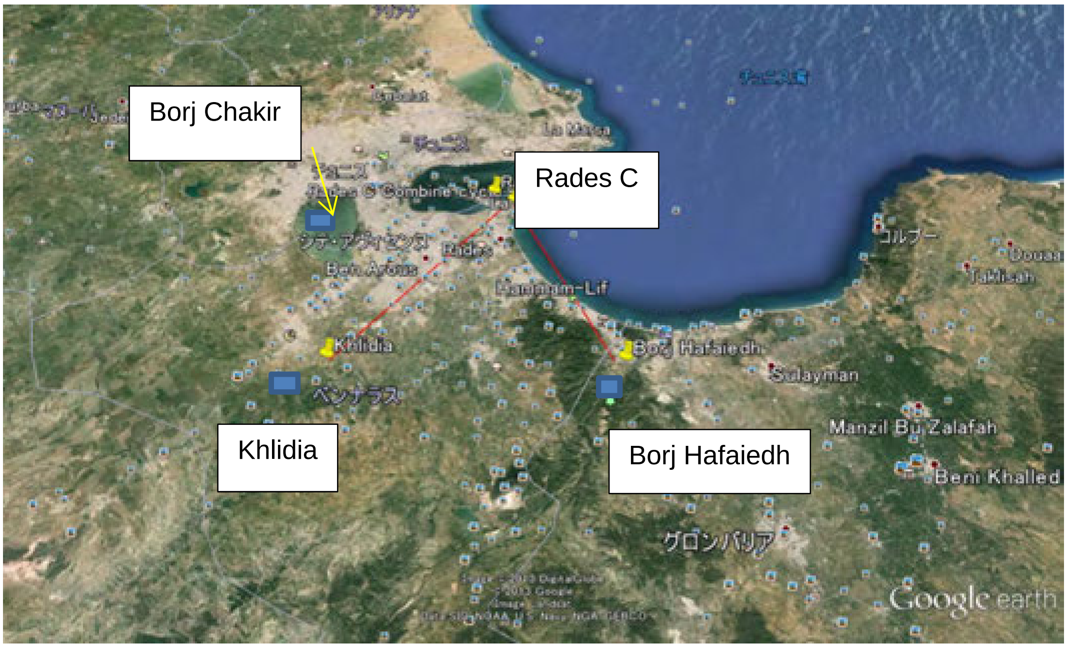
From Rades C to Borj Hafaiedh: 15 km

- Disposal Area

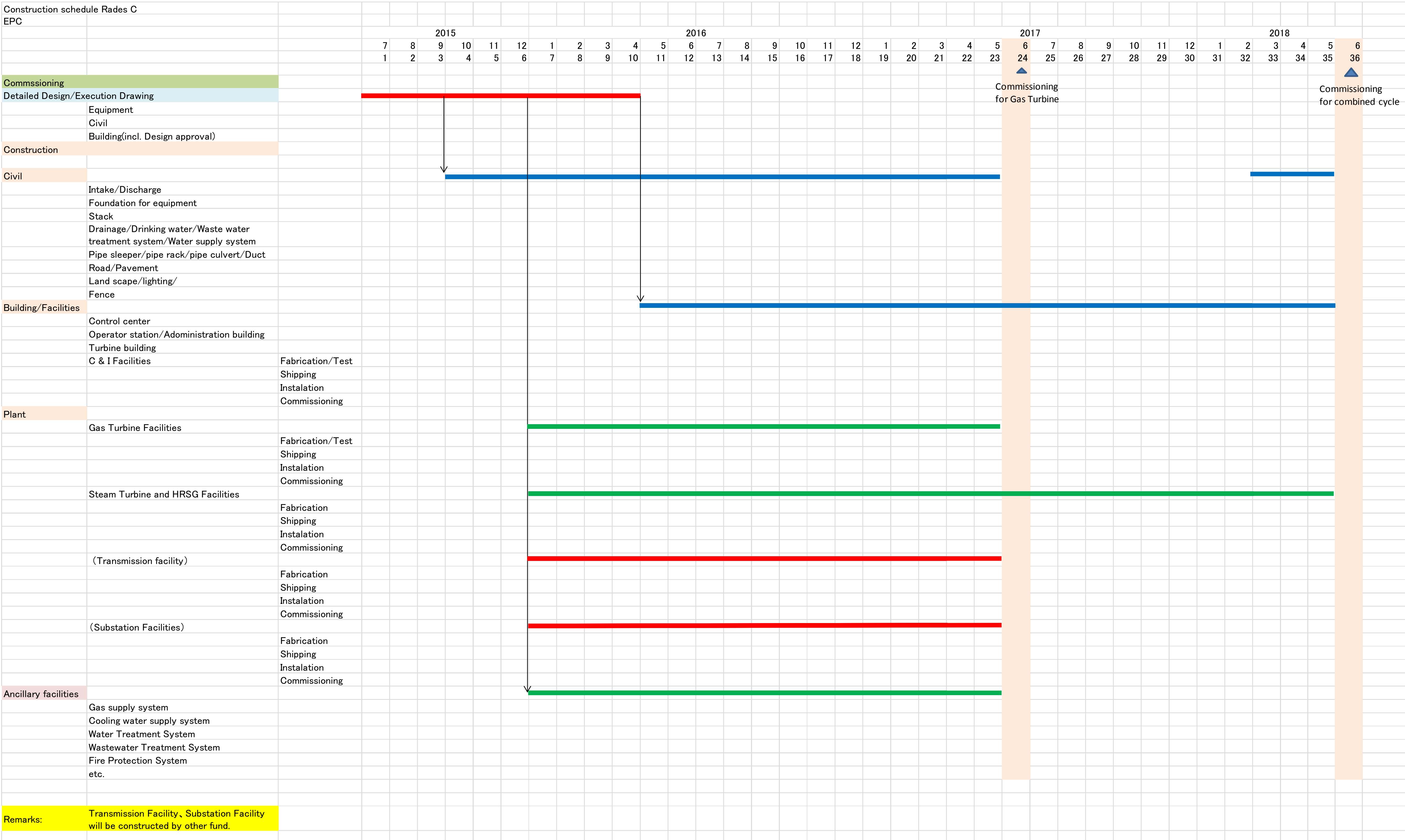
Borj Chakir (outskirts of Sidi Hsine)

Direct distance:

From Rades C to Borj Chakir: 15 km



6.4.4 Construction Schedule



Source: JICA Study Team

Figure 6.4.4-1 Construction Schedule

Chapter 7 System Analysis and Grid Connection Plan

7.1 System analysis

7.1.1 Objective

The objective of this analysis is to verify the expected impact on the power system if Rades C CCPP is installed. The Study Team will carry out three types of analysis shown below.

- Power Flow Analysis
  Verify that the operating voltage will not exceed the criteria value.
  Verify that there is no overloaded equipment.

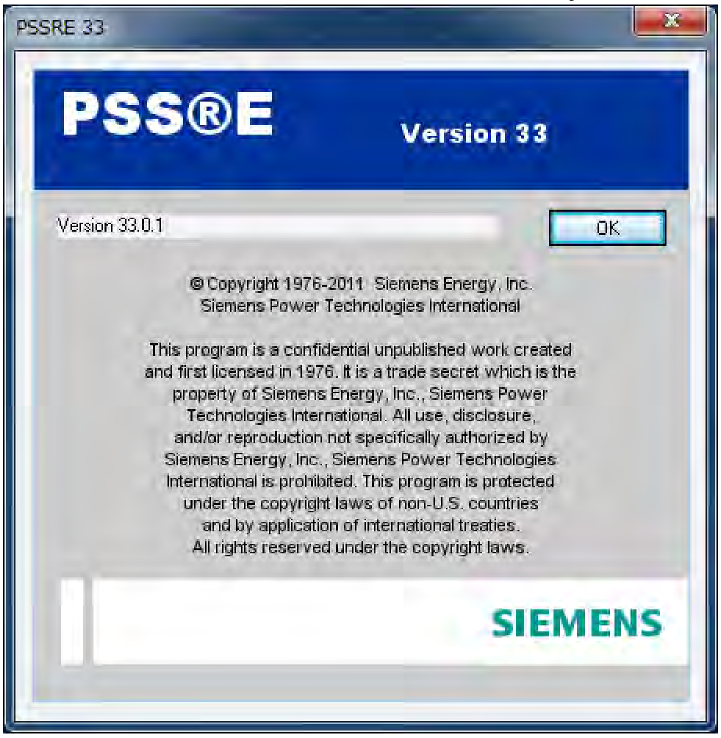
- Fault Current Analysis
  Verify that the fault current will not exceed the criteria value.

- Dynamic Stability Analysis
  Verify the system's stability even if a fault occurs in nearby Rades C CCPP.

7.1.2 Premise

The Study Team carried out the analysis by using the PSS/E data provided by STEG. The PSS/E data contains a High Voltage (HV) system (including 400 kV, 225 kV, 150 kV, and 90 kV systems) of the whole power system in Tunisia. The data used was the expected peak demand of 2017. The output of the Rades C CCPP was set at 450 MW.

Figure 7.1.2-1 shows the PSS/E version that was used in this analysis.



Source: JICA Study Team

Figure 7.1.2-1 PSS/E (version 33)

Table 7.1.2-1 shows the output of generators that were used in the PSS/E data.

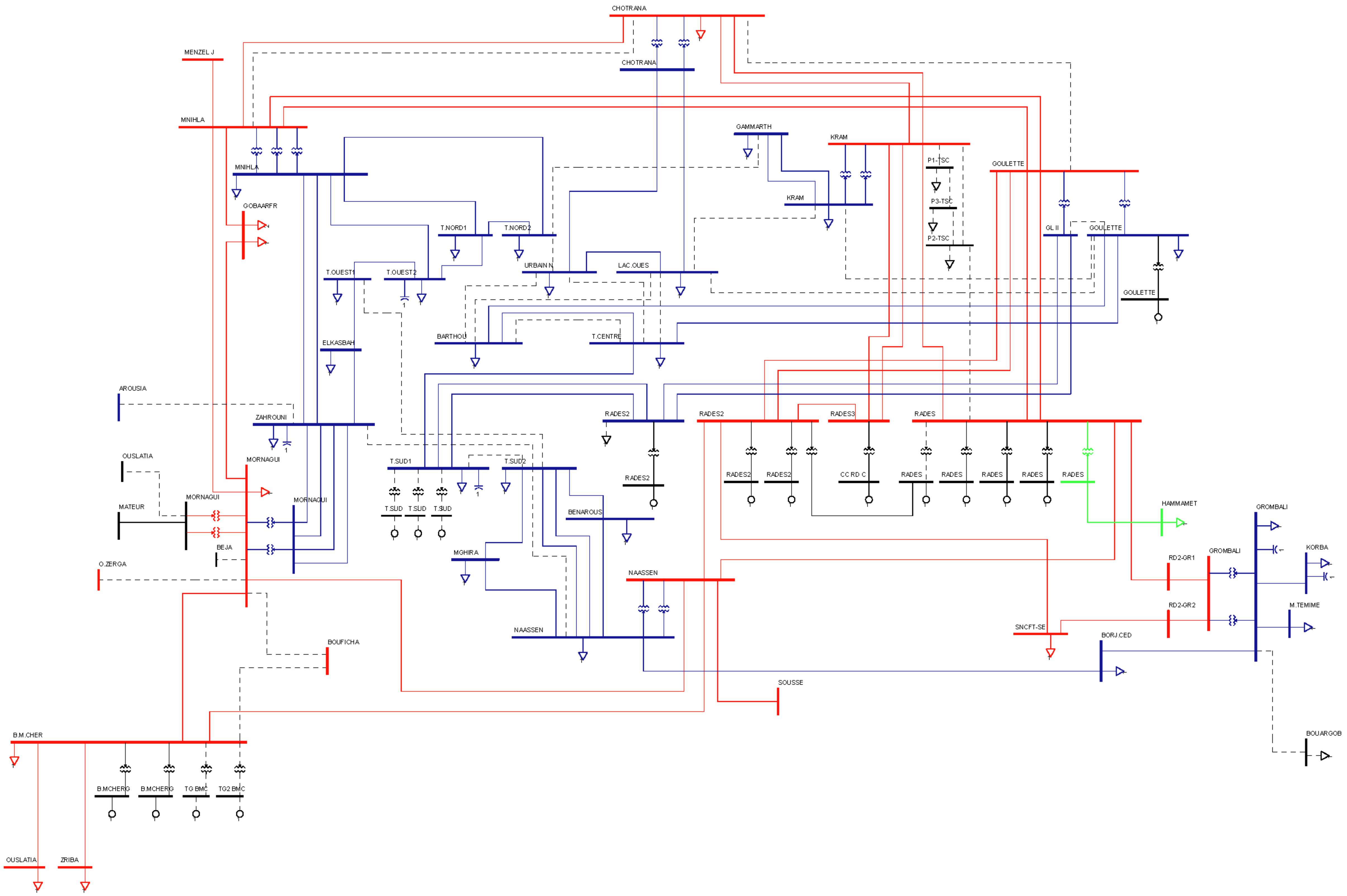
Table 7.1.2-1 Generator Output

Name	Rate Voltage (kV)	Active Power (MW)	Reactive Power (MVAR)	Rate Capacity (MVA)
Bouchemma #1	11.0	100.0	42.3	150.0
Rades A TPP #1	15.5	160.0	29.2	205.0
Rades A TPP #2	15.5	160.0	29.2	205.0
Rades B TPP #1	15.5	170.0	32.4	218.0
Rades B TPP #2	15.5	170.0	32.4	218.0
Sousse A TPP #1	15.5	135.0	46.3	187.5
Sousse A TPP #2	15.5	135.0	46.3	187.5
Sousse B CCPP #1	15.5	100.0	34.7	147.5
Sousse B CCPP #2	15.5	100.0	34.7	147.5
Sousse B CCPP #3	15.5	110.0	40.5	151.4
Bir M'cherga #1	15.5	105.0	57.7	150.0
Bir M'cherga #2	15.5	105.0	57.7	150.0
Goulette	14.0	120.0	22.7	149.2
Feriana #1	14.0	100.0	52.1	137.5
Rades II CCPP #1	15.5	115.5	22.7	150.0
Rades II CCPP #2	15.5	115.5	22.7	150.0
Rades II CCPP #3	15.5	240.0	45.4	300.0
Thyna #1	14.0	100.0	16.1	149.2
Ghannouch CCPP #1	12.5	23.0	10.0	32.0
Ghannouch CCPP #2	12.5	23.0	10.0	32.0
Ghannouch CCPP #3	15.5	383.7	157.1	500.0
Thyna #1	14.0	100.0	16.1	149.2
Sousse C CCPP	15.5	390.0	144.8	500.0
Sousse D CCPP	15.5	390.0	144.8	500.0
Feriana #1	14.0	100.0	52.1	137.5
Rades C CCPP	15.5	450.0	64.9	500.0
Total	-	4200.7	1264.9	-

Source: STEG

➢ Power Flow Analysis

Figure 7.1.2-2 shows the system diagram of Tunis and suburbs that was used in the analysis.



Source: JICA Study Team

Figure 7.1.2-2 A System Diagram of Tunis and Suburbs

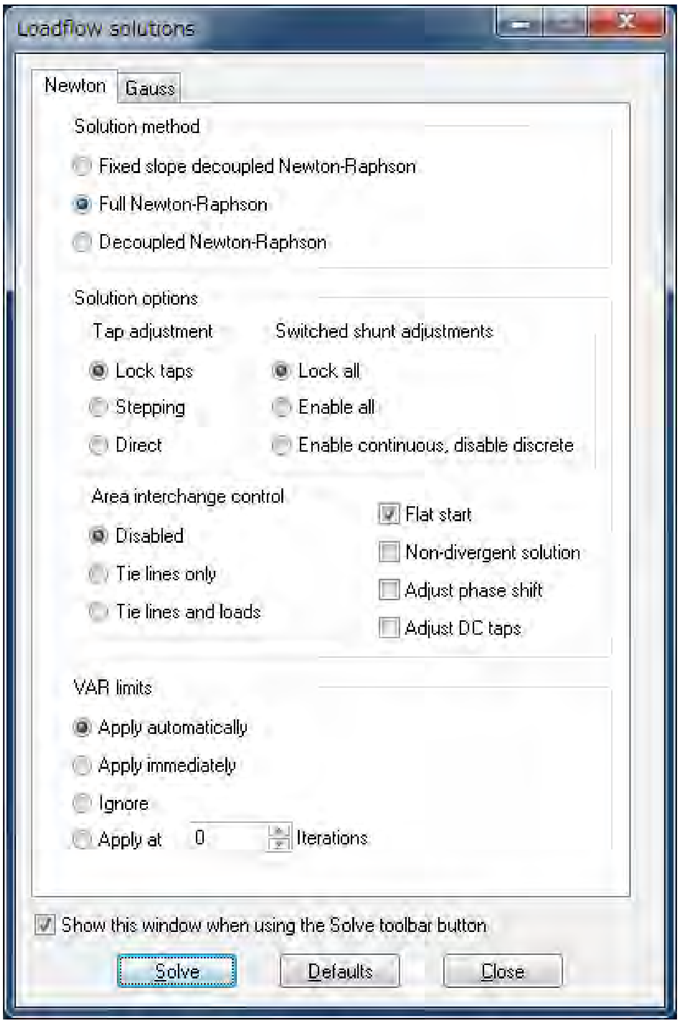
The planning criteria under normal conditions were as follows;

HV node voltage: + or -7% of rated voltage
HV overload: 100% of rated capacity
Production group reactive powers are within admissible range.

The planning criteria under N-1 conditions were as follows:

HV node voltage: + or -10% of rated voltage
HV overload: 120% of rated capacity
Production group reactive powers are within admissible range.

Figure 7.1.2-3 shows the PSS/E option that was used in the power flow analysis.



Source: JICA Study Team

Figure 7.1.2-3 Power Flow Analysis Option

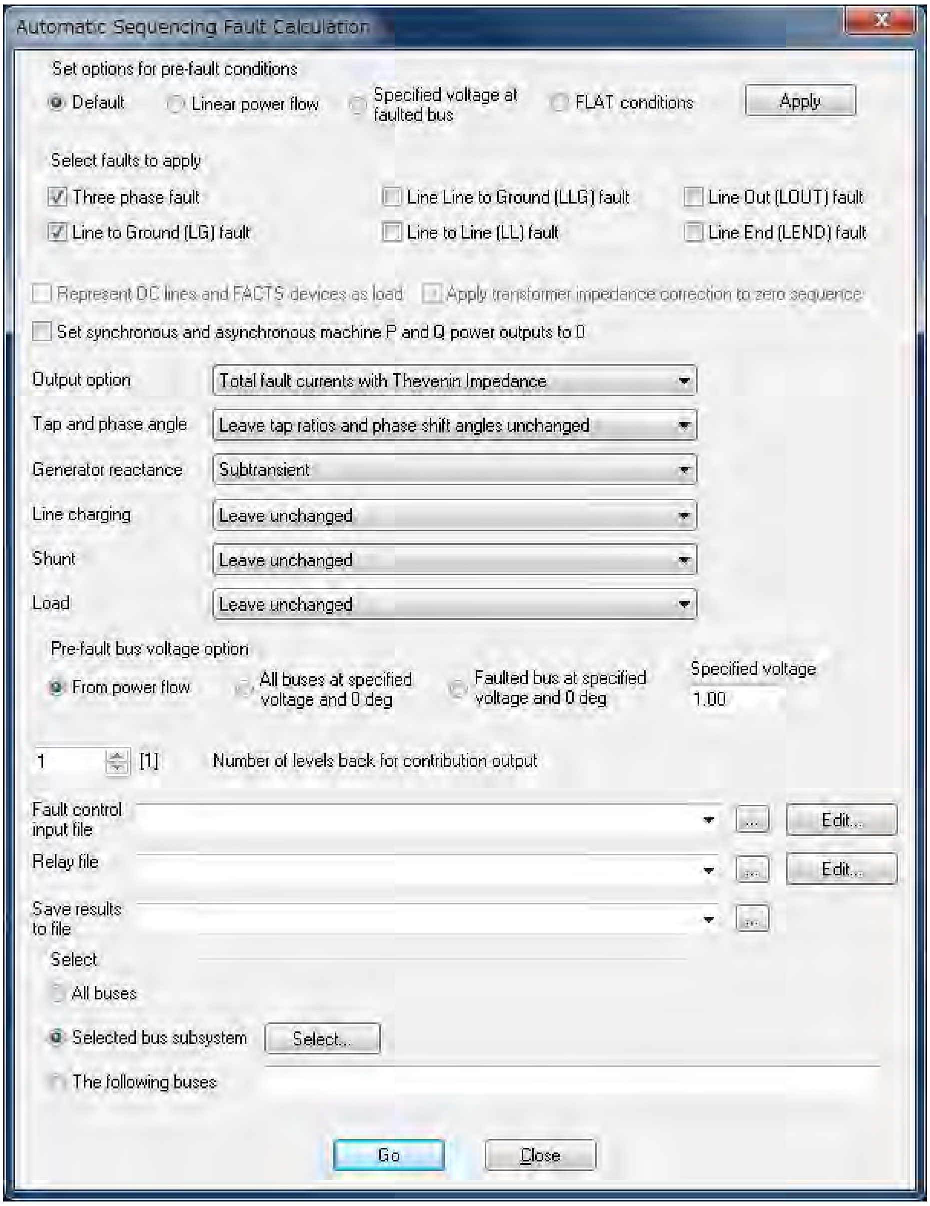
- Fault Current Analysis

The planning criteria for a short circuit current in HV were as follows:

225 kV : 31.5 kA
150 kV : 25.0 kA
90 kV : 25.0 kA

The fault current analysis was carried out in a three-phase fault and line to ground fault conditions.

Figure 7.1.2-4 shows the PSS/E option that was used in the fault current analysis.

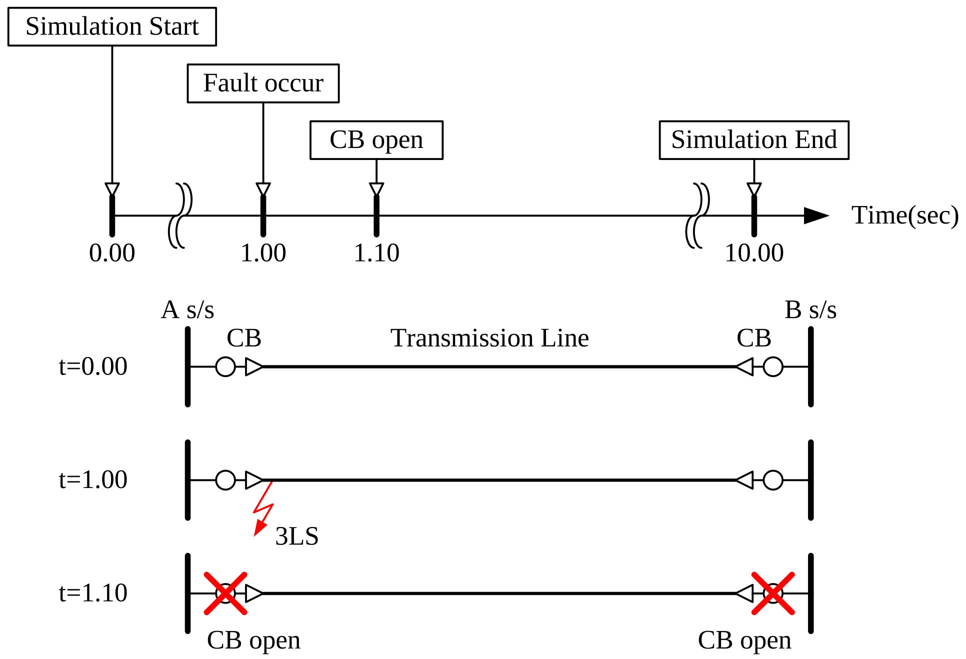


Source: JICA Study Team

Figure 7.1.2-4 Fault Current Analysis Option

- Dynamic Stability Analysis

  The fault condition was set to a three phase fault on a 225 kV transmission line in vicinity to Rades C CCPP without using a reclosing system. Figure 7.1.2-5 shows fault events that were used in the dynamic stability analysis.

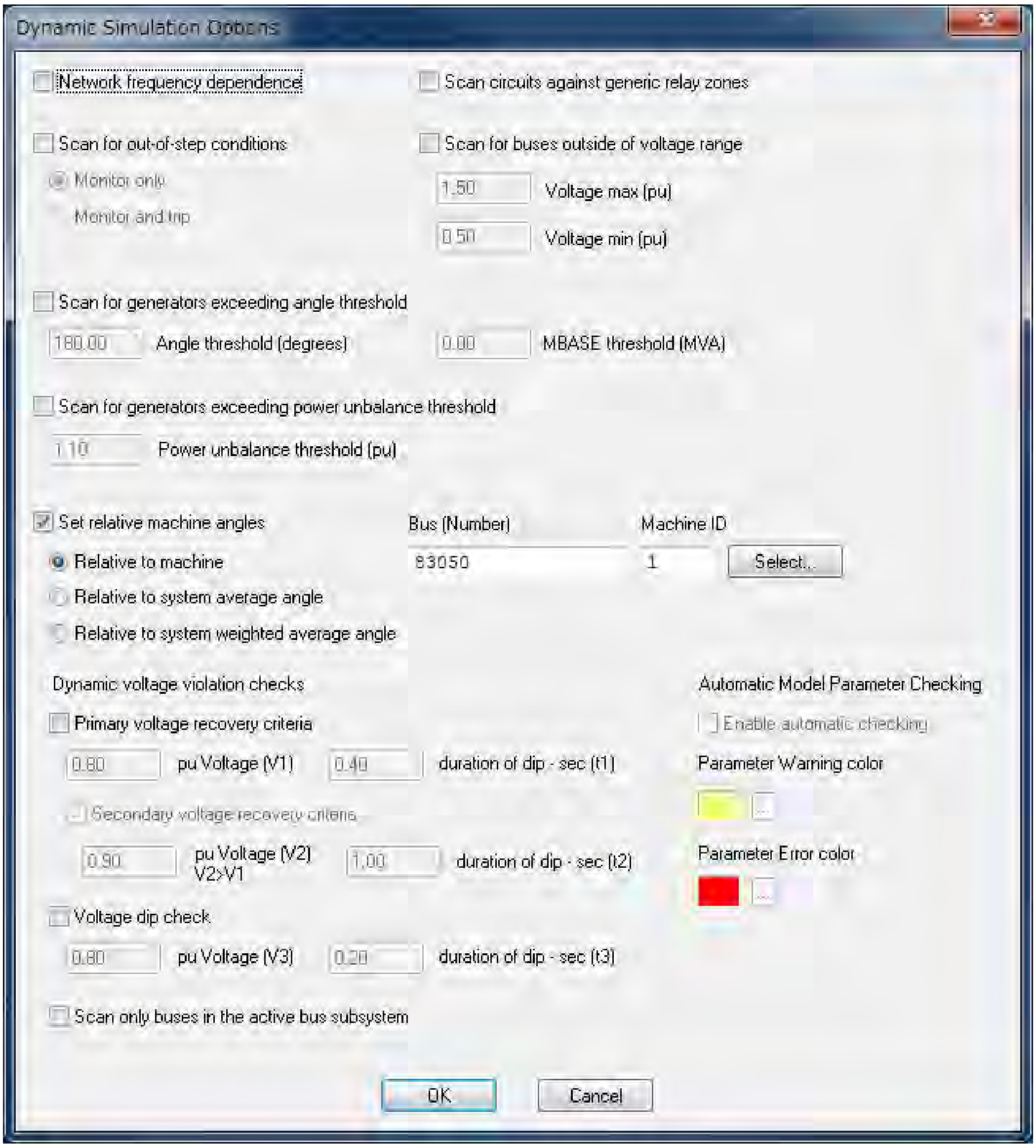


Source: JICA Study Team

Figure 7.1.2-5 Fault Events

The fault condition was set to a three phase fault. And the fault duration time was set to 100 mSec.

Figure 7.1.2-6 shows the PSS/E option that was used in the dynamic stability analysis.

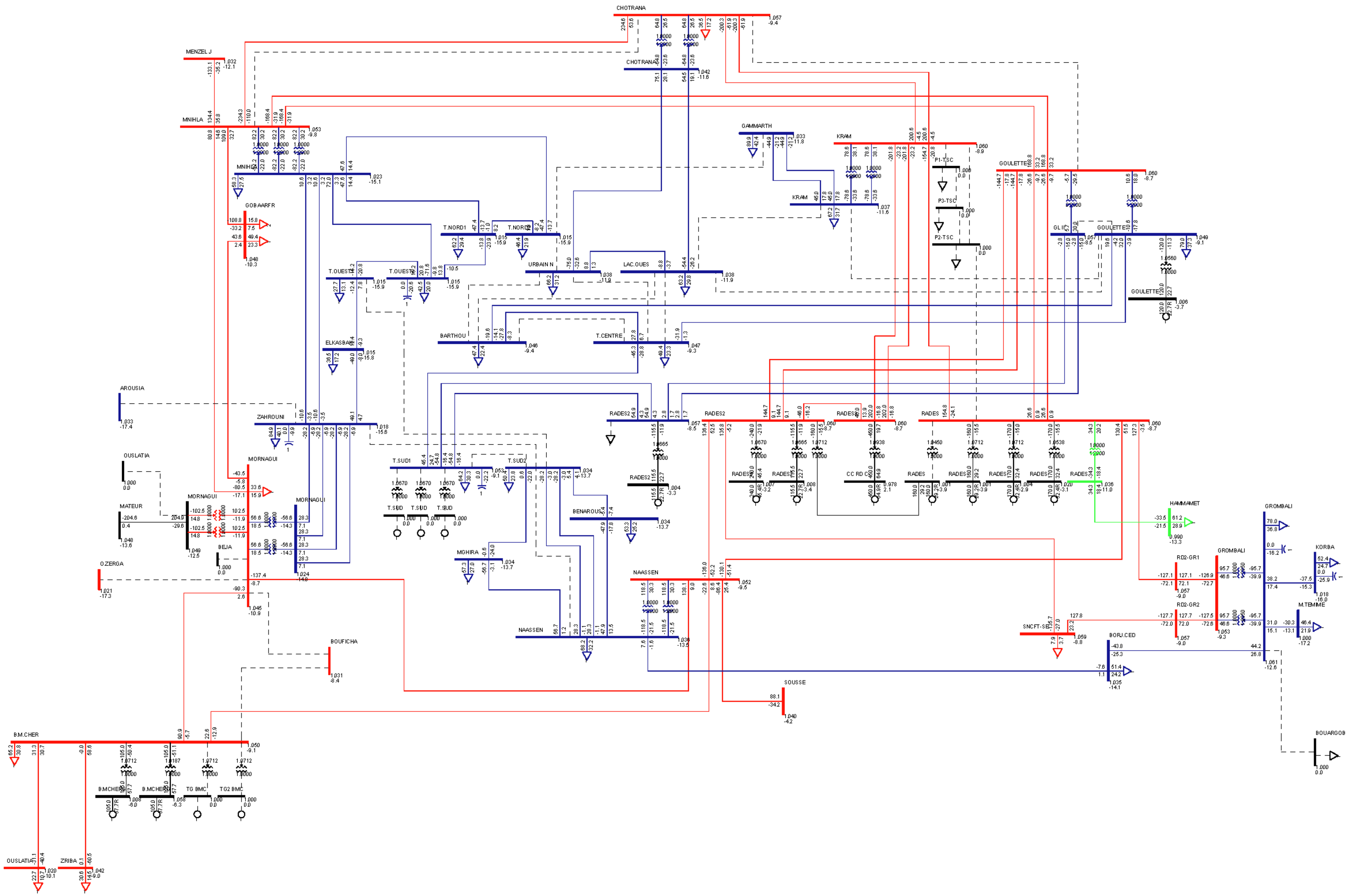


Source: JICA Study Team

Figure 7.1.2-6 Dynamic Stability Analysis Option

7.1.3 Power Flow Analysis

Figure 7.1.3-1 shows the results of a power flow analysis in normal conditions around Tunis and suburbs.



Source: JICA Study Team

Figure 7.1.3-1 Results of a Power Flow Analysis in Normal Conditions

In normal conditions, all buses were operated within the criteria voltage of normal conditions. And there was no overloaded equipment.

Table 7.1.3-1 shows the results of the power flow analysis under N-1 conditions around Tunis and suburbs.

There were several buses exceeding + or -7% from the rated voltage. But there were no problems because these were within the criteria voltage of N-1 conditions. Also, there was several overloaded equipment. However, there were no problems because these values did not exceed 120% of rated capacity.

Table 7.1.3-1 Results of the Power Flow Analysis under N-1 Conditions

N-1 Equipment					Over / Under Voltage				Overload						
From		To		ID	Name	kV	Voltage (pu)	Comment	From		To		ID	Loading (%)	Comment
Name	kV	Name	kV						Name	kV	Name	kV			
RADES	225	GOULETTE	225	1				O.K.							O.K.
RADES	225	KRAM	225	1				O.K.							O.K.
RADES	225	GROMBALIA	225	1				O.K.							O.K.
NAASSEN	225	RADES	225	1				O.K.							O.K.
RADES	225	RADES	150	1				O.K.							O.K.
KRAM	225	RADES III	225	1				O.K.							O.K.
RADES II	225	RADES III	225	1				O.K.							O.K.
GOULETTE	225	RADES II	225	1				O.K.							O.K.
RADES II	225	S.N.C.F.T	225	1				O.K.							O.K.
NAASSEN	225	RADES II	225	1				O.K.							O.K.
MNIHLA	225	GOULETTE	225	1				O.K.							O.K.
GOULETTE	225	GOULETTE	90	1				O.K.							O.K.
GOULETTE	225	GOULETTE II	90	1	GOULETTE	90	1.071	Acceptable							O.K.
					T. CENTRE	90	1.072	Acceptable							
					T. SUD1	90	1.082	Acceptable							
					RADES II	90	1.089	Acceptable							
					BARTHOU	90	1.071	Acceptable							
					GOULETTE II	90	1.089	Acceptable							
RADES II	90	GOULETTE II	90	1				O.K.							O.K.
GOULETTE	90	T. CENTRE	90	1				O.K.							O.K.
GOULETTE	90	BARTHOU	90	1				O.K.							O.K.
CHOTRANA	225	KRAM	225	1				O.K.							O.K.

N-1 Equipment					Over / Under Voltage				Overload						
From		To		ID	Name	kV	Voltage (pu)	Comment	From		To		ID	Loading (%)	Comment
Name	kV	Name	kV						Name	kV	Name	kV			
KRAM	225	KRAM	90	1				O.K.							O.K.
GAMMARTH	90	KRAM	90	1				O.K.							O.K.
MNIHLA	225	CHOTRANA	225	2				O.K.							O.K.
CHOTRANA	225	CHOTRANA	90	1				O.K.							O.K.
LAC. OUEST	90	CHOTRANA	90	1				O.K.	URBAIN N	90	CHOTRANA	90	1	106.1	Acceptable
URBAIN N	90	CHOTRANA	90	1				O.K.	LAC. OUEST	90	CHOTRANA	90	1	106.4	Acceptable
URBAIN N	90	LAC. OUEST	90	1				O.K.							O.K.
T. CENTRE	90	BARTHOU	90	1				O.K.							O.K.
T. SUD1	90	RADES II	90	1				O.K.							O.K.
T. CENTRE	90	T. SUD1	90	1	T. SUD1	90	1.072	Acceptable							O.K.
					RADES II	90	1.073	Acceptable							
					GOULETTE II	90	1.073	Acceptable							
T. SUD2	90	BEN AROUS	90	1				O.K.							O.K.
NAASSEN	90	T. SUD2	90	1				O.K.							O.K.
T. SUD2	90	MGHIRA	90	1				O.K.							O.K.
NAASSEN	90	BEN AROUS	90	1				O.K.							O.K.
NAASSEN	90	MGHIRA	90	1				O.K.							O.K.
NAASSEN	225	SOUSSE	225	1				O.K.							O.K.
BIR MCHERGA	225	NAASSEN	225	1				O.K.							O.K.
NAASSEN	225	MORNAGUIA	225	1				O.K.							O.K.
NAASSEN	225	NAASSEN	90	1				O.K.	NAASSEN	225	NAASSEN	90	1	112.3	Acceptable
NAASSEN	90	BORJ CEDRIA	90	1				O.K.							O.K.
BIR MCHERGA	225	MORNAGUIA	225	1				O.K.							O.K.

N-1 Equipment					Over / Under Voltage				Overload						
From		To		ID	Name	kV	Voltage (pu)	Comment	From		To		ID	Loading (%)	Comment
Name	kV	Name	kV						Name	kV	Name	kV			
MNIHLA	225	MORNAGUIA	225	1				O.K.							O.K.
MORNAGUIA	225	GOBAARFR	225	1				O.K.							O.K.
MORNAGUIA	400	MORNAGUIA	225	1				O.K.							O.K.
MORNAGUIA	225	MORNAGUIA	90	1				O.K.	MNIHLA	225	MNIHLA	90	1	100.8	Acceptable
									MNIHLA	225	MNIHLA	90	2	100.8	Acceptable
									MNIHLA	225	MNIHLA	90	3	100.8	Acceptable
ZAHROUNI	90	MORNAGUIA	90	1				O.K.							O.K.
MNIHLA	90	ZAHROUNI	90	1				O.K.							O.K.
ZAHROUNI	90	KASBAH	90	1				O.K.							O.K.
T. OUEST1	90	KASBAH	90	1				O.K.							O.K.
T. OUEST1	90	T. OUEST2	90	1				O.K.							O.K.
MNIHLA	90	T. OUEST2	90	1				O.K.							O.K.
T. NORD1	90	T. OUEST2	90	1				O.K.							O.K.
MNIHLA	90	T. NORD1	90	1				O.K.							O.K.
T. NORD1	90	T. NORD2	90	1				O.K.							O.K.
MNIHLA	90	T. NORD2	90	2				O.K.							O.K.
MNIHLA	225	MNIHLA	90	1				O.K.	MNIHLA	225	MNIHLA	90	2	116.9	Acceptable
									MNIHLA	225	MNIHLA	90	3	116.9	Acceptable
MNIHLA	225	GOBAARFR	225	1				O.K.							O.K.

Source: JICA Study Team

7.1.4 Fault Current Analysis

Table 7.1.4-1 shows the results of a fault current analysis around Tunis and suburbs. The fault current did not exceed the criteria current at all buses.

Table 7.1.4-1 Results of the Fault Current Analysis

Bus name	kV	Fault current (kA)	
		3LS	1LG
MORNAGUIA	400	4.95	5.30
JENDOUBA	400	2.96	2.79
MATEUR	400	4.12	4.24
BIR MCHERGA	225	13.86	16.00
MNIHLA	225	17.14	20.55
NAASSEN	225	17.15	19.15
RADES	225	19.94	26.71
SOUSSE	225	19.92	24.40
MENZEL JEMIL	225	5.96	5.41
GROMBALIA	225	15.63	17.04
GOULETTE	225	20.01	26.94
MORNAGUIA	225	14.22	15.32
RADES II	225	20.02	27.02
S.N.C.F.T	225	17.66	20.89
CHOTRANA	225	17.50	21.31
GOBAARFR	225	12.38	12.28
KRAM	225	19.05	24.64
RADES III	225	19.90	26.68
RADES II	150	4.13	3.98
GAMMARTH	90	13.18	15.35
GOULETTE	90	16.35	20.19
GROMBALI	90	15.70	17.35
MNIHLA	90	15.91	19.30
NAASSEN	90	15.56	18.97
T. CENTRE	90	15.74	18.68
T. NORD1	90	14.25	17.85
T. OUEST1	90	14.37	18.13
T. SUD1	90	15.70	17.95
ZAHROUNI	90	14.22	16.69
KRAM	90	14.69	17.68
URBAIN N	90	12.68	14.39
T. SUD2	90	14.62	17.55
MORNAGUI	90	13.82	14.79
RADES II	90	16.36	19.05
ELKASBAH	90	14.09	17.16
MGHIRA	90	14.52	17.31
LAC. OUES	90	12.44	14.01
T. NORD2	90	14.25	17.85
T. OUEST2	90	14.37	18.13
CHOTRANA	90	14.25	16.57
BARTHOU	90	14.81	17.03
BENAROUS	90	14.18	16.62
GL II	90	16.36	19.01

Source: JICA Study Team

7.1.5 Dynamic Stability Analysis

Table 7.1.5-1 shows the results of a dynamic stability analysis around Tunis and suburbs. If a fault occurred in the nearby Rades C CCPP 225 kV transmission line, the power system could still be operated in a stable way.

Table 7.1.5-1 Results of the Dynamic Stability Analysis

Fault point	Transmission Line				Result
	From node	kV	To node	kV	
CHOTRANA	MNIHLA	225	CHOTRANA	225	Stable
KRAM	CHOTRANA	225	KRAM	225	Stable
GOULETTE	MNIHLA	225	GOULETTE	225	Stable
RADES	RADES	225	GROMBALI	225	Stable
RADES	NAASSEN	225	RADES	225	Stable
RADES	RADES	225	GOULETTE	225	Stable
RADES	RADES	225	KRAM	225	Stable
RADES II	NAASSEN	225	RADES II	225	Stable
RADES II	RADES II	225	S.N.C.F.T-SE	225	Stable
RADES II	GOULETTE	225	RADES II	225	Stable
RADES III	KRAM	225	RADES III	225	Stable
RADES III	RADES II	225	RADES III	225	Stable

Source: JICA Study Team

7.1.6 Conclusion

In the case that the Rades C CCPP was installed, power flows would be sent through Kram, Goulette, Naassen and S.N.C.F.T-SE substations. The power flows would not be concentrated in one transmission line. Therefore, under normal conditions, there would be no bus voltages that operated out of criteria value (+ or –7%). And there would be no overloaded equipment.

Under N-1 conditions, the voltages of all nodes would all be within the N-1 criteria value (+ or –10%). And there would be no equipment that exceeds 120% of rated capacity.

If many generators were connected to the lines in the Rades region, the faults current would tend to increase. However, according to the fault current analysis, fault current was found to not exceed the specified value.

And according to the results of the dynamic stability analysis, if a single facility accident occurred and the main protection could work, the power system could be operated in a stable way.

Therefore, from the results of the power flow, fault current and dynamic stability analyses, there were no problems if Rades C CCPP was to be installed.

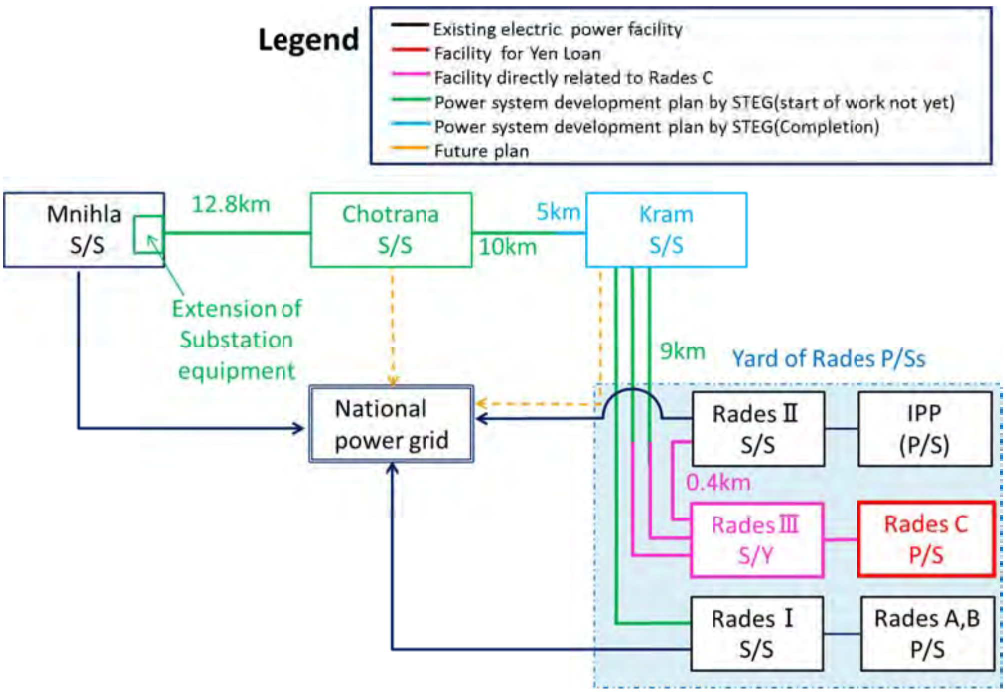
7.2 Grid Connection Plan

7.2.1 Transmission Lines and Substations to Connect to the National Power Grid

In recent years, STEG has been reinforcing 225 kV transmissions lines (T/L) and substations (S/S) based on the 11th and 12th power grid reinforcement plans around Rades A&B TPPs to transmit the generated power of Rades P/Ss, including the new Rades C, which is an important power source for Tunis city. In order to transmit power generated by Rades C to the national power grid in Tunisia, Rades III Switch yard (S/Y) and Cables between Rades III S/Y and Rades II S/S are essential facilities of the power system reinforcement plan.

The JICA Study Team reviewed the essential facilities to connect Rades C to the national grid and the facilities of the power grid reinforcement plan which are important for Rades A&B TPPs to supply power. Also, the results of this JICA study have shown that the total facilities of the reinforcement plan, including essential facilities for transmitting the power generated by Rades C, are financed by the Europe Investment Bank (EIB), which are not included in the Japanese yen loan.

The schematic diagram related to the facilities around Rades C and the location map of the facilities around Rades C are shown in Figure 7.2.1-1 and Figure 7.2.1-2, respectively.
The black lines show existing facilities, the red lines show the target of the Japanese yen loan (Rades C), the pink lines show the essential facilities for transmitting the power generated by Rades C, the green lines show the facilities for which work has not been started yet, the blue lines show facilities which have been completed, and the orange lines show the future plan of the power system reinforcement plan. A summary of the facilities are described below.



Source: JICA Study Team

Figure 7.2.1-1 Schematic Diagram related to the Facilities around Rades C

Source: JICA Study Team

Figure 7.2.1-2 Location Map of the Facilities around Rades C

(1) Summary of the essential T/Ls and S/Ss for connecting to the national power grid
A summary of the essential T/Ls and S/Ss for transmitting the power generated by Rades C, which are the pink colored lines, are Rades III S/Y and three cables between Rades III S/Y and Rades II S/S in Table 7.2.1-1, and the detailed contents are described in 7.2.2.

Table 7.2.1-1 Essential T/Ls and S/Ss for Transmitting the Power Generated by Rades C

Facilities	Main electric device	Explanation	Financing institution
Rades III S/Y	◆ Circuit breaker (CB) ◆ Disconnecting switch (DS) ◆ Potential transformer (PT) ◆ Current transformer (CT), etc.	✓ New GIS S/Y ✓ Start of construction: ➢ Not yet ✓ Completion date: ✧ Sep. 2016	Discussion with European Investment Bank (EIB)
Underground cable between Rades III S/Y and Rades II S/S	◆ Number of Circuits: 1 circuit ◆ Length: 0.4 km ◆ Transmission capacity: 420 MW ◆ Conductor: To be determined ◆ Installation type: Buried conduit	✓ A new cable (one) between Rades III S/Y and Rades II S/S ✓ Work not started yet ✓ Completion date: ✧ April 2015	Discussion with EIB
	◆ Number of Circuits: 2 circuits ◆ Length: 0.4 km ◆ Transmission capacity: 400 MW ◆ Conductor: To be determined ◆ Installation type: Buried conduit	✓ Two new cables between Rades III S/Y and Rades II S/S, connecting to the two cables from Kram S/S ✓ Work not started yet ✓ Completion date: ➢ April 2015	Discussion with EIB

Source: JICA Study Team

(2) Summary of T/Ls and S/Ss around Rades C Reinforced Based on the Power System Development Plan

Based on the 11th and 12th power system development plans, STEG has been reinforcing its power grid. These projects shown in Table 7.2.1-2 have a close relation with the new Rades C construction project, and detailed contents are described in 7.2.3.

Table 7.2.1-2 T/Ls and S/Ss around Rades C Related to the Power System Development Plan

Name of S/S or cable section and insulation type	Electrical equipment	Financing institution
✧ Name: Kram ✧ Type: New GIS S/S	◆ Transformer: 225/90/11 kV, 200 MVA x 2 units ◆ CB, DS, PT, CT, etc. ◆ Construction already completed	Discussion with EIB
✧ Name: Chotrana ✧ Type: New GIS S/S (work not started yet)	◆ Transformer: 225/90/11 kV, 200 MVA x 2 units 225/33 kV, 40 MVA x 3 units ◆ CB, DS, PT, CT, etc. ◆ Work not started yet ◆ Completion date: Dec. 2014	Discussion with EIB
✧ Name: Mnihla ✧ Type: Existing AIS S/S (work not started yet)	◆ Extension of electrical equipment (CB, DS, PT, CT, etc.) ◆ Existing transformer: 225/90/11 kV, 100 VA x 3 units ◆ Completion date: Aug. 2015	Discussion with EIB
✧ Section between Rades I S/S and Kram S/S (work not started yet)	◆ Number of circuits: 1 ◆ Length: Approx. 9.4 km ◆ Transmission capacity 420 MW ◆ Conductor: To be determined ◆ Installation type: Buried conduit ◆ Completion date: Apr. 2015	Discussion with EIB
✧ Section Kram S/S -Rades II S/S (work not started yet) ✧ Once these cables are connected to Rades II S/S, finally both two cables are scheduled to be connected to Rades III S/Y	◆ Number of circuits: 2 circuits ◆ Length: Approx. 9.0 km ◆ Transmission capacity：400 MW x 2 ◆ Conductor: To be determined ◆ Installation type: Buried conduit ◆ Completion date: Apr. 2015	Discussion with EIB
✧ Section between Kram S/S - Chotrana S/S ✧ The work of the 5 km section from Kram S/S has been completed	◆ Number of circuits: 2 circuits ◆ Total length: 15 km The 5 km section from Kram S/S is completed, but the remaining 10 km section has not been completed yet. ◆ Transmission capacity: 400 MW x 2 ◆ Conductor: Aluminium (2000 mm^2) ◆ Installation type: Buried conduit ◆ Completion date: Apr. 2015	Discussion with EIB
✧ Chotrana S/S -Mnihla S/S (work not started yet)	◆ Number of circuits: 1 circuit ◆ Length: Approx. 12.8 km ◆ Transmission capacity: 420 MW ◆ Conductor: To be determined ◆ Installation type: Buried conduit ◆ Completion date: Mar. 2016	Discussion with EIB

Source: JICA Study Team

7.2.2 Essential Transmission Lines and Substation for Connecting to the National Power Grid

(1) Rades III S/Y

Rades III S/Y, which is a new GIS type, will be constructed in close proximity to Rades C by September 2016 as shown in Figure 7.2.2-1. The main function of Rades III S/Y is to receive the power generated by Rades C and to distribute it to Rades II S/S and Kram S/S. As mentioned before, the financing institute for this construction is EBI. Therefore, the S/Y is outside of the Japanese yen loan.

Source: JICA Study Team

Figure 7.2.2-1 Location of Rades III S/Y

There are no original Tunisian technical standards for electrical equipment. The specifications are determined by the International Electrotechnical Commission (IEC), and those of the main equipment of the S/Y are shown in Table 7.2.2-1. The JICA Study Team checked the specifications and found no problems with the specifications since appropriate specifications had been selected.

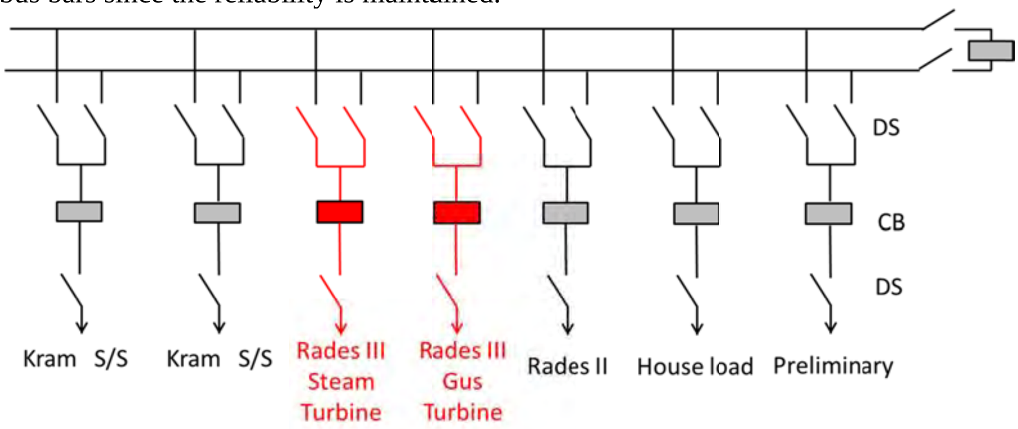
In addition, the short circuit current was determined as 31.5 kA under STEG's standards, and there are no problems with this specification since a sufficiently large value for CB's short circuit current has been selected.

Table 7.2.2-1 Specification of Electrical Equipment in Rades III S/Y

Equipment	Item	Value
Circuit breaker (CB)	Nominal voltage [kV]	245
	Rated current [A]	3,150
	Short circuit breaking current [kA]	40
Disconnecting switch (DS)	Nominal voltage [kV]	245
	Rated current [kA]	2,500
Cable head	BIL [kV]	1,050
Arrester	Rated voltage [kV]	245
	BIL [kV]	1,050

Source: JICA Study Team

A single diagram of Rades III S/Y is shown in Figure 7.2.2-2. The composition of the bus bars is double bus bars in Rades III S/Y. There are no problems with the composition of bus bars since the reliability is maintained.



Source: JICA Study Team

Figure 7.2.2-2 Single Diagram of New Rades III S/Y

Finally, on the point of land acquisition, there is a STEG building for Rades A&B on the land for Rades III S/Y, and the building will be removed before the commencement of the Rades III S/Y construction. There are no problems with the land acquisition and the construction work since the land is owned by STEG and within the yard of Rades A&B TPPs.

Figure 7.2.2-3 Land of Planned Rades III S/Y

Figure 7.2.2-4 Planned Cable Route around Rades III S/Y

(2) Cables between Rades III S/Y and Rades II S/S

A total of three cables (three circuits) will be installed between Rades III S/Y and Rades II S/S by April 2015, which are the colored pink lines shown in Figure 7.2.2-5.

One circuit cable is simply connected between Rades III S/Y and Rades II S/S, and the remaining two circuits cables will be connected to the cables from Kram S/S, which were once connected to Rades II S/S. As a result, the section between Rades III and Kram S/S directly will be connected by the two circuits (cables) before the connection of Rades C to Rades III S/Y.

The commencement of construction has not been determined yet, and only some parts of the specifications such as the transmission capacity and the number of circuits have been determined, so the JICA Study Team conducted an outline review. The specification of the cables was determined based on the IEC. For reference, the specification and installation conditions of similar cables are shown in Table 7.2.2-2 and Table 7.2.2-3, respectively, and a general diagram of cables installation is shown in Figure 7.2.2-6.

Source: JICA Study Team

Figure 7.2.2-5 Cables Route between Rades III S/Y and Rades II S/S

Table 7.2.2-2 General Specification of Cables

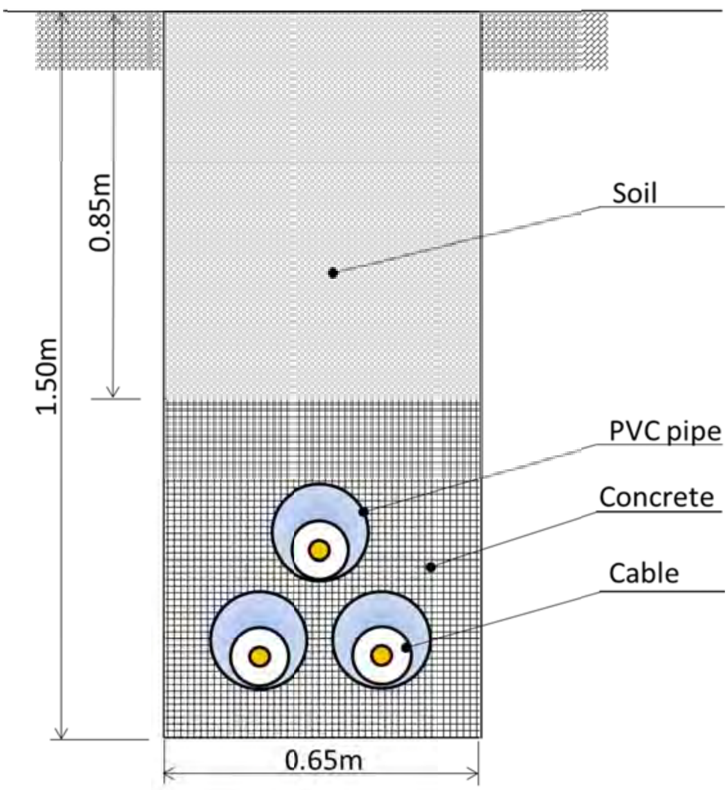
Type of cable	To be determined
Number of cores	Single core (to be determined)
Conductors	To be determined
Nominal system voltage [kV]	225 [Phase to Phase]
Rated frequency [Hz]	50
Transmission capacity [MW]	420
Basic impulse level [kV]	1,050
Short circuit current [kA]	31.5

Source: JICA Study Team

Table 7.2.2-3 Installation Condition of Cables

Type of laying	Conduit type (to be determined)
Spacing	To be determined
Depth of laying [m]	Appoxi.1.5 meters (bottom of triangle arrangement)
Ground temperature [°C]	35
Soil thermal resistivity [Km/W]	1.2
Sheath voltage	150
Right of way [m]	0.65

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2.2-6 Installation Conditions of General 225 kV Cables

In addition, buried conduits for cables will be installed in the land owned by STEG as shown in Figure 7.2.2-7 and Figure 7.2.2-8, and it is not necessary to acquire land for cable installation. It is not more difficult to install the cables inside the yard than out of the yard since it is easy to ascertain any obstacles, such as gas pipes and other cables, which are underground.

Figure 7.2.2-7 Planned Area for Installing Cables (Point A)

Figure 7.2.2-8 Planned are for installing Cablese near Rades II S/S (PointB)

7.2.3 T/Ls and S/Ss around Rades C Reinforced based on the Power Grid Reinforcement Plan

(1) Substations

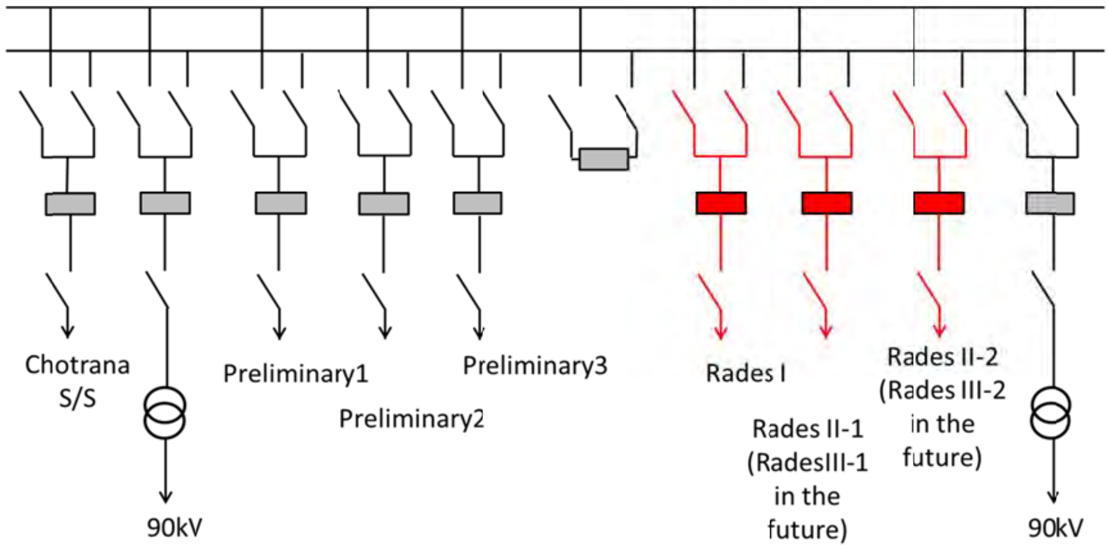
1) Kram S/S

Kram S/S is located 5 km (in direct distance) north – northeast from Rades P/Ss as shown in Figure 7.2.2-2. The insulated type of the S/S is an Air Insulated substation (AIS) type, and the primary voltage is 225 kV, and the secondary is 90 kV. Although the S/S itself was completed in August 2013, almost all of the cables are not connected except the 5 km cables halfway to Chotrana S/S. Therefore, this substation is not charged at the present.

The cable head and planned cable of Kram S/S are shown in Figure 7.2.3-1 and Figure 7.2.3-2, respectively. The main equipment in this S/S is a transformer 225/90/11 kV x 2 units, CB, DS, PT, and CT, etc. as shown in Table 7.2.1-2. In addition, the composition of bus bar type in the S/S are double bus bars type as shown Figure 7.2.3-3.

Figure 7.2.3-1 90 kV Cable Head of Kram S/S

Figure 7.2.3-2 Planned Cable of Kram S/S



Source: JICA Study Team

Figure 7.2.3-3 Single Diagram of Kram S/S

2) Chotrana S/S

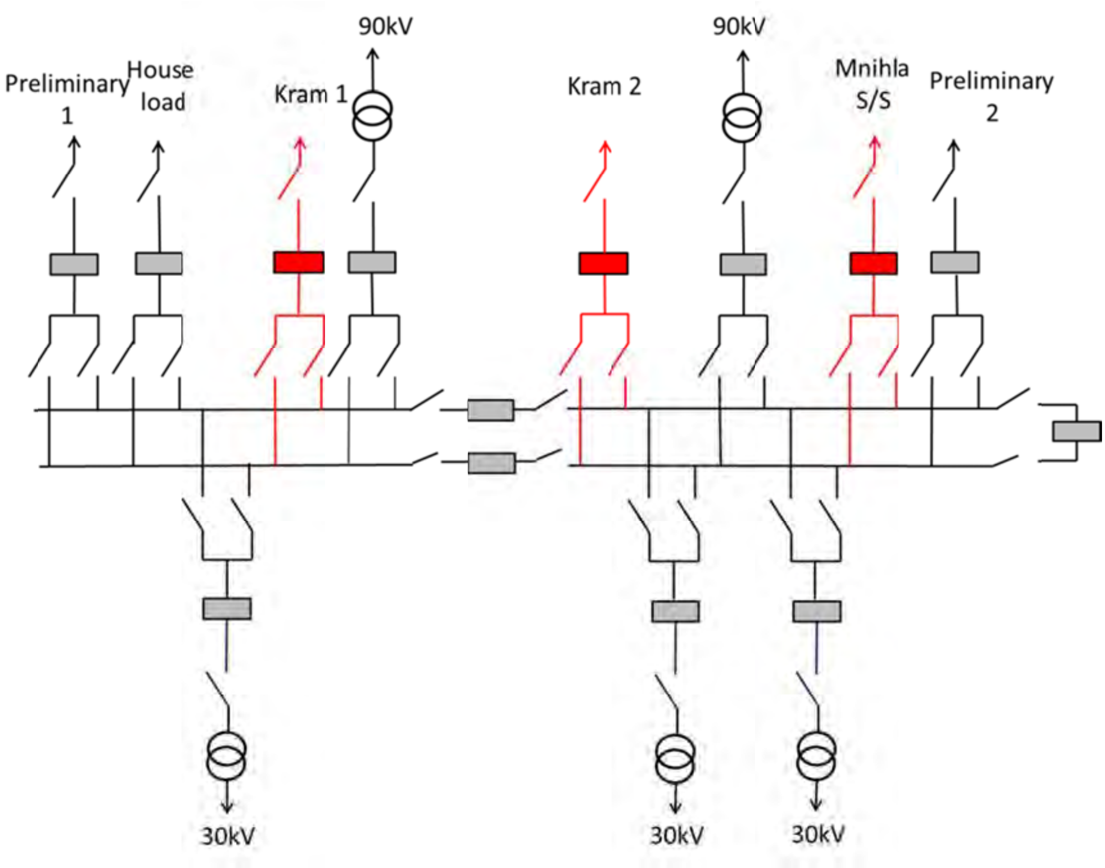
Chtrana S/S is located 10 km (in direct distance) west – northwest from Kram S/S as shown in Figure 7.2.1-2. The S/S`s main function is to step down the voltage from 225 kV to 90 kV for the T/Ls, and step down to 30 kV for the Distribution lines. The S/S construction will be completed by December 2014.

At present the land owned by STEG for Chotrana S/S is a vacant land lot as shown in Figure 7.2.3-4 and Figure 7.2.3-5.

The main equipment for this S/S is a transformer 225/90/11 kV x 2 units, CB, DS, PT, and CT, etc., as shown Table 7.2.1-2. In addition, the composition of bus bars are the double bus bars (four bus type) type shown Figure 7.2.3-3.

Figure 7.2.3-4 Land for Chotrana S/S

Figure 7.2.3-5 Area around Chotrana S/S



Source: JICA Study Team

Figure 7.2.3-6 Single Diagram of Chotrana S/S

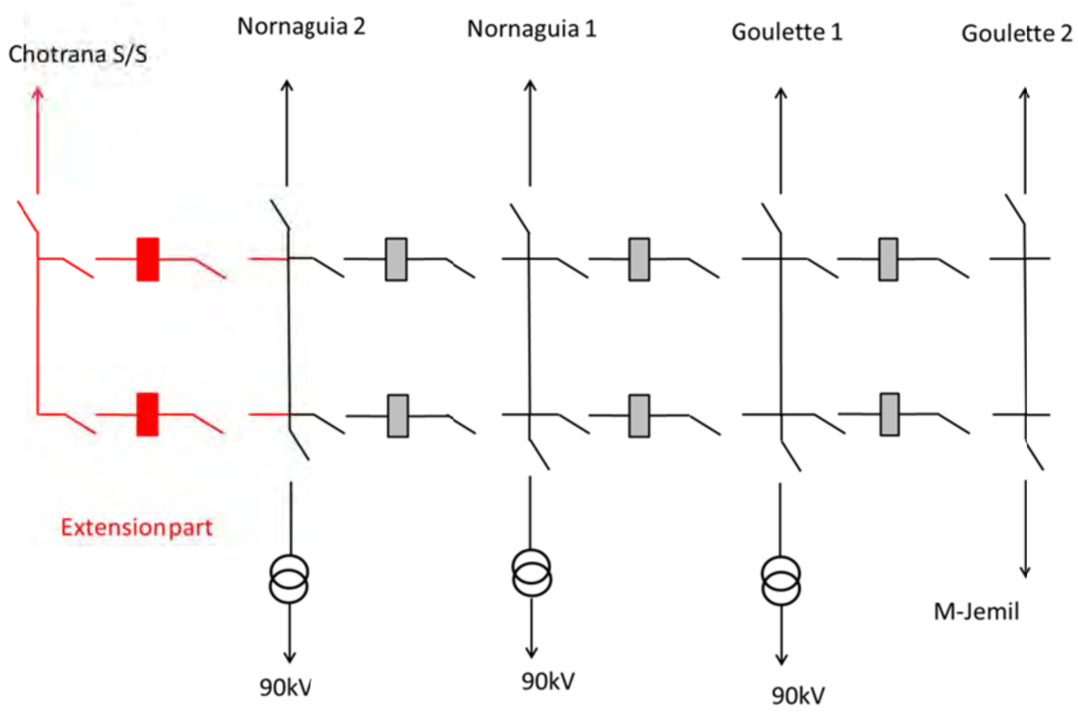
3) Mnihla S/S

Mnihla S/S is located 8 km (in direct distance) west – northwest from Chotrana S/S as shown in Figure 7.2.1-2.

In order to connect the cable from Chotrana S/S, an extension bay will be constructed in this S/S by August 2015 as shown Figure 7.2.3-7 and Figure 7.2.3-8. Since the land for the extension bay is within this S/S, it is not necessary to newly acquire land. A feature of this S/S is that the ring bus type, whose bars are connected as a grid pattern, has been adopted to secure the reliability of the S/S. However, the ring bus bar type is only applied in this S/S in the Tunis area.

Figure 7.2.3-7 Existing Mnihla S/S

Figure 7.2.3-8 Land for Extension Bay



Source: JICA Study Team

Figure 7.2.3-9 Single Diagram of Mnihla S/S

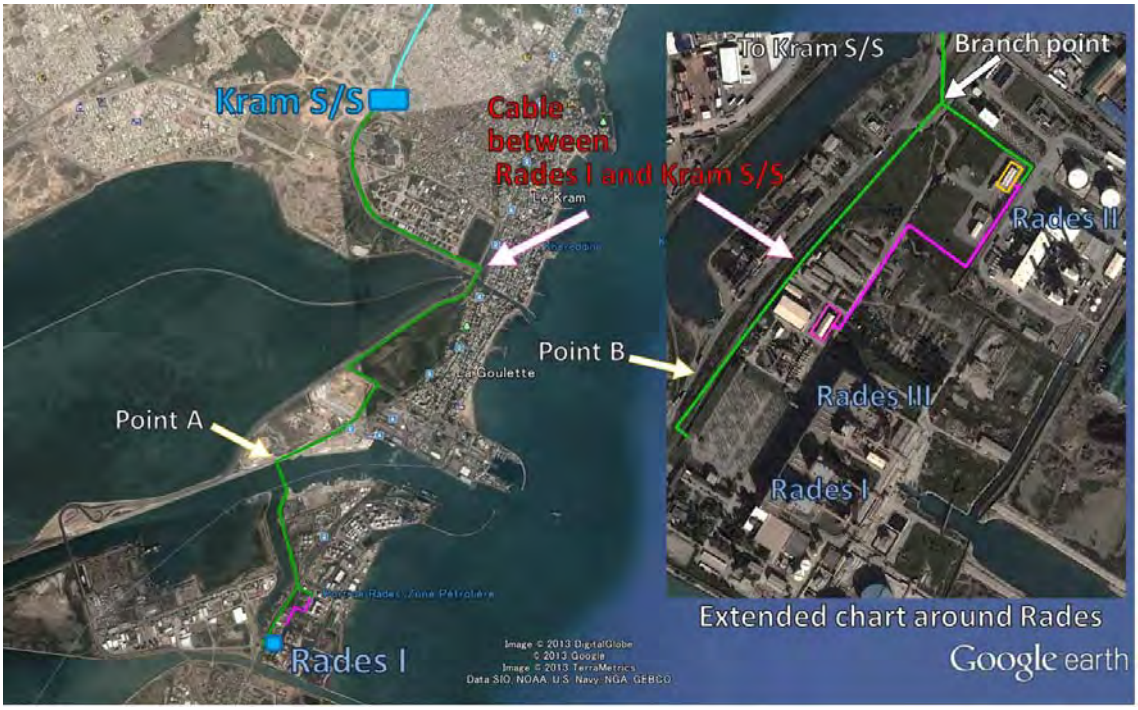
(2) Cables

1) Cable between Rades I - Kram S/S

The length of the cable from Rades I S/S to Kram S/S is 9.4 km. The transmission capacity is 420 MW x 1 circuit, and the cable installation type will be a buried conduit type as shown Table 7.2.1-2.

The feature of this cable is that it will be installed parallel to the cables between Rades II S/S and Kram S/S by the nearby northwest corner (the branch point) of Rades P/Ss, and after the branch point (as shown Figure 7.2.3-10) this cable will be separately connected to Rades I S/S. The cable between Kram S/S and the branch point will be installed under the side of the road or the sidewalk, etc., and the cable between the branch point and Rades I S/S will be installed within the yard of Rades P/Ss.

Although part of the cable will pass under the canal, general underground cables will be used as bridge cable types not used in Tunisia. The planned route and location of the cable are shown in Figure 7.3.2-11 and Figure 7.3.2-12.



Source: JICA Study Team

Figure 7.2.3-10 Route Map between Kram S/S and Rades I S/S

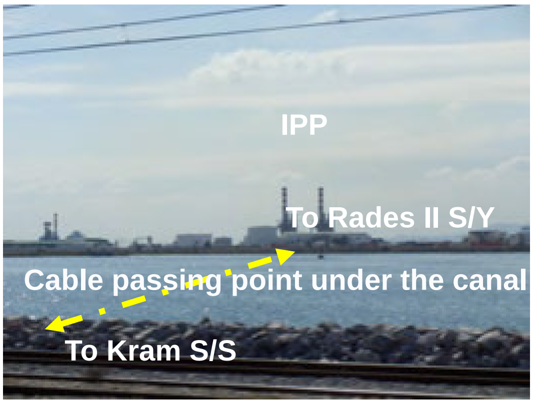


Figure 7.2.3-11 Planned Route of Cable (Point A)

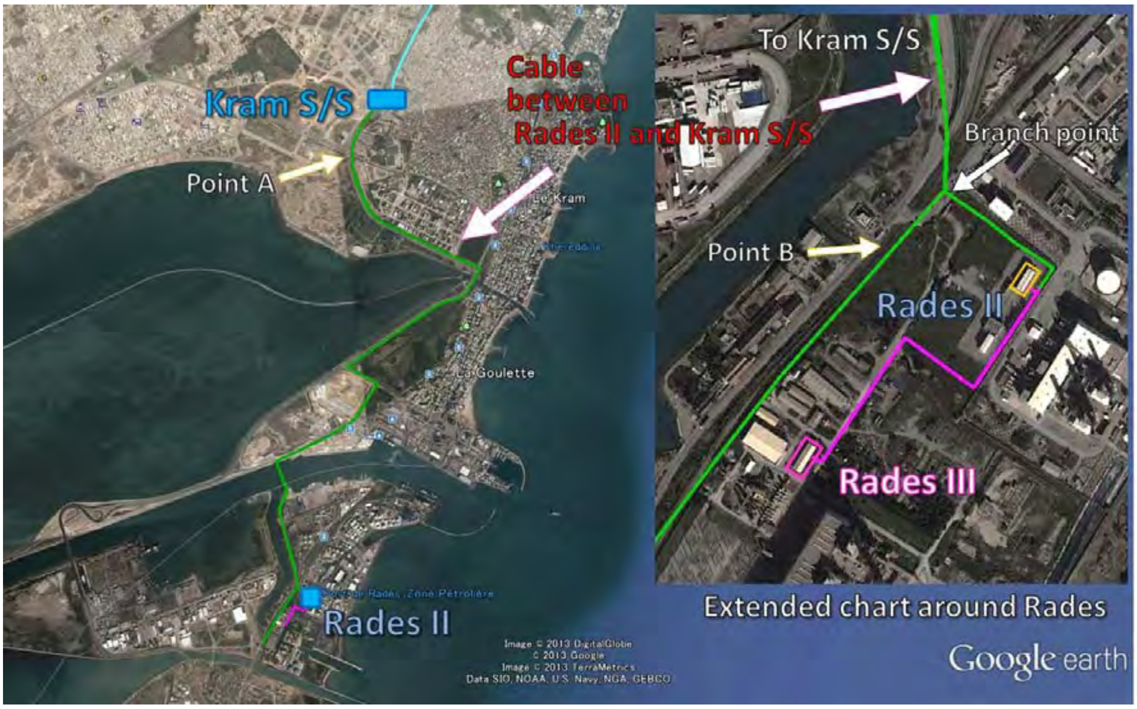
Figure 7.2.3-12 Location of Cable around Rades I (Point B)

2) Cable between and Rades II S/S and Kram S/S

The length of the cable from Rades II S/S to Krams S/S is 9.4 km. The transmission capacity is 420 MW x 1 circuit, and a buried conduit type will be used as shown in Table 7.2.1-2. The feature of this section is that this cable will be installed in parallel to the cables between Rades I and Kram S/S by the branch point, and after the branch point this cable will be separately connected to Rades II S/Y.

The cable between Kram S/S and the branch point will be installed under the side of the road or the sidewalk, etc., and the cable between the branch point and Rades II S/S will be installed within the yard of Rades A&B TPPs.

However, once these two circuits (cables) are connected to Rades II S/S, before the connection of Rades C to Rades III S/Y, these cables will be connected to the two cables between Rades III S/Y and Rades II S/S. The cable routes are shown in Figure 7.3.2-14 and Figure 7.3.2-15.



Source: JICA Study Team

Figure 7.2.3-13 Route Map between Kram S/S and Rades II S/S

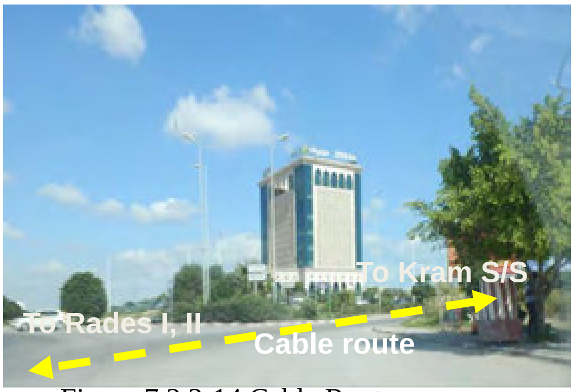


Figure 7.2.3-14 Cable Route (Point A)

Figure 7.2.3-15 Branch of Cables (Point B)

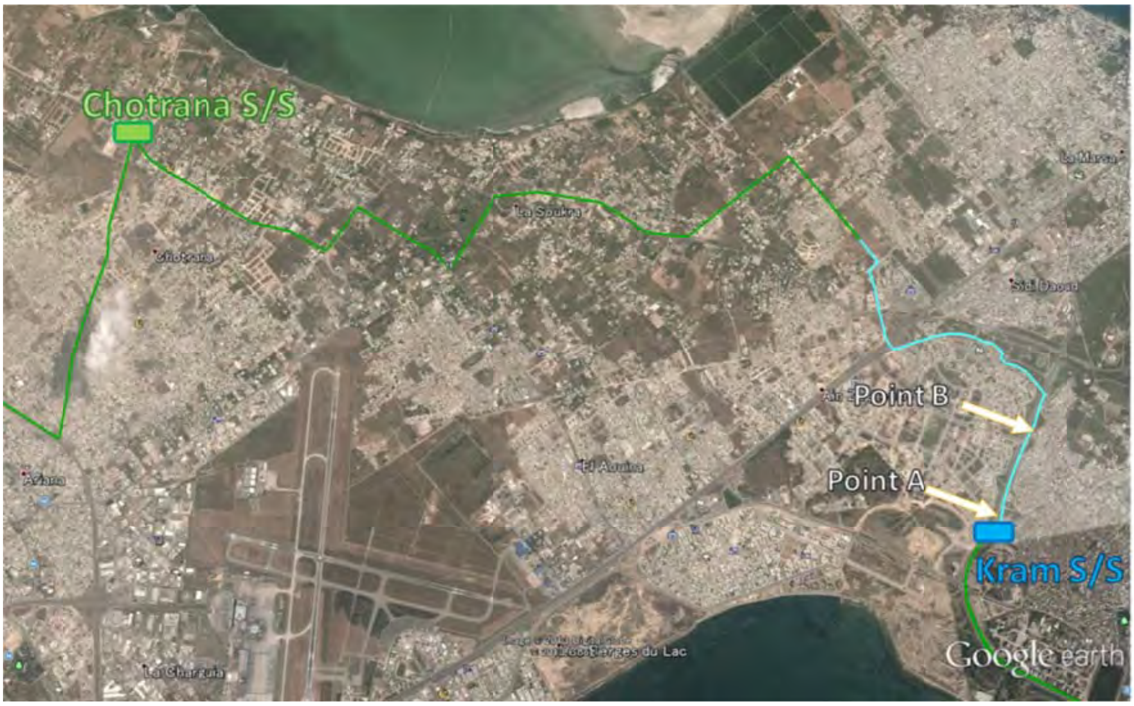
3) Cable between Kram S/S - Chotrana S/S

The length of the cable from Kram S/S to Chotrana S/S is 15 km. The transmission capacity is 420 MW x 2 circuits, and it will be a buried conduit type as shown in Table 7.2.1-2. A feature of this section is that the 5 km part from Kram S/S has been completed based on the Tunisian government's preference to have them parallel to the existing 225 kV overhead transmission lines. The remaining 10 km part will be constructed by April 2015.A summary of the cables specification is shown in Table 7.2.3-1.

Table 7.2.3-1 Specification of Cable between Kram S/S -Chotrana S/S

Voltage [kV]	225
Transmission capacity [MW]	400
Number of circuit [circuit]	2
Cable type	CV cable (Single core cable x 3)
Conductor type	Aluminium
Cross section area [mm^2]	2000
Installation type	Buried conduit type
Length [km]	Approx. 15 km (The 5 km section from Kram S/S was completed as of Sep. 2013)

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2.3-16 Cable Route between Chotrana S/S and Kram S/S

Figure 7.2.3-17 Cable Installation (Point A)

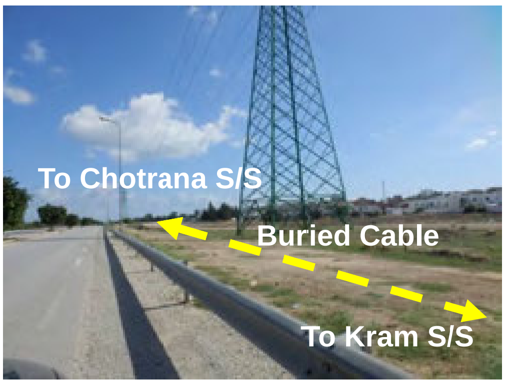


Figure 7.2.3-18 Buried Cable near Kram S/S (Point B)

4) Cables between Chotrana S/S and Mnihla S/S
The length of the cable from Chotrana S/S to Mnihla S/S is 15 km. The transmission capacity is 420 MW x 2 circuits, and it will be a buried conduit type as shown in Table 7.2.1-2. This cable will be installed under the side of the road and sidewalk by March 2016 as shown in Figure 7.3.2-19.

Photographs of the cable route are shown in Figure 7.3.2-20 and Figure 7.3.2-21.

Source: JICA study team

Figure 7.2.3-19 Route map between Mnihla S/S and Chotrana S/S

Figure 7.2.3-20 Cable Route (Point A)

Figure 7.2.3-2 Cable Route (Point B)

7.2.4 Conclusion

STEG has been reinforcing the power grid for the stability of the power systems in Tunisia. In constructing Rades C, the essential facilities (Rades III S/Y and the cables between Rades III S/Y and Rades II S/S) were reviewed. From the review conducted by the JICA Study Team, the following items have been confirmed.

- The essential facilities are out of the scope of a Japanese yen loan for the reason that they are financed by EIB.
- There are no problems with these essential facilities from the viewpoint of technical specification, construction method and schedules, and land acquisition.

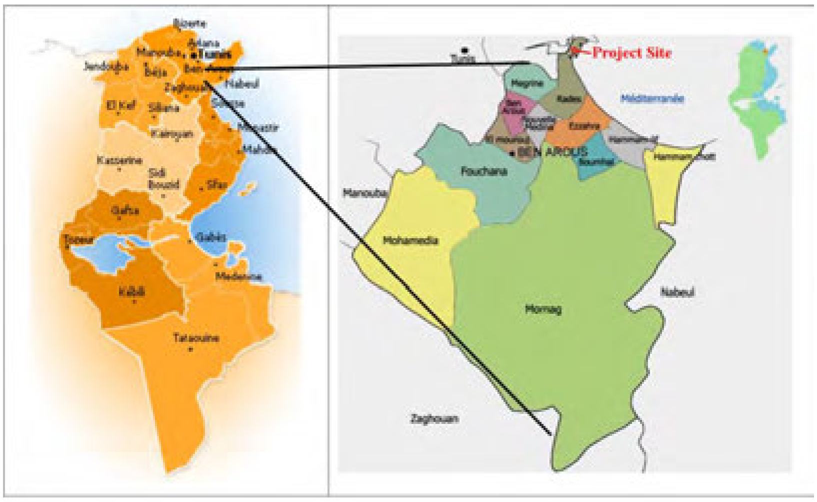
Other facilities related to the power development plan around Rades P/Ss were described in this report since these facilities are important for transmitting power generated by Rades C to the national grid.

Chapter 8 Environmental and Social Considerations

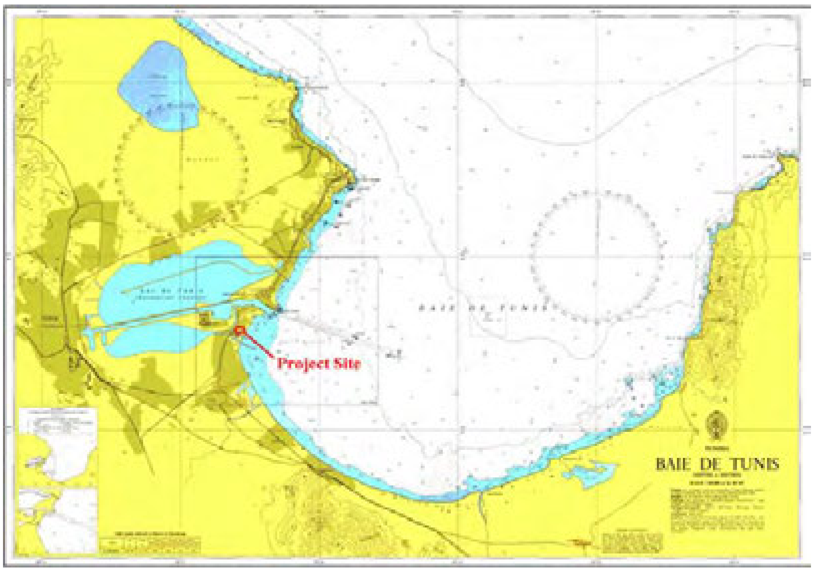
8.1 Environmental Situation

8.1.1 Location of the Project Site

Rades C Power Plant of the Project is constructed within the site of Rades Power Plant Group (Radès A&B Power Plants owned by STEG (the project proponent) and Rades II owned by Carthage Power Company, an IPP enterprise, are in operation) located in Rades County, Ben Arous Governorates 10km away from the capital city of Tunis Figure 8.1-1, Figure 8.1-2, Figure 8.1-3). Radès C Power Plant occupies 5.4ha of the total area of 25.4ha of Radès A&B Power Plants and the related facilities.



Source: EIA Report for Rades C Project
Figure 8.1-1 Location of Ben Arous Governorates



Source: JICA Study Team
Figure 8.1-2 Location of the Project Site

Source: EIA Report for Rades C Project

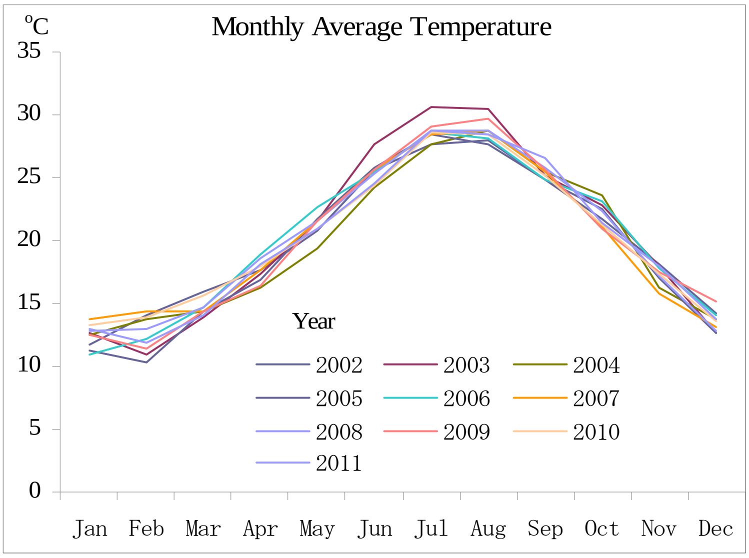
Figure 8.1-3 Scenery around the Project Site

8.1.2 Natural Environment

(1) Climate

1) Temperature

Figure 8.1-4 describes the monthly average atmospheric temperatures measured from 2002 to 2011 at the Carthago meteorological station located approximately 15 km from the project site. The average temperature tends to become high in July and August and decrease from September.

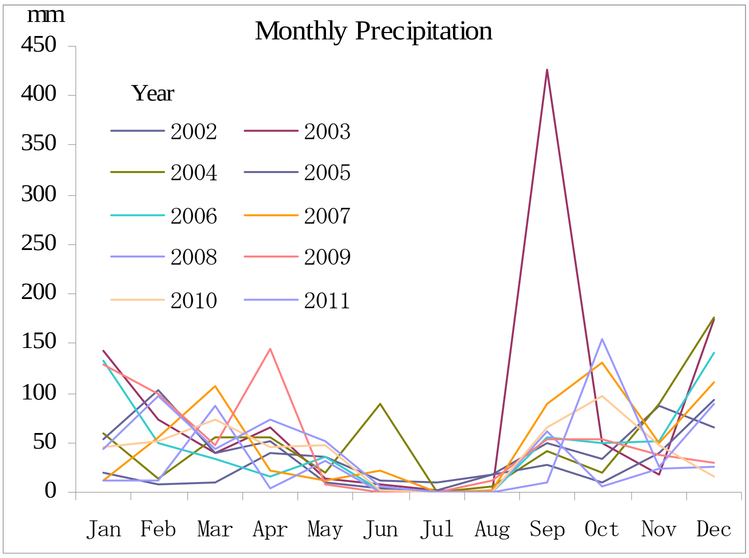


Source: Prepared by the JICA Survey Team based on documentation from STEG

Figure 8.1-4 Monthly Average Temperatures at the Carthago Meteorological Station

2) Precipitation

Figure 8.1-5 describes the monthly precipitation measured from 2002 to 2011. The yearly precipitation varies widely every year, from 265.4 mm to 1,011.6 mm. Monthly averages also vary every year, but they tend to decrease from January to June, with the minimum precipitation occurring from June to August, and starts to rise from September.

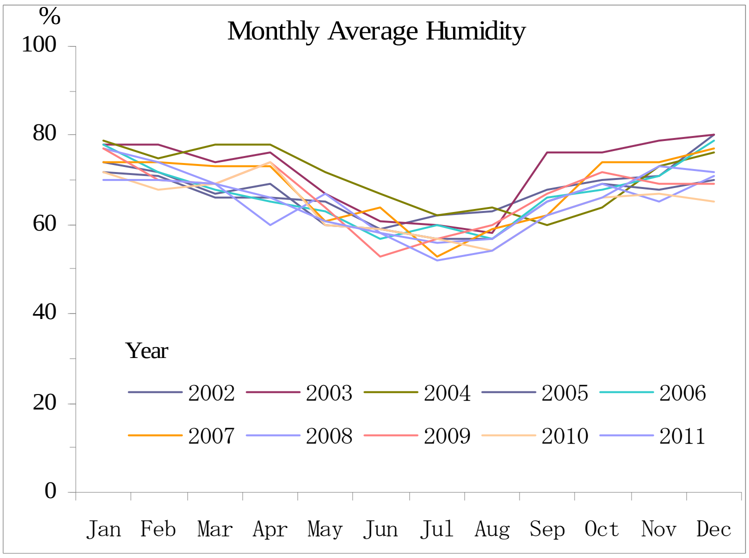


Source: Prepared by the JICA Survey Team based on documentation from STEG

Figure 8.1-5 Monthly Precipitation at the Carthago Meteorological Station

3) Humidity

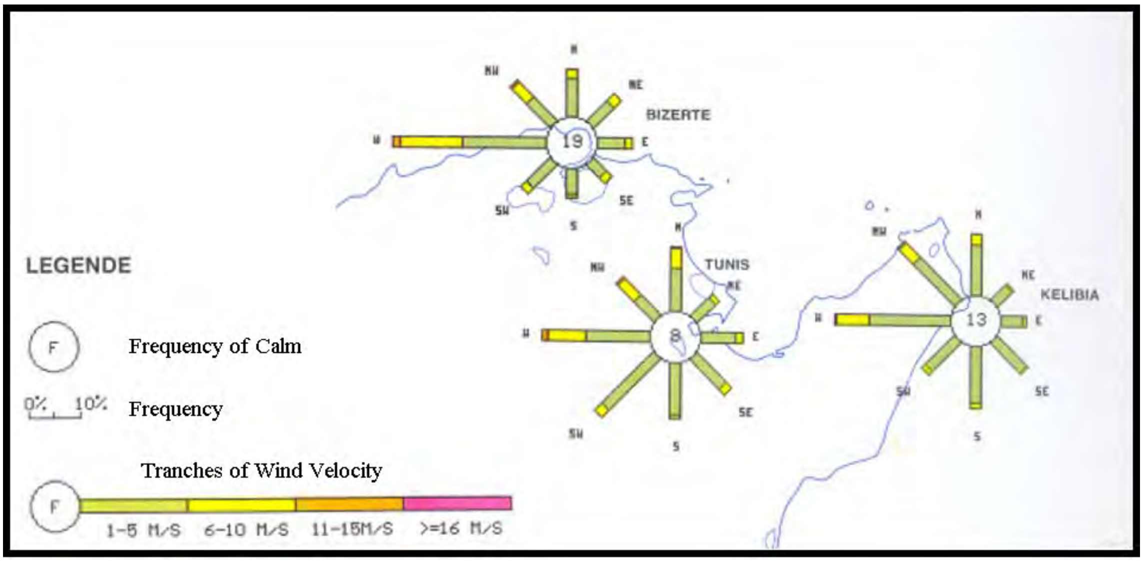
Figure 8.1-6 describes the monthly average humidity measured from 2002 to 2011 at the Carthago meteorological station. The monthly average humidity in this period was 52~80%. The monthly average varies in conjunction with the monthly precipitation, and tends to become the lowest in June and August and rise from September.



Source: Prepared by the JICA Survey Team based on documentation from STEG

Figure 8.1-6 Monthly Average Humidity at the Carthago Meteorological Station

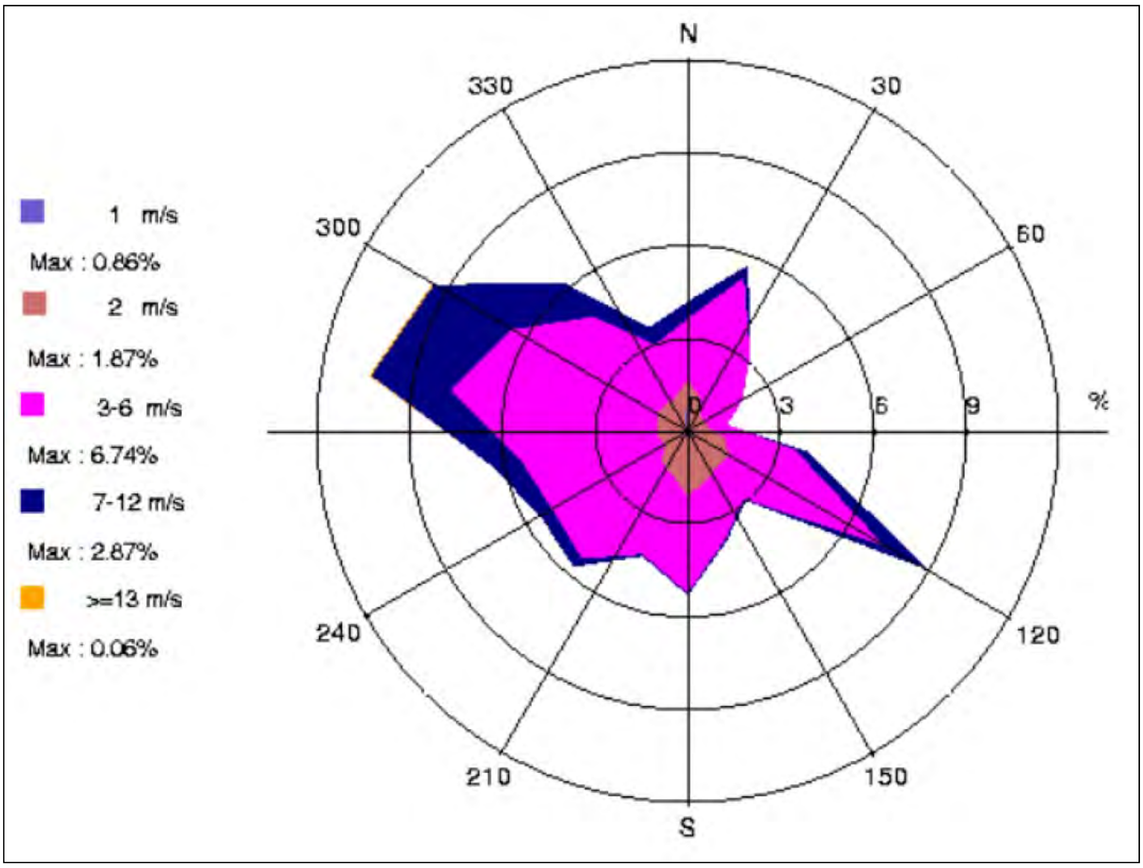
4) Wind direction/wind speed
Figure 8.1-7 describes the wind rose including wind direction and wind speed at the meteorological station at Bizerte, Tunis-Carthage and Kelibia in the Gulf of Tunis. The observation was conducted at 10m ground height every 3 hours (8 times a day). The data from 1970 to 1990 indicates that west wind is dominant with the average wind speed of approximately 7m/s.



Source: EIA Report for Rades C Project

Figure 8.1-7 Annual Wind Rose in the Gulf of Tunis (1970 - 1990)

Figure 8.1-8 shows the wind roses in Tunis-Carthage from 2010 to 2012. The data indicates that wind direction from WNW to west is dominant and the wind speed is high.



Source: EIA Report for Rades C Project

Figure 8.1-8 Wind Rose in Tunis-Carthage (2010 - 2012)

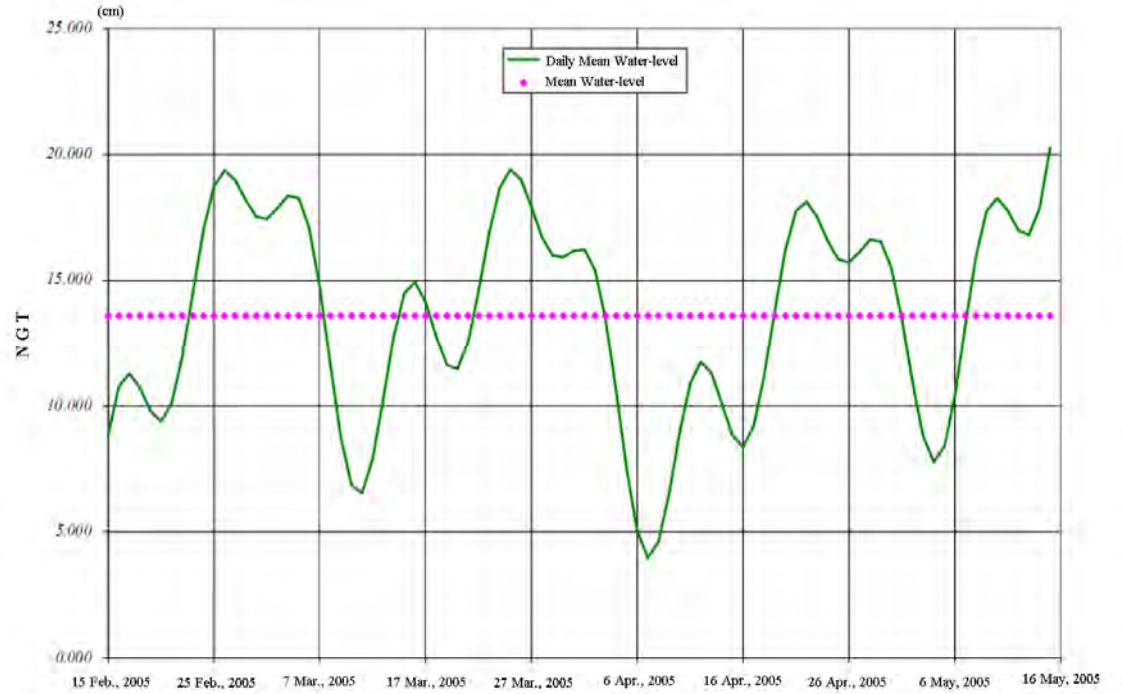
(2) Oceanographic Features

1) Tidal

Tidal level at the Gulf of Tunis fluctuates between NGT = 0m (the Zero Leveling General of Tunisia) and NGT = +0.41m. The result of the observation of tidal level conducted from February 15 to May 15 of 2005 at La Goulette Port near the project site indicates the following characteristics:

- Average tidal level at the La Goulette port was NGT = +20cm
- Tidal range in neap tide was very small.
- Tidal range in spring tide was approximately 30cm
- Tidal range in equinoxes was exceptionally high (36.3cm).

The Change in the daily mean water-level (NGT) in the Port of La Goulette is shown in Figure 8.1-9.



Source: EIA Report for Rades C Project

Figure 8.1-9 Change in the Daily Mean Water-level (NGT) in the Port of La Goulette

2) Current

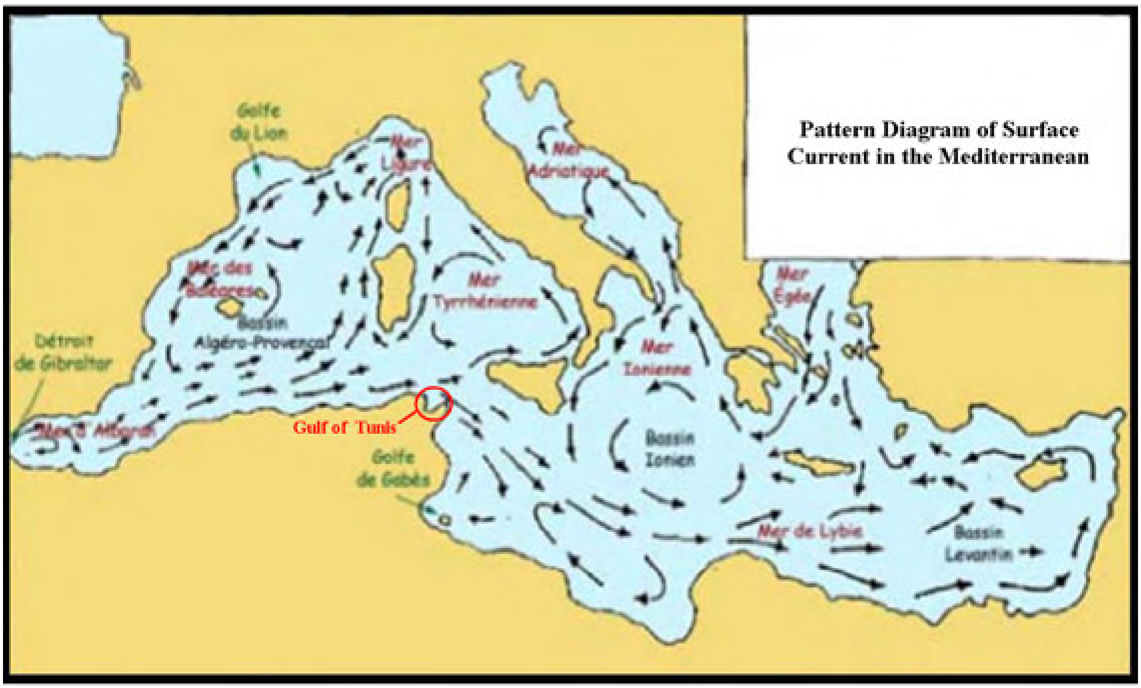
Currents are categorized into 4 types.

- Surface Current
- Current Due to Wind
- Tidal Current
- Current Wave

The current in the coastal area of Tunisia is low in the maximum speed (0.10 m/sec) and has narrow area of current wave. Accordingly, surface current and current due to wind will cause major influence on thermal effluent diffusion.

a. Surface Current

The Mediterranean connects to the Atlantic only through Straits of Gibraltar, and as quantity of evaporation from the sea surface is quite large, it has high salinity and low tidal level. The eastern part of the Mediterranean has higher rate of evaporation quantity, resulting in lower sea level and higher salinity. Low-salinity sea water from the Atlantic flows into the eastern area of Mediterranean, pushing high-salinity sea water of the eastern area westward back into the Atlantic through Straits of Gibraltar. In this manner, low-salinity water, which is comparatively light, flows eastward near the sea surface, whereas deep current consists of heavier high-salinity sea water flowing westward.



Source: EIA Report for Rades C Project

Figure 8.1-10 Pattern Diagram of Surface Current in the Mediterranean

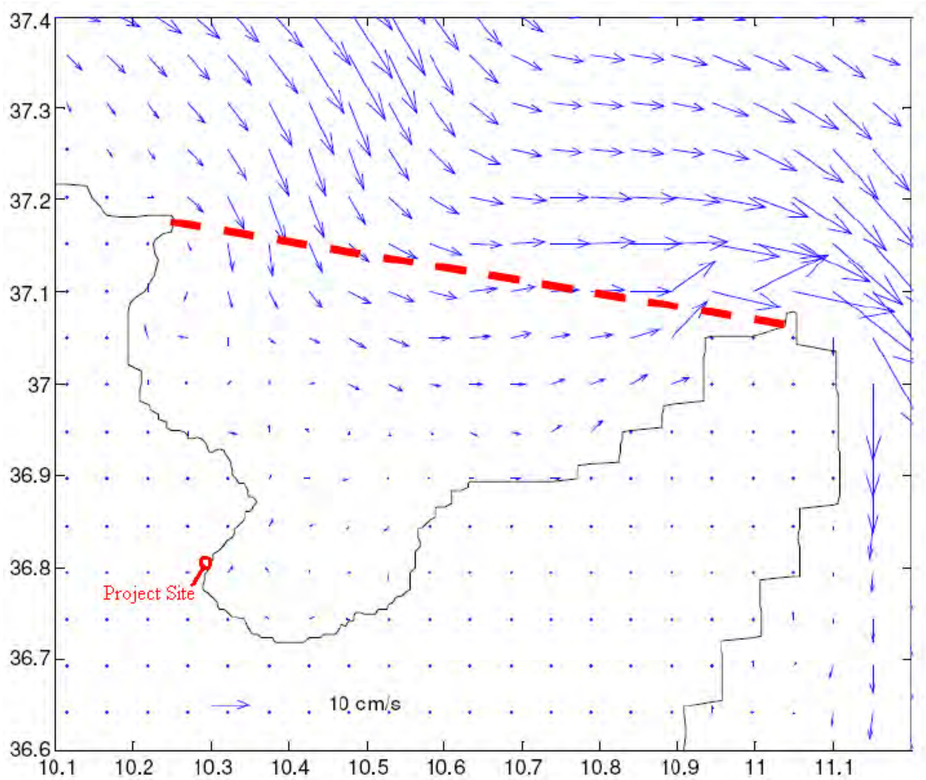
b. Current Due to Wind

When wind blows on the sea surface, sea surface water moves downwind by the pressure of wind and current due to wind occurs. Through Figure 8.1-11 to Figure 8.1-13 describes the simulation of current of sea water in the Gulf of Tunis in each wind direction.

Under calm condition with no influence of wind, the surface current of the Mediterranean flowing from west to east causes inflow of sea water from the western coast of Gulf of Tunis, but reaching only near the center of the gulf (Figure 8.1-11).

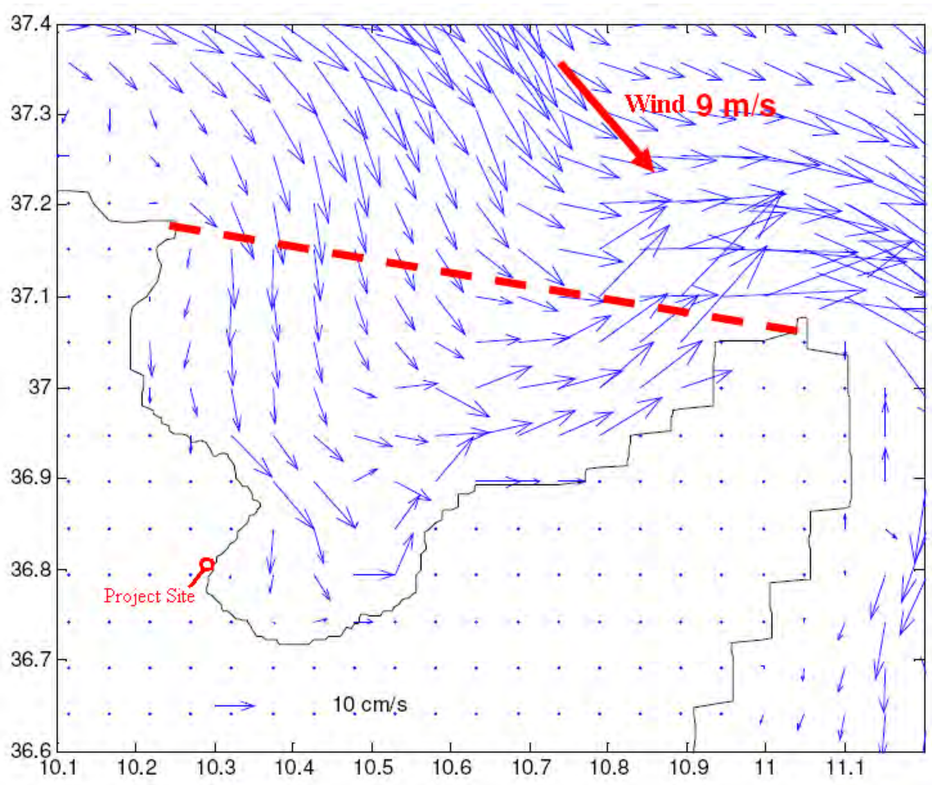
In case of north-western wind, this sea current is enhanced and the clockwise inflow of seawater reaches deep into the Gulf of Tunis, then flows out from the eastern coast of the gulf into the Mediterranean (Figure 8.1-12).

In case of eastern wind, the surface current does not flow into the Gulf of Tunis and the current in the gulf flow counterclockwise (Figure 8.1-13).



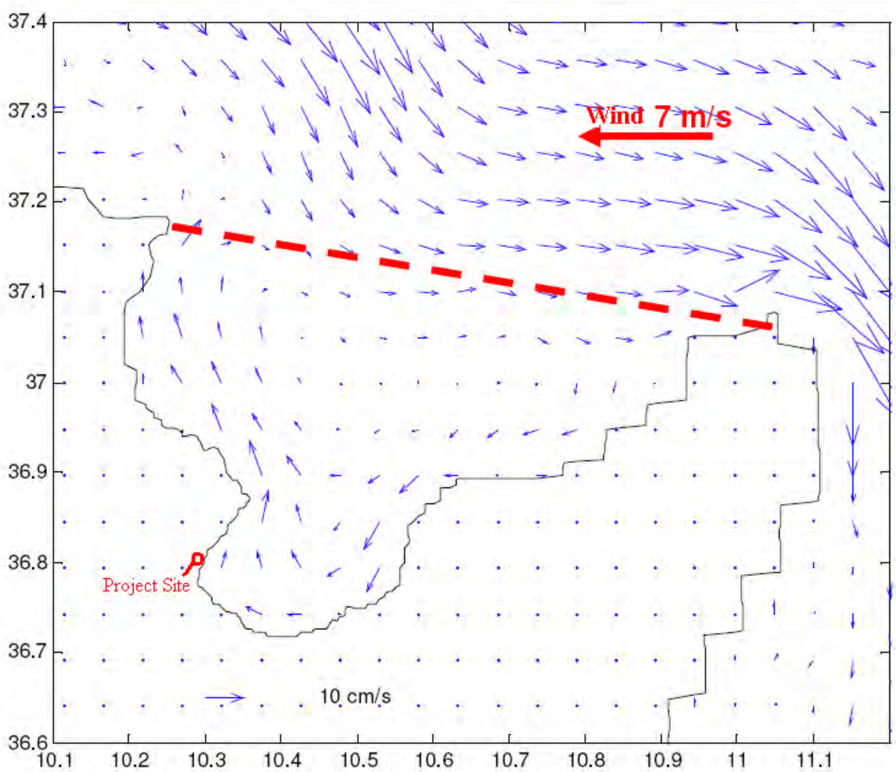
Source: EIA Report for Rades C Project

Figure 8.1-11 Mean Circulation in the Gulf of Tunis Generated by Calm (less than 1m/s)



Source: EIA Report for Rades C Project

Figure 8.1-12 Mean Circulation in the Gulf of Tunis Generated by NW Wind (9m/s)



Source: EIA Report for Rades C Project

Figure 8.1-13 Mean Circulation in the Gulf of Tunis Generated by East Wind (7m/s)

(3) Natural Environment

1) Situations around the project site

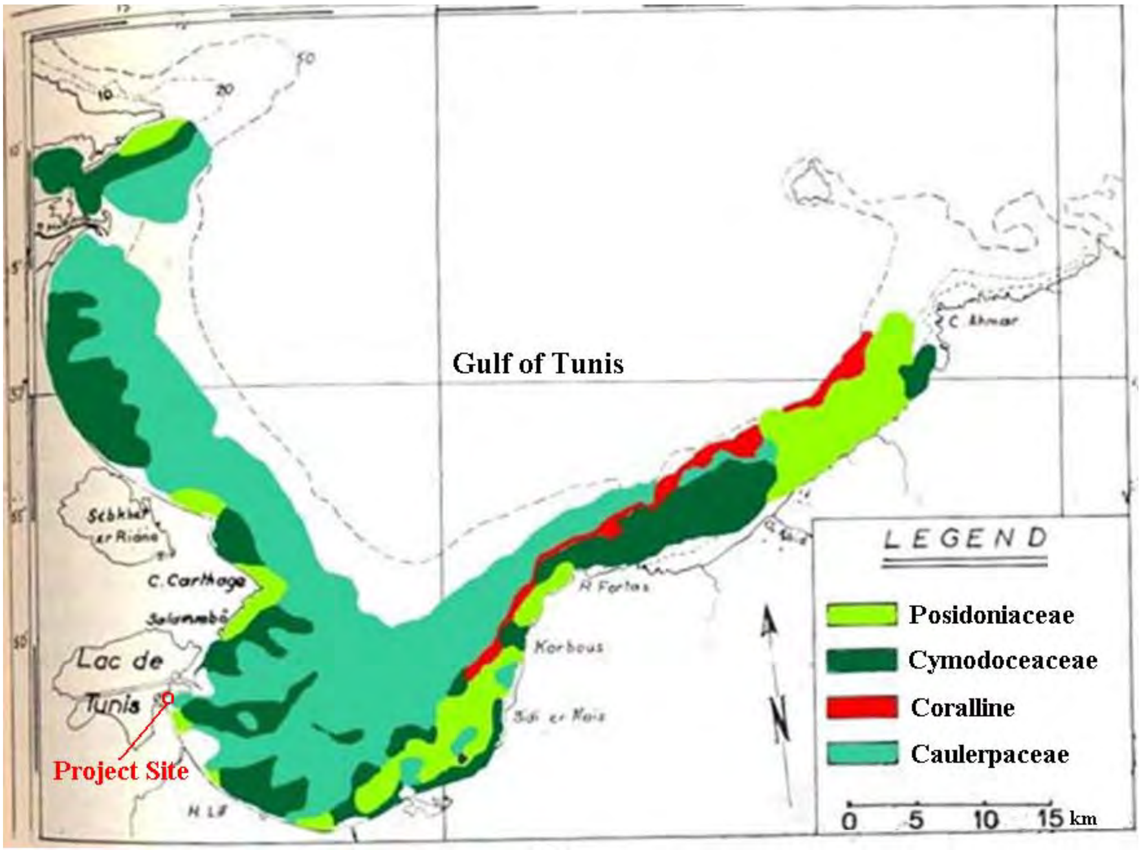
The area around the project site is, as shown in Figure 8.1-14, The remain of a labor camp and material storage site from the time of construction of Rades B TPP are still standing on the site, and well-developed area and no forest is seen. Little vegetation grows except some grass plants and trees planted in the green belt in the site. There are no primary forests, natural forests and mangrove wetlands around the site. The outlet of waste water faces shoaling beach, with no tidal flat or coral reef.

Source: Prepared by the JICA Survey Team based on a Google earth

Figure 8.1-14 Situations around the Project Site

2) Sea-grass and Algae Habitat in the Gulf of Tunis

There is little information of sea-grass and algae habitat in theGulf of Tunis. Figure 8.1-15 shows the distribution of sea-grass bed in the Gulf of Tunis in 1972. The sea-grass bed spread in the whole shallow sea area of the gulf at that time, but the area has decreased since then due to decreased water clarity and eutrophication.



Source: EIA Report for Rades C Project

Figure 8.1-15 Sea-grass and Algae Habitat in the Gulf of Tunis (1972)

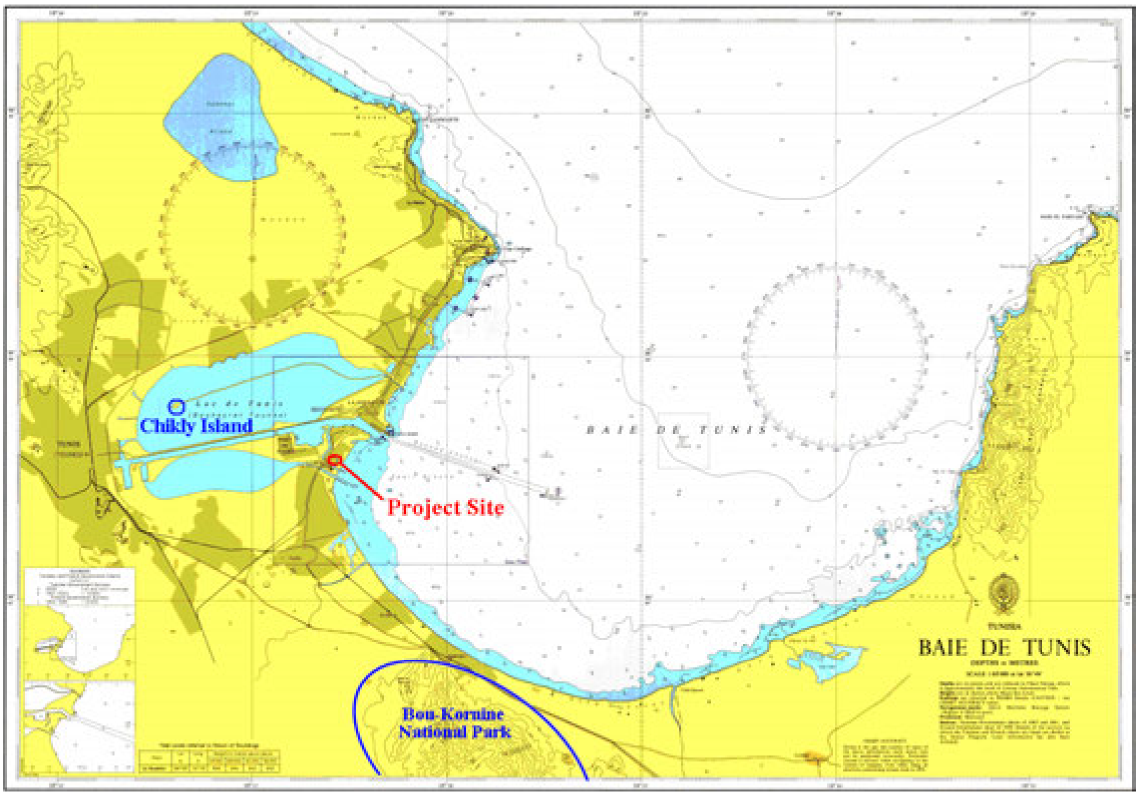
3) Nature Reserve and National Park

Figure 8.1-16 shows the Nature Reserve and National Park around the project site. The nearest nature reserve from the site is Chikly Island located in Lake of Tunis 6km west of the project site. This area is forbidden of development due to archaeological monument, and is also a protected area of water bird (Figure 8.1-17). In 8km southeast of the project site is Bou-Kornine Natinal Park (Figure 8.1-18) which is the protected area for the habitat of Barbary Sheep.

Nature reserve is stipulated by Forest Code Law No.88-20: “by natural reserve is meant a little-extended natural site whose aim is preserving animals’ or plants’ individual or group species natural life, as well as their habitat, and the conservation of migrant fauna species of national or global importance”[1].

National Park is stipulated by the same law: “by national park is meant a relatively extended land parcel with one or many ecosystems a little or not transformed by human exploitation and occupation where vegetal and animal species, geomorphologic sites and habitats offer special interest from scientific, educational and recreational stands, or which include natural landscapes of great aesthetic value”[1].

[1] www.cbd.int/database/attachment/?id=1170



Souce: JICA Study Team

Figure 8.1-16 Location of Protected Area and National Park near the Project Site

Source: http://commons.wikimedia.org/wiki/File:IleChikliLacTunis.jpg

Figure 8.1-17 Scenery of Chikly Island

Source: http://en.m.wikipedia.org/wiki/File:Gulf_of_Tunis_with_Mount_Bou_Kornine.jpg

Figure 8.1-18 Scenery of Bou-Kornine Mountain

4) Migration birds

Chikly Island is a nature reserve and also a landing zone of migrant birds. STEG conducted survey of migrant birds in all over Tunisia from 2012 July to 2013 June for the construction of wind power station. The result of the survey indicates that migrant birds landing in Tunisia tend to migrate directly to north, which means that the project site is not supposed to be the main flyway of migrant birds (Figure 8.1-19).

Source: STEG

Figure 8.1-19 Diagram of Main Fryway of Migratory Birds in Tunisia

8.1.3 Social Environment

(1) Land Use

The Project Site is located in Rades County, one of twelve counties in Ben Arous Governorate, with 1,955 ha and 47,910 inhabitants (2010). It is only 10 km from the center of the Capital Tunis and to the east of Tunis. The northern part of Rades County is occupied by Rades Port, its warehouses and related facilities. Rades port is the biggest commercial port in Tunisia with approximately 6 million tons of treatment annually. There is also an industrial zone in the north-west of the county with more than 40 industries. Residential area is spread mainly along the seashore and in the center of the county. One residential area is, however, located 300 m from STEG Rades administration building and around 600m from the project site. This area is called “Mallaha” area, with an estimated population of 4,000 inhabitants according to the people living there (Figure 8.1-20). To the south and aouth-west of the county, there is a large forest area.

Source: http://193.95.122.123/atlas/en/node/644

Figure 8.1-20 Land Use in Rades County

(2) Social Feature near the Project Site

The social features of Rades County and Ben Arous Governorate are shown in Table 8.1-1. Rades County is mostly an industrial area and there is no rural area. The population density is higher than the average in Ben Arous Governorate, as well as the density of housings. Social Infrastructure development such as portable water, electricity, and sewage is also in a high level in Ben Arous Governorate.

Table 8.1-1 Social Feature of Rades County and Ben Arous Governotrate

Indicators	Rades County	Ben Arous Governorate	Observations
Area (km^2)	19.93	666.75	-
Population	47,910	571,464 [1)]	2010
Annual Growth Rate	2.31%	3.13% [1)]	1994/2004
Urban Population	37,910	517,242 [10)]	2010
Rural Population	-	54,222 [10)]	2010
Population Density (inhab/km^2)	2,404	857	2010
Number of Households	11,295	117,901 [2)]	2004
Average Household Size	3.69	4.00 [2)]	2004
Activity Rate	49.0%	49.0% [4)]	2004
Unemployment Rate	11.0%	13.0% [4)]	2004
Number of Dwellings	13,465	136,064 [5)]	2004
Housing Density (houseing/ha)	6.83	2.04 [6)]	2004
Main Urban Center	Rades	Ben Arous	-
Rate of Drinking Water Supply	99.9%	97.9% [3)]	2004
Electrification Rate	99.9%	98.9% [3)]	2004
Rate of Connection to the Sewerae System	95.4%	86.2% [3)]	2004
Number of Pimary Schools	13	151 [7)]	2008
Number of Colleges – Secondary Schools	5	58 [7)]	2008
Number of Basic Health Centers	4	46 [8)]	2008
Number of Post Office	4	30 [9)]	2008

Source: http://193.95.122.123/atlas/en/node/664
1) http://193.95.122.123/atlas/en/node/498
2) http://193.95.122.123/atlas/en/node/504
3) http://193.95.122.123/atlas/en/node/508
4) http://193.95.122.123/atlas/en/node/518
5) http://193.95.122.123/atlas/en/node/564
6) http://193.95.122.123/atlas/en/node/581
7) http://193.95.122.123/atlas/en/node/586
8) http://193.95.122.123/atlas/en/node/594
9) http://193.95.122.123/atlas/en/node/601
10)http://www.ins.nat.tn/demog/population/fr/tab4_fr_evolution.xls

The nearest residential area of Mallaha is composed of several story apartment buildings and is a rather isolated area in the middle of industrial zone. There are stores for daily life and some restaurants. One elementary school is also located. Many people living there are mainly working for industrial factories nearby and some of them are even working for STEG.

(3) Industry

Ben Arous Governorate had 585 companies with over 10 employees including around 50% of textile and clothing industries, mechanical and electrical (2007). In 2008, Industry in Ben Arous Governoraet provides some 55,190 jobs nearly 40% (20,033 jobs) are offered by the branch Mechanical / electrical and more than 10% for the textile clothing (11,978 jobs). The food industry provides nearly 10% of industrial jobs with more than 6,000 jobs.

Table 8.1-2 Structure of Industry in Rades County and BenArous Governorate

Area	Rades County	Ben Arous Governorate	Observations
Number of Companies [1)]	43	558	2007
Number of Employees by Industrial Sector [2)]	3,594	55,190	2008

Source: 1) http://193.95.122.123/atlas/en/node/547
2) http://193.95.122.123/atlas/en/node/549

(4) Road Traffic

According to the 2007 census, the main roads in the governorate registered a traffic of 284,192 vehicles/day on a main road N1. Section R33 registered 176,527 vehicles/day including 27,546 heavy vehicles or 15.6% (Figure 8.1-21).

Source: http://193.95.122.123/atlas/en/node/606

Figure 8.1-21 Road Traffic near the Project Site

8.2 Environmental Impact Assessment and Other Legal System

8.2.1 Overview of Environmental Administration

Environmental administration in Tunisia started with the establishment of the National Agency for Environment Protection (Agence Nationale de Protection de l'Environnement, ANPE) by virtue of Law No.88-91 in 1988. Prior to that date, however, a certain number of ministries had started to set up some regulations or standards under respective authority.

The first ministry with the name "Environment" was the Ministry of Environment and Territorial Exploitation (Ministère de l'Environnement et de l'Aménagement du Territoire), created by decree No.92-1098 dated June 9, 1992. The direction in charge of environment of the said ministry was transferred in September 2002 to the Ministry of Agriculture, Environment and Water Resources (Ministère de l'Agriculture, de 'Environnement et des Ressources Hydrauliques). An independent ministry in terms of environment was finally created later in November 2004 as the Ministry of Environment and Sustainable Development

(Minstère de l'Environnement et du Développement Durable, MEDD). This ministry, however, was reintegrated in January 2011 to the Ministry of Agriculture.

After a short period of independence as the Ministry of Environment since December 2011, the ministry was again merged with ministry of equipment in March 2013, to become the current Ministry of Equipement and Environment (Minsitère de l'Equipement et de l'Environnement, MEE). Currently, therefore, a substantial part of policy issues for the environment are under MEE's authority, leaving certain areas to other ministries, like fauna and flora related issues to the Ministry of Agriculture and Water Resources.

A certain number of national agencies are working closely with and under MEE. Since its establishment, ANPE has assumed an important role as an agency in charge of evaluating Environmental Impact Assessments (EIA). The National Agency for Waste Management (Agence Nationale de Gestion des déchets, ANGED), created in 2005 by decree No. 2005-2317, controls all kinds of waste in Tunisia. Moreover, since the Project is located nearby the seashore, the Agency for Littoral Protection and Exploitation (Agence de Protection et d'Aménagement du Littoral, APAL) is also concerned with water discharge into public sea areas.

8.2.2 Environment Related Legal Framework

(1) Main Laws and Regulations Concerning Environment

Below are the main laws and regulations concerning environmental issues in Tunisia and closely related to the Project.

- Law No.66-27 promulgating Labor Code (April, 1966)
- Law No.75-16 promulgating Water Code (March, 1975)
- Decree No. 84-1556 of 29 on the regulation of industrial estates relating to the noise level (December 1984)
- Law No.86-35 related to protection of archeologic assets, historical monuments and natural and urban sites (May, 1986)
- Law No.88-20 promulgating Forest Code (April, 1988)
- Law No.88-91 related to the creation of the National Agency for Environment Protection (August, 1988)
- Tunisian Standard No.106-02 related to Effluent (July, 1989)
- Decree No.90-2273 related to the status of controllers of the National Agency for Environment Protection (December, 1990)
- Decree No.91-362 related to Environmental Impact Assessments (March, 1991)
- Law No.92-115 simplifying administrative procedures of the National Agency for Environment Protection (November, 1992)
- Decree No.93-303 detemining the attributions of the Ministry of Environment and Territorial Expoitation (February, 1993)
- Law No.94-16 related to exploitation and maintenance of Industrial Zones (January 1994)
- Tunisian Standard No.106-04 related to Air (December, 1994)
- Decree No.95-72 related to the creation of the Agency for Coastal Protection and Development (July, 1995)
- Law No.96-29 introducing an urgent national intervention plan against marine pollution (April, 1996)
- Law No.96-41 related to Solid Waste, its Management and Disposal (June, 1996)
- Decree No.2000-2339 determining a list of Hazardous Waste (October, 2000)

- Decree No.2005-2317 related to the creation of the National Agency for Waste Management (August 2005)
- Decree No.2005-2933 detemining the attributions of the Ministry of Environment and Sustainable Development (November 2005)
- Decision of Ministry of Agriculture and Water Resources dated July 19, 2006 determining the list of rare fauna and flora having risk of extinction
- Decree No.2010-2519 fixing upper limits of polluted air from stationary sources (September, 2010)

(2) Main Regulation Standards

We enumerate the main standards in Tunisia for air, water, and noise, etc., in connection with thermal power projects.

1) Air Quality

Air quality standards (No.106-04; December, 1994) are shown in Table 8.2.1. There are two reference values. “Standards” values are allowed, to some extent, to exceed a certain frequency (allowable frequency). “Guidelines” values are targeted to be applied with the objective of long term environmental and health effects.

Note that in Table 8.2.1, IFC/ EHS guidelines (General 2007) are shown as reference values. The guideline value of the ambient air quality standards will be the reference value for the monitoring results of the Project, considering the cumulative impact of other pollution sources, such as vessels and cars.

Table 8.2-1 Ambient Air Quality Standards

(Unit: μg/m^3, (ppm))

Parameter	Averaging time	Allowable frequency	Tunisian Standards related to Air (No. 106-04)		IFC/EHS guidelines (General; 2007)
			Standards	Guidelines	
CO	8 hrs	Twice/ 30 days	10,000 (9)	10,000 (9)	-
	1 hr	Twice/ 30 days	40 (35)	30 (26)	-
NO_2	Year	-	200 (0.106)	150 (0.080)	40
	1 hr	Once/ 30 days	660 (0.350)	400 (0.212)	200
O_3	8 hrs	-	-	-	160
	1 hr	Once/ 30 days	235 (0.12)	150 - 200 (0.077 - 0.102)	-
PM_{10}	Year	-	80	40 - 60	70
	24 hrs	-	-	-	150
	1 hr	Once/ 12 months	260	120	-
SO_2	Year	-	80 (0.030)	50 (0.019)	-
	24 hrs	Once/ 12 months	365 (0.12)	125 (0.041)	125
	3 hrs	Once/ 12 months	1,300 (0.50)	-	-

Parameter	Averaging time	Allowable frequency	Tunisian Standards related to Air (No. 106-04)		IFC/EHS guidelines (General; 2007)
			Standards	Guidelines	
	10 min	-	-	-	500
Pb	Year	-	2	0.5 - 1	-
H_2S	1 hr	Once/ 12 months	200	-	-

Source: Tunisian Standards related to Air (No. 106-04), IFC/EHS guidelines (General; 2007)

2) Emission Gas Standards

Standards for exhaust gas emissions from a stationary source (2010-2519 September 2010) are shown in Table 8.2.2. In this Project, the fixed source of exhaust gas is a gas turbine and fuel is natural gas. In addition, emergency fuel (5 days expected per year) is a diesel oil.

Note that in Table 8.2.2, IFC / EHS guidelines (Thermal Power Plant 2008) are shown as reference values. The emission gas standards are applied for the Project.

Table 8.2-2 Emission Gas Standards of Gas Turbines

(Unit: mg/m^3 ,(ppm))

Parameter	Fixing Upper Limit of Polluted Air from Stationary Source (2010-2519)		IFC/EHS guidelines (Thermal; 2008)	
	Natural gas	Diesel oil	Natural gas	Diesel oil
SO_2	10 (3)	120 (41)	-	Use of 1% or less S fuel*1 Use of 0.5% or less S fuel*2
NO_2 (20 <MW <50)	80 (39)	120 (58)	51 (25)	152 (74)
(MW >50)	50 (24)	120 (58)		
CO	85 (68)	85 (68)	-	-
Dust	10	20	-	-
PM_{10}	-	-	-	50*1 30*2

Notes: The values are converted into 15% of O_2 concentration.
*1: Non-degraded airshed
*2: Degraded airshed: Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or in their absence.
Source: Fixing upper limit of polluted air from stationary source (2010-2519), IFC/EHS guidelines (Thermal; 2008).

3) Water Quality

a. Ambient Water Quality Standards

There are no standards in Tunisia concerning water quality and environmental standards. Only emission conditions of industrial and domestic wastewater are only defined.

b. Discharged Wastewater Standards

Discharged wastewater standards (Tunisian standard No.106-02 July, 1989) are shown in Table 8.2-3. Reference values vary depending on the place where the water is discharged, however water will be discharged into the sea in this Project.

Note that in Table 8.2-3, industrial wastewater values as well as domestic wastewater values of IFC / EHS guidelines are shown for reference (Thermal Power Plant 2008 and 2007 General, respectively). The discharged wastewater standards are applied for the Project.

Table 8.2-3 Discharged Wastewater Standards

Parameter	Unit	Tunisian Standard related to Effluent (No.106-02)			IFC/EHS guidelines	
		Discharge into sea	Discharge into continental water	Dischar-ge into sewage network	Industry wastewater (Thermal Power Plant; 2008)	Sanitary sewage (General; 2007)
Temperature	°C	35	25	35	-*	-
pH	-	6.5 - 8.5	6.5 - 8.5	6.5 – 9	6 – 9	6 – 9
Suspended Solid	mg/L	30	30	400	50	50
Settled Solid	mg/L	0.3	0.3	-	-	-
COD	mg/L	90 (Excepting bathing water and aquacult-ure)	90	1,000	-	125
BOD_5	mg/L	30	30	400	-	30
Cl	mg/L	-	600	700	-	-
Cl_2	$mgCl_2/L$	0.05	0.05	1	-	-
ClO_2	mg/L	0.05	0.05	0.5	-	-
Chlorine residual	mg/L	-	-	-	0.2	-
SO_4	mg/L	1,000	600	400	-	-
Magnesium (Mg)	mg/L	2,000	200	300	-	-
Potassium (K)	mg/L	1,000	50	50	-	-
Sodium (Na)	mg/L	-	300	1,000	-	-
Calcium (Ca)	mg/L	-	500	-	-	-
Aluminium (Al)	mg/L	5	5	10	-	-
Color scale platinum cobalt	mg/L	100	70	-	-	-
Sulfide	mg/L	2	0.1	3	-	-
Fluoride	mg/L	5	3	3	-	-
NO_3-N	mg/L	90	50	90	-	-
NO_2-N	mg/L	5	0.5	10	-	-
NH_3-N	mg/L	30	1	100	-	-
T-N	mg/L	-	-	-	-	10
PO_4-P	mg/L	0.1	0.05	10	-	-
T-P	mg/L	-	-	-	-	2
Phenols	mg/L	0.05	0.002	1	-	-
Oils saponifibles	mg/L	20	10	30	-	-
Tolat aliphatic hydrocarbons	mg/L	10	2	10	10	10

Parameter	Unit	Tunisian Standard related to Effluent (No.106-02)			IFC/EHS guidelines	
		Discharge into sea	Discharge into continental water	Discharge into sewage network	Industry wastewater (Thermal Power Plant; 2008)	Sanitary sewage (General; 2007)
(Oil, grease, tar)						
Chloride solvents	mg/L	0.05	0	0.1	-	-
Anionic detergents (ABS)	mg/L	2	0.5	5	-	-
Boron (B)	mg/L	20	2	2	-	-
Iron (Fe)	mg/L	1	1	5	1.0	-
Copper (Cu)	mg/L	1.5	0.5	1	0.5	-
Tin (Sn)	mg/L	2	2	2	-	-
Manganese (Mn)	mg/L	1	0.5	1	-	-
Zinc (Zn)	mg/L	10	5	5	1.0	-
Molybdenum (Mo)	mg/L	5	0.05	5	-	-
Cobalt (Co)	mg/L	0.5	0.1	0.5	-	-
Bromine active Br_2	mg/L	0.1	0.05	1	-	-
Barium (Ba)	mg/L	10	0.5	10	-	-
Silver (Ag)	mg/L	0.1	0.05	0.1	-	-
Arsenic (As)	mg/L	0.1	0.05	0.1	0.5	-
Berylium (Be)	mg/L	0.05	0.01	0.05	-	-
Cadmium (Cd)	mg/L	0.005	0.005	0.1	0.1	-
Cyanogen (CN^-)	mg/L	0.05	0.05	0.5	-	-
Hexavalent chromium (Cr^{6+})	mg/L	0.5	0.01	0.5	0.5 (T-Cr)	-
Trivalent chromium (Cr^{3+})	mg/L	2	0.5	2	-	-
Antimony (Sb)	mg/L	0.1	0.1	0.2	-	-
Nickel (Ni)	mg/L	2	0.2	2	-	-
Selenium (Se)	mg/L	0.5	0.05	1	-	-
Mercury (Hg)	mg/L	0.001	0.001	0.01	0.005	-
Lead (Pb)	mg/L	0.5	0.1	1	0.5	-
Titanium (Ti)	mg/L	0.001	0.001	0.01	-	-
Pesticides - Insecticides - Organic phosphorous compounds - Carbamate compounds - Chemical herbicides - Fungicides - PCB & PCT	mg/L	0.005	0.001	0.01	-	-
Fecal coliform bacterium	MPN/ 100 mL	2,000	2,000	-	-	400

Parameter	Unit	Tunisian Standard related to Effluent (No.106-02)			IFC/EHS guidelines	
		Discharge into sea	Discharge into continental water	Dischar-ge into sewage network	Industry wastewater (Thermal Power Plant; 2008)	Sanitary sewage (General; 2007)
Fecal streptococci	MPN/ 100 mL	1,000	1,000	-	-	-
Salmonella	MPN/ 500 mL	Absence	Absence	-	-	-
Vibrio cholerae	MPN/ 100 mL	Absence	Absence	-	-	-

Notes: *: Elevated temperature areas should be minimized by adjusting intake and outfall design though the project specific EIA depending on the sensitive aquatic ecosystems around the discharge point.
Source: Tunisian Standard related to Effluent (No.106-02), IFC/EHS guidelines (General; 2007) and (Thermal; 2008).

4) Noise
Decree No. 84-1556 of 29 December 1984 on the regulation of industrial estates. Under Article 26 of this Decree, the noise level generated by a business day shall not exceed 50 dBA, measured at the facade of the closest house from the noise source. For reference, IFC/ EHS guidelines (General 2007) are shown in Table 8.2-4. IFC/EHS guideline requires should not exceed the levels in the Table, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site. The decree of the noise level is applied for the Project.

Table 8.2-4 Noise Level Values of IFC/EHS Guidelines

Receptor	One hour LAeq (dBA)	
	Daytime 07:00-22:00	Nighttime 22:00-07:00
Residential, Institutional, and Educational	55	45
Industrial and Commercial	70	70

Source: IFC/EHS guidelines (General; 2007)

5) Solid waste
The law concerning management and disposal of solid waste (Law No. 96-14) stipulates criteria for the classification of solid wastes and disposal methods for each classified solid waste. Solid waste is classified mainly as follows. Household waste, hazardous waste, stabilized waste (such as scrap metal and waste plastic), packaging materials, and special waste (such as sludge of wastewater treatment plants and medical waste). The collection of solid waste is under the responsibility of local governments, and disposal is carried out by the national agency for waste management and disposal (ANGED).
Regulation on hazardous waste (Regulation No. 2339-2000) stipulates 20 types of hazardous waste (Table 8.2-5). Detailed items are shown for thermal power plants.

Table 8.2-5 List of Hazardous Waste

Code	Designation
01	**Radioactive waste**
0101	Medical waste

Code	Designation
0102	Non-medical waste
0103	Waste from consumable products containing radioactive agents
0104	Nuclear reactors' waste
02	**Waste from medical or veterinary centers and from associated research**
0201	Waste maternity, diagnosis, treatment or human disease prevention units
0202	Waste from research, diagnosis, treatment or animal-disease prevention
03	**Waste from primary production (agriculture, horticulture, hunting, fishing, aquaculture and food processing production)**
0301	Waste from primary production
0302	Waste from fruit, vegetables, cereals, food oil processing; and from canned food and tobacco production
04	**Waste from mine exploration and exploitation, and from ore processing**
0401	Waste from metallic minerals physical and chemical processing
0402	Waste from non-metallic minerals physical and chemical processing
0403	Drilling and other waste muds
05	**Waste from wood, paper, card-board, panels and furniture processing**
0501	Waste from wood protection products
0502	Waste from paper, card-board and paper paste processing
06	**Waste from leather and textile industries**
0601	Leather industry waste
0602	Textile industry waste
07	Waste from oil refining, natural gas purification and carbon pyrolitc treatment
0701	Muds and solid waste containing hydrocarbons
0702	Used filtration clays
0703	Waste from coal pyrolitic treatment
0704	Waste from natural gas purification
0705	Waste from oil regeneration
08	**Waste from mineral chemistry processes**
0801	Acid solutions waste
0802	Alcaline solutions waste
0803	Salt waste and their solutions
0804	Waste containing metals
0805	Waste from in situ waste
0806	Waste from sulfur chemistry and desulfuration processes
0807	Waste from halons chemistry
0808	Waste from phosphates chemistry
0809	Waste from mineral chemistry
09	**Waste from organic chemistry processes**
0901	Waste from basic organic products making, formulation, distribution and use (MFDU)
0902	Waste from basic organic products MFDU
0903	Waste from organic dyes and pigments MFDU
0904	Waste from organic pesticides MFDU
0905	Waste from pharmaceutical products MFDU
0906	Waste from grease, soaps, detergents, disinfectants and cosmetic substances
0907	Waste from MFDU of chemical products resulting from fine chemistry and of chemical products not mentioned elsewhere
10	**Waste from MFDU coating products (polish, vitreous (glass) enamels), putty (fillers) and printing inks**

Code	Designation
1001	Waste from paints and polish
1002	Waste from MFDU printing inks
1003	Waste from MFDU glues and fillers (putty) including sealing (water-proofing) products
11	**Waste from photographic industry**
1101	Waste from photographic industry
12	**Waste from thermic processes**
1201	Waste from electric power plants and other combustion plants
120101	Fly ash
120102	Sulfuric acid
1203	Pyrometallurgy aluminum waste
1204	Waste from lead pyrometallurgy
1205	Waste from zinc pyrometallurgy
1206	Waste from copper pyrometallurgy
1207	Waste from cement (concrete), lime and plaster manufacture and by-products
13	**Inorganic waste containing metals from metals treatment and coating, and from non-irony metals hydrometallurgy**
1301	Liquid and mud waste from metals (for example, galvanic processes, zinc coating, stripping, engraving, phosphatisation, alkaline cleaning and degreasing
1302	Mud and solids from non-irony hydrometallurgic metals
1303	Mud and solids from waste tempering processes
14	**Waste from shaping and surface mechanical treatment metals and plastic materials**
1401	Waste from shaping (ironing, soldering, pressing, stretching, turnmilling/ turning, cutting and filing)
1402	Waste from hydraulic and steam degreasing
15	**Used oils except food oils**
1501	Used brake hydraulic and liquid oils
1502	Used engine, gear-box and lubricating oils
1503	Used isolating, heat-transfer and other fluids
1504	Bilge oils hydrocarbons (fuels)
1505	Content of hydraulic/ hydrocarbon separators
1506	Used oils non-specified elsewhere
16	**Waste from organic substances used as solvents**
1601	Waste from metals degreasing and machine maintenance
1602	Waste from textile cleaning and natural products degreasing
1603	Waste from electronic industries
1604	Coolants and aerosol and moss propellers
1605	Waste from solvents and coolants recovery (distillation caps/ waste)
17	**Construction and demolition waste**
1701	Isolating materials
18	**Waste from waste-treatment plants, sanitation and used-water plants, and water industry**
1801	Waste from waste burning or municipal pyrolyse and like wastes from small businesses, industries and administration offices
1802	Waste from specific physico-chemical industrial wastes (e.g., dechroming, decyanuring and neutralization)
1803	Vitrified waste and waste from vitrification
1804	Discharge leachates (= *toxic liquids from waste in waste landfills*)

Code	Designation
1805	Waste from used-water treatment plants non-specified elsewhere
19	Household and like waste from small businesses, industries and offices, including the parts collected separately
1901	Separately collected parts
20	**Wastes non-specified elsewhere**
2001	End-of-life vehicles
2002	Discarded equipment and shredding waste
2003	Explosives waste
2004	Batteries and accumulators
2005	Waste from the cleaning of transport and storage tanks

Source: List of Hazardous Waste (Regulation No.2000-2339)

(3) International Conventions and Treaties

Below are the main international conventions and treaties relating to environmental protect which Tunisia has ratified.

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington Convention)
- Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention)
- African Convention on the Conservation of Nature and Natural Resources
- Agreements for protection of trans-boundary movements of Migratory Birds
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
- Convention on Biological Diversity
- United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
- Bern Convention on the Conservation of European Wildlife and Natural Habitats
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78 Convention)
- Stockholm Convention on Persistent Organic Pollutants
- United Nations Framework Convention on Climate Change

8.2.3 Overview of Environmental Impact Assessments

(1) Procedures of Environmental Impact Assessments (EIAs)

Procedures for EIAs have been established by decree No.91-362 in 1991, and some modifications have been made by decree No.2005-1991 dated July 11, 2005. The Annex-I of the decree, shows a list of 26 projects as category A and another list of 24 projects as category B. Category A is deemed to be equivalent to category B and Category B equivalent to category A respectively under the “Japan International Cooperation Agency (JICA) Guidelines for Environmental and Social Considerations (April 2010)”. Establishment of an EIA is mandatory for projects classified as category A and category B. In addition, 18 projects are listed in Annex-II of the said decree. These projects are not required to conduct an EIA, but the implementing agency is required to take measures as stipulated in the ordinance of the respective ministry responsible for the project (Table 8.2-6).

Since power plants of 300 MW or more are classified as category B, this Project belongs to category B by Tunisian regulations.

Table 8.2-6(1) Projects of Category A (Annex-I)

No.	Project
1	Management facility of domestic waste with treatment capacity not over 20t/day
2	Treatment/manufacturing facility for construction material, glass and ceramics
3	Drugs and medicines manufacturing facility
4	Non-ferrous metalworking facility
5	Metalworking/surface treatment facility
6	Oil/natural gas exploring/test-drilling project
7	Soil and sand-drilling and collecting site/metal mining site producing not over 300 thousand tons/year.
8	Sugar/yeast producing facility
9	Dyeing facility, knitting product washing facility
10	Development of industrial complex not over 15 ha
11	Urbanization project of 5 ha to 20 ha
12	Tourist area development project of 10 ha to 30 ha
13	Mineral fiber manufacturing facility
14	Food manufacturing/processing/storing facility
15	Meat processing facility
16	Vehicle (part) manufacturing/assembling factory
17	Dockyard
18	Airplane manufacturing/maintaining facility
19	Shellfish culture facility
20	Desalination facility in a factory or tourist facility
21	Sea-bathing/spa facility
22	Hotels of more than 300 beds
23	Paper/cardboard manufacturing facility
24	Elastomer/peroxide manufacturing facility

Source: Decree No. 2005-1991 related to Environmental Impact Assessment.

Table 8.2-6(2) Projects of Category B (Annex-I)

No.	Project
1	Oil refining plant, gasification/liquefaction facility with coal/oil shale treatment capacity of more than 500t/day
2	Power generation facility of more than 300 MW
3	Management facility of domestic waste with treatment capacity over 20t/day
4	Hazardous waste management facility
5	Cement/lime/plaster manufacturing facility
6	Manufacturing facility of chemicals, pesticide, paint, abrasive, and bleach generally considered as hazardous, unwelcome facility having bad effect on health.
7	Iron/steel manufacturing facility
8	Project concerning soil-drilling and natural resource development producing over 300 thousand tons/year.

No.	Project
9	Pulp-manufacturing and cellulose-processing facility
10	Project concerning construction of railways, main roads, highways, bridges and interchanges.
11	Project concerning construction of airport with runway of over 2100 m long.
12	Project concerning commercial port, fishing port and leisure port
13	Project concerning development of industrial area over 5ha.
14	Urbanization project with the area of over 20 ha
15	Tourist area development project of over 30 ha
16	Transportation facility for crude oil and gas
17	Municipal effluent treatment facility
18	Centralized treatment facility for industrial effluent
19	Tanner
20	Irrigation plant using treated water for agriculture
21	Large-scaled dam project
22	Agricultural project not listed in Annex-II
23	Desalination facility for drink water supply to urban areas
24	Hotels of more than 1000 beds
25	Extraction, treatment and washing facility for metals/non-metals
26	Phosphorus and its byproduct treatment facility

Source: Decree No. 2005-1991 related to Environmental Impact Assessment.

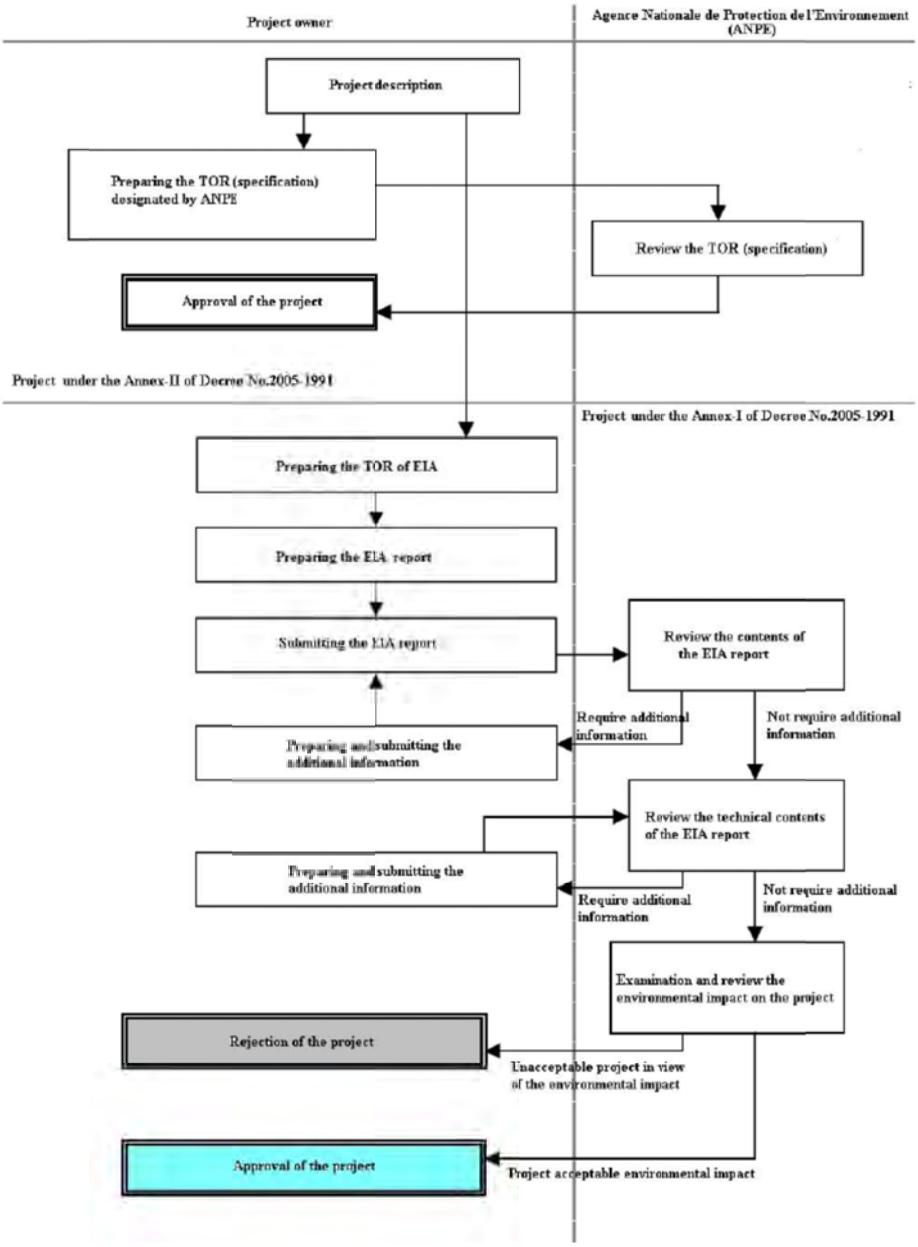
Table 8.2-6(3) Projects Listed in Annex-II

No.	Project
1	Urbanization project with an area of less than 5 ha; Touristic area development project of less than 10 ha
2	Project concerning construction of schools or educational facility
3	Pipeline installation project for water supply
4	Transmission line installation project not listed in Annex-I and not passing through a (legally-protected) vulnerable area.
5	Coastal area development project not cited in Annex-I
6	Olive oil extraction facility
7	Vegetable/animal oil extraction facility
8	Livestock farming facility
9	Textile industry not listed in Annex-I.
10	Large metal parts press/cutting facility
11	Hydrocarbon transport/storing facility, vehicle washing facility
12	Starch food manufacturing facility
13	Conventional rock quarry
14	Gas/chemical substances storage facility
15	Boiler/reservoir construction project, sheet metal plant
16	Laundry industry using water
717	Small-scaled water storage facility
18	Manufacturing facility for nutritional supplement and others

Source: Decree No.2005-1991 related to Environmental Impact Assessment.

For projects belonging to Annex-2, for which an EIA is not required, the implementing agency must submit to ANPE some necessary specification (design) documents and upon the evaluation/approval of ANPE, the project will be approved.

On the other hand, for projects belonging to category A or B, an EIA must be examined by ANPE for its content and technical justification. ANPE is supposed to issue its comments on the EIA within 21 working days after the submission of an EIA report for Category A projects and within three months for Category B projects. If no comments are received from ANPE, the project is deemed to be approved. In the case where ANPE's comments require further investigation, further time is required before receiving approval (Figure 9.1). In addition, an EIA is supposed to be executed not by the implementing agency itself but by an external professional organization (consulting firm or professional expert in environmental issues).



Source: Japan Bank for International Cooperation (JBIC) "Environmental profile of Tunisia (2006)" and JICA Study Team.

Figure 8.2-1 Flow of EIA Procedure

For the EIA of this project, STEG, through its bidding procedures, selected a Tunisian consulting firm TPE (Tunisia Protec Environment). The EIA report was completed in December 2013 and submitted by STEG to ANPE (Agence Nationale de Protection de l'Environnement) on 10th of December, 2013. The EIA report was approved by ANPE on 13th of February, 2014.

STEG received 8 points as condition of approval and has to provide an updated EIA that includes all those points to ANPE. STEG. will respond to the conditions of EIA Approval (Table 8.2-7)

Table 8.2-7 Response to Conditions of EIA Approval

No.	Conditions	Background of Conditions	Correspondence
1	Cumulative Impact of all power plants with the monitoring of the previous projects	ANPE has argued that one season measurements data are not enough to evaluate the simulated model.	STEG ordered TPE (environmental consultant who prepared the submitted EIA report to ANPE) to conduct a second simulation based on sea water temperatures measured in two different seasons (cold and hot seasons).STEG has already provided TPE the result of temperature measurements done in July 2008 and in March 2010 in addition to data mesured in September 2013. Once TPE finish a second simulation of thermal effluent diffusion, they will update the EIA report with the result of second simulation. STEG plans to submit the updated EIA to ANPE as soon as possible.
2	The effect of increasing the outlets volume of the thermal dispersion and its spreading into the sea	ANPE requested to show the difference of thermal effluent dispersion between before and after operation of Rades C.	By remodeling the thermal dispersion model, STEG ordered TPE to provide two simulations. The first one will present the thermal dispersion of the existing power plants: Rades A, Rades B and IPP. The second one will present the cumulative impact of thermal dispersion of all power plants including the future one, Rades C.
3	Mode of management of salty waters	ANPE requested to describe how salty waters from purification system will be managed.	STEG ordered TPE to update the EIA report by adding an explicative paragraph describing how salty waters, which are of very small quantity comparing to cooling waters, will be managed. In the existing Rades A and B, the salty waters are directly evacuated into the sea, because they contain no chemicals.
4	Construction phase impact on underground water	ANPE requested to explain how to manage waste water	The power plant will be installed on drilled stakes, so that most of the leveling works would be dry. Once the drilling

No.	Conditions	Background of Conditions	Correspondence
		from underground.	reaches the underground water, pumping for evacuating underground water will be performed. This discription will be written in the updated EIA.
5	Details of outlets dispersion model in the sea (wind direction, water currents, etc.)	ANPE requested to indicate details of data set which used for thermal effluent dispersion model.	The data used for simulating thermal dispersion will be appended to the updated EIA report.
6	Detailed environmental monitoring plan	----	The updated environmental monitoring plan, which is same as Attachment 20, will be included in the updated EIA report.
7	The revised environmental management plan	----	The updated environmental management plan, which is same as Attachment 19, will be included in the updated EIA report.
8	The presentation of the minutes of all public hearings conducted in the framework of this project	----	All minutes of public hearings will be appended to the updated EIA report.

Source: STEG

(2) Contents of an EIA report

Decree No.2005-1991 stipulates that an EIA report shall include at least the following items.

a. A detailed overview of the project
b. Current situation of the project site and analysis of natural resources and other items that may be affected by the implementation of the project
c. Analysis of impacts the project can have on natural resources, flora and fauna, protected areas including forests, historical sites, protected breeds and national parks, etc.
d. Possible avoidance, reduction or measures together with their cost estimates that the implementing agency could take against estimated negative impacts to be caused by the implementation of the project
e. Detailed environmental management plan

(3) Gaps between the EIA Report and JICA Guideline

Table 8.2-8 shows the gaps between the items treated by the EIA report for Rades C Project and the items required by the JICA guidelines.

Table 8.2-8 Discrepancies between the EIA Report and the Contents required by the JICA Guidelines for Environmental and Social Considerations

Content	JICA Guidelines for Environmental and Social Considerations	EIA Report	Gap and Action taken
Executive Summary	Concisely discusses significant findings and recommended actions.	No executive summary	There is a gap. The JICA Study Team elaborated an executive

Content	JICA Guidelines for Environmental and Social Considerations	EIA Report	Gap and Action taken
			summary in the Team's final report.
Policy, Legal, and Administrative Framework	The framework within which the EIA report is to be carried out.	Chapter I	There is no gap.
Project Description	Describes the proposed project and its geographic, ecological, social and temporal context, including any off-site investments that may be required (e.g., dedicated pipelines, access roads, power plants, water supply, housing, or raw material and product storage facilities). It also indicates the need for any resettlement or social development plan. It normally includes a map showing the project site and the area affected by the project.	Chapter III	There is no gap.
Baseline Data	Assesses the dimensions of the study area and describes relevant physical, biological, and socio-economic conditions, including all changes expected to occur before the project commences. Additionally, it takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about project site, design, operation, or mitigation measures, and it is necessary to indicate the accuracy, reliability, and sources of the data.	Chapter IV	There is a lack of some baseline data. JICA and the JICA Study Team obtained certain baseline data and stateed them in the Team's final report.
Environmental Impacts	Predicts and assesses the project's likely positive and negative impacts in quantitative terms, to the extent possible. It identifies mitigation measures and any negative environmental impacts that cannot be mitigated, and explores opportunities for environmental enhancement. It identifies and estimates the extent and quality of available data, essential data gaps and uncertainties associated with predictions, and it specifies topics that do not require further attention.	Chapter V	There is no gap.
Analysis of Alternatives	Systematically compares feasible alternatives to the proposed project site, technology, design, and operation including the "zero option (without project)" situation in terms of the following: the potential environmental impacts; the feasibility of mitigating these impacts; the capital and recurrent costs; the suitability under local conditions; and the institutional, training, and monitoring requirements. For each of the	No analysis of alternatives	The JICA Study Team made analysis of five alternatives (including "zero option" and stated them in the Team's

Content	JICA Guidelines for Environmental and Social Considerations	EIA Report	Gap and Action taken
	alternatives, it quantifies the environmental impacts to the extent possible, and attaches economic values where feasible. It also states the basis for selecting the particular proposed project design, and offers justification for recommended emission levels and approaches to pollution prevention and abatement.		final report.
Environmental Management Plan	Describes mitigation, monitoring, and institutional measures to be taken during construction and operation in order to eliminate adverse impacts, offset them, or reduce them to acceptable levels.	Chapter VI-VII ”	There is no detailed “Environmental Monitoring Plan”. JICA and the JICA Study Team discussed detailed “Environmental Monitoring Plan” with STEG and stated it in the Team’s final report.
Community Consultation	Includes a record of consultation meetings (date, venue, participants, procedures, opinions of major local stakeholders and responses to them, and other items), including consultations for obtaining the informed views of the affected people, local nongovernmental organizations (NGOs), and regulatory agencies.	Chapter VII	The JICA Study Team has supported to hold stakeholders meetings.
Annexes	World Bank safeguard policy OP 4.01 Annex B (i) List of EIA report contributors - individuals and organizations. (ii) References - written materials both published and unpublished, used in the study preparation. (iii) Record of interagency and consultation meetings, including consultations for obtaining the informed views of the affected people and local NGOs. The record specifies any means other than consultations (e.g., surveys) that were used to obtain the views of affected groups and local NGOs. (iv) Tables presenting the relevant data referred to or summarized in the main text. (v) List of associated reports (e.g., resettlement plan or indigenous people development plan).	Some information available in the main text and its annexes	No gap in substance. Resettlement plan or indigenous people development plan is not applicable.

Source: JICA Study Team.

(4) Other required environmental permits

Before granting an approval on EIA report, ANPE's practice is to consult with other relevant institutions such as APAL in case of this project. Since STEG has already obtained an approval of ANPE, there remains no environmental permit which is further required.

(5) International conventions and Tunisian laws relating to protect wildlife and species of flora

Table 8.2-9 shows relation between the international conventions and Tunisian laws relating to protect wildlife.

Table 8.2-9 Relationship between the International Conventions and Tunisian Laws

International sonventions	Tunisian Laws
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	Law No.86-64
Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington Convention)	Law No.74-12
Agreements for protection of trans-boundary movements of Migratory Birds	Law No.86-63
Convention on Biological Diversity	Law No.93-45
Bern Convention on the Conservation of European Wildlife and Natural Habitats	Law No.95-75

Source: Japan Bank for International Cooperation (JBIC) "Environmental profile of Tunisia (2006)"

Protected species lists of flora and fauna in Tunisia (Decision of Ministry of Agriculture and Water Resources dated July 19, 2006) are shown in Table 8.2-10 and Table 8.2-11 respectively. Capturing and picking of these species are prohibited and for certain number of species their natural habitat is designated as part of national park etc. for protection purpose. Species listed as red list category under IUCN (International Union for Conservation of Nature and Natural Resources), species regulated for international transactions under CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), and endangered or threatened species listed in Barcelona Convention[2] are marked for reference together with category and rank.

[2] In 1975, 16 Mediterranean countries and the European Community adopted the Mediterranean Action Plan (MAP), the first-ever Regional Seas Programme under UNEP's umbrella.
In 1976 these Parties adopted the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention). Seven Protocols addressing specific aspects of Mediterranean environmental conservation complete the MAP legal framework:
* Dumping Protocol (from ships and aircraft)
* Prevention and Emergency Protocol (pollution from ships and emergency situations)
* Land-based Sources and Activities Protocol
* Specially Protected Areas and Biological Diversity Protocol
* Offshore Protocol (pollution from exploration and exploitation)
* Hazardous Wastes Protocol
* Protocol on Integrated Coastal Zone Management (ICZM)
The 17th COP meeting made the list of endangered or threatened species regarding "Specially Protected Areas and Biological Diversity Protocol".

Table 8.2-10 Proteced Species of Flora in Tunisia (Decision of Ministry of Agriculture and Water Resources dated July 19, 2006)

Class	Order	Family	Scientific Name	English Name	Conservation Status		
					IUCN 1) 2013/Jan	CITES 2) 2013/Jun	Barcelona Convention 2012 3)
Magnoliopsida	Fagales	Fagaceae	*Castanea sativa*	Chestnut	-	-	-
Magnoliopsida	Fagales	Fagaceae	*Quercus afares*	Oak	-	-	-
Pinopsida	Pinales	Pinaceae	*Cedrus atlantica*	Atlas Cedar	EN	-	-
Pinopsida	Pinales	Cupressaceae	*Cupressus simperverens*	Mediterranean Cypress	-	-	-
Magnoliopsida	Sapindales	Aceraceae	*Acer monspessulanurm*	Maple	-	-	-
Magnoliopsida	Rosales	Rosaceae	*Prunus avium*	Wild Cherry	-	-	-
Magnoliopsida	Rosales	Cannabaceae	*Celtis australis*	European Nettle Tree	-	-	-
Magnoliopsida	Rosales	Ulmaceae	*Ulmus compestris*	Field Elm	-	-	-
Magnoliopsida	Sapindales	Anacardiaceae	*Pistacia atlantica*	Mt. Atlas mastic tree	-	-	-
Magnoliopsida	Fabales	Leguminosea	*Acacia radiana*	-	-	-	-
Magnoliopsida	Polygonales	Polygonaceae	*Calligonum azel*	-	-	-	-
Magnoliopsida	Polygonales	Polygonaceae	*Calligonum arich*	-	-	-	-
Magnoliopsida	Rosales	Rosaceae	*Cotoneaster racemiflora*	-	-	-	-
Magnoliopsida	Fabales	Leguminosea	*Genista saharae*	-	-	-	-
Magnoliopsida	Lamiales	Lamiaceae	*Marrubium deserti*	-	-	-	-
Magnoliopsida	Gentianales	Asclepiadaeae	*Periploca laevigata*	-	-	-	-
Magnoliopsida	Rosales	Rosaceae	*Poterium spinosum*	-	-	-	-
Magnoliopsida	Rosales	Rosaceae	*Prunus syriaca*	Mirabelle Prune	-	-	-
Magnoliopsida	Rosales	Rosaceae	*Sorbus aria*	Whitebeam	-	-	-
Magnoliopsida	Solanales	Solanacea	*Withania frutescens*	-	-	-	-
Magnoliopsida	Fabales	Leguminosea	*Anthyllis barba jovis*	Beard of Jupiter	-	-	-
Magnoliopsida	Fabales	Leguminosea	*Anthyllis sericea*	-	-	-	-
Magnoliopsida	Caryophyllales	Chenopodia-Ceae	*Atriplex mollis*	-	-	-	-
Magnoliopsida	Polygonales	Polygonaceae	*Calligonum comosum*	-	-	-	-
Magnoliopsida	Rosales	Rhamnaceae	*Rharmnus frangula*	-	-	-	-
Magnoliopsida	Brassicales	Brassicaceae	*Oudneya africana*	-	-	-	-
Magnoliopsida	Fabales	Leguminosea	*Prosopis stephaniana*	-	-	-	-
Magnoliopsida	Rhamnales	Rhamnaceae	*Ziziphus spinachus*	-	-	-	-
Magnoliopsida	Sapindales	Anacardiaceae	*Rhus tripartitum*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Aristida pulmosa*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Aristida ciliate*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Aristida obtuse*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Cymbopogon schoenantus*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Dactylis glomerata*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Digitaria commutata*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Pennisetum dichotomum*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Pennisetum elatum*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Pennisetum Sotaceum*	-	-	-	-
Liliopsida	Poales	Poaceae	*Cecnchrus ciliaris*	African Foxtail Grass	-	-	-
Liliopsida	Poales	Poaceae	*Tricholaena lanerife*				-
Liliopsida	Cyperales	Gramineae	*Panicum turgidum*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Stipa fontasii*	-	-	-	-

Class	Order	Family	Scientific Name	English Name	Conservation Status		
					IUCN 1) 2013/Jan	CITES 2) 2013/Jun	Barcelona Convention 2012 3)
Liliopsida	Liliales	Asphodela-Ceae	*Asphodelus acaulis*	-	-	-	-
Magnoliopsida	Scrophulariales	Scophularia-ceae	*Anarrhinum brevifolium*	-	-	-	-
Liliopsida	Liliales	Colchicaceae	*Colchicum autonnale*	Autumn Crocus	-	-	-
Gnetopsida	Ephedrales	Ephwdraceae	*Ephedra alata alenda*	-	LC	-	-
Magnoliopsida	Malvales	Cistaceae	*Helianthermum confertum*	-	-	-	-
Liliopsida	Cyperales	Gramineae	*Sporobolus marginatus*	-	-	-	-
Magnoliopsida	Rosales	Rosaceae	Rosaceae	Rose	-	-	-
Magnoliopsida	Violales	Violaceae	*Viola* spp.	-	-	-	-
Liliopsida	Orchidales	Orchidaceae	*Orchis* spp.	Orchid	-	II	-
Liliopsida	Liliales	Liliaceae	Liliaceae	Tulip	-	-	-
Magnoliopsida	Primulales	Primulaceae	*Cyclamen* spp.	Cyclamen	-	II	-
Liliopsida	Liliales	Iridaceae	*Iris* spp.	-	-	-	-

Notes: Categoly of IUCN; **LC** (Least Concern), **NT** (Near Threatened), **VU** (Vulnerable),
EN (Endangered), **CR** (Critically Endangered), **EW** (Extinct in the Wild)
Categoly of CITES; **I** (Appendices I), **II** (Appendices II), **III** (Appendices III)
Source; 1) http://www.iucnredlist.org/search
2) http://www.cites.org/eng/resources/species.html
3) Annex II to Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Revised at the 17th COP meeting (UNEP/MAP, 2012)

Table 8.2-11 Proteced Species of Fauna in Tunisia (Decision of Ministry of Agriculture and Water Resources dated July 19, 2006)

Class	Order	Family	Scientific Name	English Name	Conservation Status		
					IUCN 1) 2013/Jan	CITES 2) 2013/Jun	Barcelona Convention 2012 3)
Mammalia	Artiodactyla	Bovidae	*Bubalus bubalis*	Water buffalo	-	-	-
Mammalia	Cetartiodatyla	Cervidae	*Cervus elaphus barbarus*	Red Deer	LC	III	-
Mammalia	Artiodactyla	Bovidae	*Addax nasomaculatus*	Addax	CR	I	-
Mammalia	Artiodactyla	Bovidae	*Oryx dammah*	Scimitar-horned Oryx	EW	I	-
Mammalia	Artiodactyla	Bovidae	*Gazella dorcas*	Dorcas Gazelle	VU	III	-
Mammalia	Artiodactyla	Bovidae	*Gazella dama mhorr*	Dama Gazelle	CR	I	-
Mammalia	Artiodactyla	Bovidae	*Gazella leptoceros*	Slender-horned Gazelle	EN	I	-
Mammalia	Artiodactyla	Bovidae	*Gazella cuvieri*	Cuvier's Gazelle	EN	I	-
Mammalia	Artiodactyla	Bovidae	*Ammotragus lervia*	Barbary Sheep	VU	II	-
Mammalia	Carnivora	Felidae	*Acinonyx jubatus*	Cheetah	VU	I	-
Mammalia	Carnivora	Mustelidae	*Lutra lutra*	Eurasian Otter	NT	I	-
Mammalia	Carnivora	Phocidae	*Monachus monachus*	Mediterranean Monk Seal	CR	I	-
Mammalia	Carnivora	Canidae	*Fennecus zerda*	Fennec Fox	LC	II	-
Mammalia	Carnivora	Hyaenidae	*Hyaena hyaena*	Striped Hyaena	NT	-	-
Mammalia	Carnivora	Mustelidae	*Mustela nivalis*	Least Weasel	LC	-	-
Mammalia	Carnivora	Felidae	*Leptailurus serval*	Serval	LC	II	-
Mammalia	Carnivora	Felidae	*Lynx caracal caracal*	Desert Lynx	LC	II	-
Mammalia	Eulipotyphla	Soricidae	*Crocidura russula*	White-toothed	LC	-	-

Class	Order	Family	Scientific Name	English Name	Conservation Status		
					IUCN 1) 2013/Jan	CITES 2) 2013/Jun	Barcelona Convention 2012 3)
				Shrew			
Mammalia	Rodentia	Hystricidae	*Hystrix cristata*	Crested Porcupine	LC	-	-
Mammalia	Rodentia	Ctenodactyli-dae	*Ctenodactylus gundi*	North African Gundi	LC	-	-
Mammalia	Chiroptera	-	All species of Chiroptera	Bat	LC – NT	II	-
Mammalia	Carnivora	Felidae	*Felis silvestris*	Wildcat	LC	II	-
Aves	Falconiformes	-	Falconiformes	Raptors	LC – EN	I – II	O
Aves	Strigiformes	Strigidae	All species of Strigidae	Owls	LC	II	-
Aves	Charadriiformes	Recurvirostri-dae	*Recurvirostra avosetta*	Pied Avocet	LC	-	-
Aves	Charadriiformes	Scolopacidae	*Calidris* spp.	Sandpiper	LC	-	-
Aves	Charadriiformes	Scolopacidae	*Tringa* spp.	Redshank	LC	-	-
Aves	Charadriiformes	Glareolidae	*Cursorius* spp.	Courser	LC	-	-
Aves	Charadriiformes	Scolopacidae	*Glareola* spp.	Pratincole	LC	-	-
Aves	Charadriiformes	Charadriidae	*Charadrius* spp.	Plover	LC	-	O
Aves	Charadriiformes	Recurvirostri-Dae	*Himantopus* spp.	Stilt	LC	-	-
Aves	Anseriformes	Anatidae	*Anas strepera*	Gadwall	LC	-	-
Aves	Anseriformes	Anatidae	*Tadorna Tadorna*	Common Shelduck	LC	-	-
Aves	Anseriformes	Anatidae	*Anas platyrhynchos*	Mallard	LC	-	-
Aves	Anseriformes	Anatidae	*Cygnus* spp.	Swan	LC	-	-
Aves	Anseriformes	Anatidae	*Oxyura leucocephala*	White-headed Duck	EN	II	-
Aves	Charadriiformes	Laridae	Laridae	Gull	LC – NT	-	-
Aves	Podicipedifor-mes	Podicipedi-dae	Podicipedidae	Grebes	LC	II	-
Aves	Anseriformes	Anatidae	*Mergus* spp.	Smew	LC	-	-
Aves	Gruiformes	Rallidae	*Aenigmatolimnas marginalis*	Striped Crake	LC	-	-
Aves	Gruiformes	Rallidae	*Rallus* spp.	Rail	LC	-	-
Aves	Gruiformes	Rallidae	*Sterna* spp.	Tern	LC	-	-
Aves	Pelecaniformes	Pelecanidae	*Pelecanus* spp.	Pelican	LC	-	-
Aves	Procellariifor-mes	Hydrobatidae	*Hydrobates pelagicus*	European Storm-petrel	LC	-	O
Aves	Procellariifor-mes	Procellariidae	*Puffinus puffinus*	Manx Shearwater	LC	-	-
Aves	Procellariifor-mes	Sulidae	*Morus bassanus*	Northern Gannet	LC	-	-
Aves	Ciconiiformes	Ardeidae	*Egretta garzetta*	Little Egret	LC	-	-
Aves	Ciconiiformes	Ciconiidae	*Ciconia ciconia*	White Stork	LC	-	-
Aves	Phoenicopteri-formes	Phoenicopteri-dae	*Phoenicopterus ruber*	American Flamingo	LC	II	-
Aves	Gruiformes	Gruidae	*Grus grus*	Common Crane	LC	II	-
Aves	Ciconiiformes	Threskiornithi-Dae	*Platalea leucorodia*	Eurasian Spoonbill	LC	II	-
Aves	Struthionifor-mes	Struthionidae	*Struthio camelus camelus*	Ostrich	LC	-	-

Class	Order	Family	Scientific Name	English Name	Conservation Status		
					IUCN [1] 2013/Jan	CITES [2] 2013/Jun	Barcelona Convention 2012 [3]
Aves	Gruiformes	Otididae	*Outarde houbara*	Houbara Bustard	VU	-	-
Aves	Passeriformes	-	Except bird pests in agriculture listed in the order of hunting	-	-	-	-
Amphibia	Caudata	Salamandridae	*Pleurodeles poireti*	Edough Ribbed Newt	EN	-	-
Amphibia	Caudata	-	Terrestrial salamanders	-	-	-	-
Amphibia	Anura	Bufonidae	All species of Bufonidae	True Toads	LC	-	-
Amphibia	Anura	Hylidae	*Hyla meriodionalis*	Mediterranean Tee Fog	-	-	-
Reptilia	Testudines	-	Tortues marines	Sea turtles	VU – CR	I	O
Reptilia	Testudines	Testudinidae	*Testudo gracea gracea*	Common Tortoise	VU	II	
Reptilia	Testudines	Emydidae	*Emys orbicularis*	European Pond Turtle	NT	-	
Reptilia	Testudines	Geoemydidae	*Mauremys leprosa*	Mediterranean Turtle	VU	-	
Reptilia	Squamata	Gekkonidae	Gekkonidae	Geckos	LC	-	
Reptilia	Squamata	Agamidae	Agamidae	Agamas	LC	-	
Reptilia	Squamata	Chamaeleoni-Dae	*Chamaeleo chamaeleon*	Mediterranean Chameleon	LC	II	
Reptilia	Squamata	Lacertidae	Lacertidae	Lezards	LC - CR	-	
Reptilia	Squamata	Scincidae	Scincidae	Scinques	LC	-	
Reptilia	Squamata	Viperidae	Viperidae	Viper	LC - VU	-	
Reptilia	Squamata	Elapidae	*Naja Arabica*	-	LC	II	
Reptilia	Squamata	Boidae	*Eryx jaculus*	-	-	II	
Insecta	Mantodea	-	Mantodea	Mantis	-	-	
Insecta	Phasmatodea	Phasmatidae	Phasmatidae	Phasma	-	-	
Insecta	Lepidoptera	Papilionidae	*Papilio* spp.	Swallowtail	-	-	
Insecta	Coleoptera	Lucanidae	*Lucanus* spp.	-	-	-	
Insecta	Coleoptera	Scarabaeidae	*Scarabaeus* spp.	Scarabee	-	-	

Notes: Categoly of IUCN; **LC** (Least Concern), **NT** (Near Threatened), **VU** (Vulnerable), **EN** (Endangered), **CR** (Critically Endangered), **EW** (Extinct in the Wild)
Categoly of CITES; **I** (Appendices I), **II** (Appendices II), **III** (Appendices III)
Source; 1) http://www.iucnredlist.org/search
2) http://www.cites.org/eng/resources/species.html
3) Annex II to Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Revised at the 17th COP meeting (UNEP/MAP, 2012)

8.3 Comparison of Alternatives Including Zero Option

8.3.1 Zero option (the case where the project is not implemented)

In case the project is not implemented, the predicted problem of power supply shortage will not be so solved (Table 8.3-1).

Table 8.3-1 Comparison with the Zero Option

Items	Project implementation	Zero option
Technical aspects	- Construction of the power plant within the existing plant site	N/A
Economic aspects	- The project, in spite of construction cost, will contribute to the promotion of economic growth of Tunisia. - Contribution to the regional economic vitalization is also expected, including employment of local people, utilization of local materials, etc.	- Although no construction cost is needed, shortage of electric supply will interfere with the economic growth of Tunisia. - There will be no contribution to the local economy as well, including job opportunities for local people.
Environmental-social consideration	- Certain environmental impact is predicted, although this project is an additional installation to the existing facility. Appropriate environmental protection measures shall be taken.	- Maintaining the status-quo (certain environmental impact from the existing facility is predicted).

Source: JICA Study Team

8.3.2 Comparison with Renewable Energy

The government of the Republic of Tunisia has been trying to promote renewable enery, wind power through STEG and solar photovoltaic, through the National Agency for Energy Management (Agence Nationale de Maîtrise d'Energy; ANME). However, realized generating capacity remains still very limited (Wind power 245 MW, Solar photovoltaic 6 MW etc. at the end of 2012). Constraints of appropriate location for installation, necessity for constructing new massive transmission lines, needs to construct an additional power plant during night time in case of solar panels, still high cost for installation are some of the reasons for not being able to replace the proposed project by renewable enrgy (Table 8.3-2).

Table 8.3-2 Comparison with Renewable Energy

Item	Proposed combined cycle project	Renewable energy
Technical aspects	- The new power plant can cope with the projected electricity demande increase in 2017, because the site has already been preparated. - Construction on existing site of Rades does not require any additional infrastructure such as road, gas pipeline.	- Given the past record and no preparation made until now, it is quite difficult to install necessary generation capacity within the required time. - Additional power plant is also needed during night time in case of solar panels. - Once project sites are selected, study for transmission lines is needed and new road construction may be required depending on sites.
Economic aspects	- High efficiency in power generation and lower cost per power generation unit (US$ 0.09/kWh).	- Still high cost for installation of facilities. In case of solar panels, a total surface of 400 ha (0.8ha/MW) is needed with an

Item	Proposed combined cycle project	Renewable energy
		estimated cost of 700 Million US$ for installment (US$ 1,400/kW) to get an equivalent capacity of 500 MW, without taking account of low operation rate of solar panels. - Power generation cost is estimated US$ 0.2-0.4/kWh. - Additional construction cost of transmission lines or new roads, as well as an additional power plant for the night time is also needed.
Environmental-social consideration	- CO_2 is produced by the project operation. - The project relates to the expansion of the existing power plant within the site, and is not supposed to cause additional significant impact on the natural environment. - Rades A Power Plant started operation in 1985, Rades B PP in 1998 and Rades II PP in 2002. The existing power plants have about 30 years of history within the local community through operation and expansion. The project relates to the expansion of the existing power plant within the site, and significant impact on the local community will be avoided.	- Practically no CO_2 emission, but an additional power plant, whice is needed during night time, will produce CO_2, if a thermal power plant is required. - Since huge land is necessary for installation, some impact may occur to natural environment. - Resettlement may be necessary depending on the location of transmission lines or new roads. - Since a new project (s) is to be launched, local community may suffer from some changes.

Source: JICA Study Team.

8.3.3 Consideration of an Alternative Site

According to the results of the consideration of a balance between electrical power supply and demand in the survey regarding transmission network enhancement, it was concluded that northern Tunisia would be the most efficient location selection for introducing a new power plant. However, the initial planned site at Kalaat El Andalous involves land acquisition. The process of land acquisition requires a long period of time, leading to the extension of the project implementation period, and considering that there is no candidate site immediately available northern Tunisia, STEG selected the vacant area of Rades TPPs site as the alternative site for the project (Table 8.3-3).

Table 8.3-3 Consideration of an Alternative site

Items	The project site	Kalaat El Andalous
Technical aspects	- There are already surrounding roads constructed, improved and ready for transportation of	- Construction and improvement of the surrounding roads is essential for transportation of

Items	The project site	Kalaat El Andalous
	materials.	materials.
Economic aspects	- The land for the project is already available and acquisition of new land is not necessary.	- Acquisition of new land is necessary.
Environmental-social consideration	- The project relates to the installation of a new power plant in an existing power plant site, and environmental impact related to the new facility is insignificant. - Additionally, the existing power plant is integrated into the local society and significant impact on the local society will be avoided.	- New acquisitions of land will significant affect the local society.

Source: JICA Study Team.

8.3.4 Consideration of Fuel

Rades TPP is already equipped with a gas station connected to the domestic gas supply network of Tunisia. In view of a stable gas supply and low environmental effects compared to other fuel, natural gas will be chosen as the fuel to be used in the Project (Table 8.3-4).

Table 8.3-4 Consideration of Fuel

Items	Natural gas	Oil	Coal
Technical aspects	- Fuel can be supplied only by building a pipeline between the site and the existing gas station.	- There is only a light fuel oil tank for auxiliary use. In order to use oil as the main fuel, a new jetty with fuel discharge facility needs to be constructed.	- Construction of a new jetty equipped with a coal discharge facility is needed. - A coal storage site and ash disposal site must be constructed as well.
Economic aspects	- Fuel costs are expensive, but construction costs for fuel supply facilities are very low, because there is the existing gas station by the project site.	- High fuel costs are expected, as well as high construction costs for fuel supply facility.	- Although fuel costs are low, construction costs of fuel supply facility will be high. - In addition, construction of a new coal storage site and ash disposal site requires land acquisition.
Environmental-social consideration	- As natural gas contains almost no ash and sulfur, dust and SOx will not be generated.	- Ash and sulfur will be generated and dust collector and de-sulfurization equipment will be	- Coal generates ash and dust collecting equipment will be needed. - De-sulfurization

Items	Natural gas	Oil	Coal
	- Amout of CO_2 emissions per thermal unit in the combustion natural gas is about 75% compared to oil combustion and about 60% compared to coal combustion[3].	needed. - Amout of CO_2 emissions per thermal unit in the combustion oil is about 130% compared to natural gas combustion and about 75% compared to coal combustion[2].	equipment will also be necessary depending on the sulfur contents of coal. - Land acquisition is also necessary and it is expected that this will have a significant impact on the local society. - Amout of CO_2 emissions per thermal unit in the combustion coal is about 170% compared to natural gas combustion and about 130% compared to oil combustion[2].

Source: JICA Study Team.

8.3.5 Consideration of Power Generation Method

In the case of using natural gas as fuel, a combined cycle system would be adopted for its advantage in high efficiency compared to other power generation methods and economic performance (Table 8.3-5).

Table 8.3-5 Consideration of Power Generation Method

Item	Combined Cycle	Conventional Thermal Power Generation
Technical aspects	- Power generation with only gas turbine would also be possible, while with relatively smaller generation power, resulting in a shorter construction period before starting operation.	- The plant could not start operation before all the facilities were completed, resulting in a longer construction period.
Economic aspects	- High efficiency in power generation and lower cost per power generation unit.	- Lower power generation efficiency compared to the combined cycle, resulting in higher cost per power generation unit.
Environmental-social consideration	- High power generation efficiency and lower CO_2 generation per power generation	- Lower power generation efficiency compared to the combined cycle, resulting in

[3] IPCC (2006); Guidelines for Natural Gas Inventories.

Item	Combined Cycle	Conventional Thermal Power Generation
	unit. - Amount of CO_2 emissions are estimated to be 0.519 ton/ MWh[4].	higher CO_2 generation per power generation unit. - Amount of CO_2 emissions are estimated to be 0.608 ton/ MWh[3].

Source: JICA Study Team.

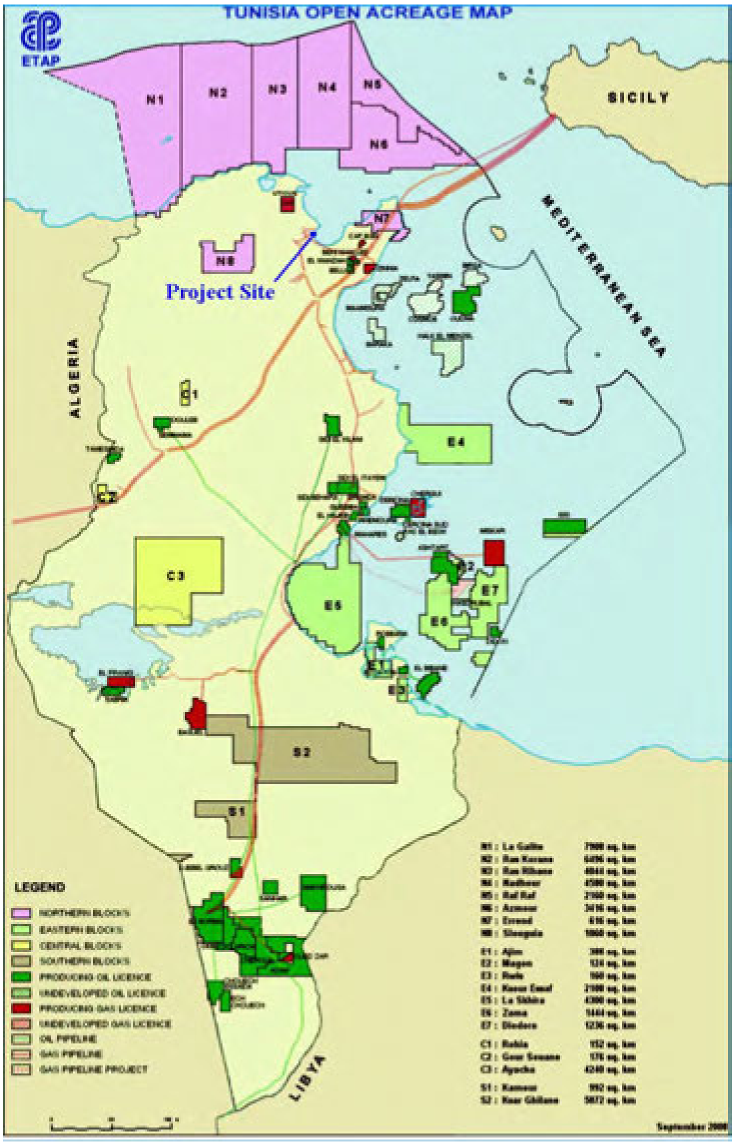
8.4 Consideration of Associated Facilities

The facilities associated to the power plant which is the main body of the project includes gas pipeline for fuel transportation and transmission line facilities. No other associated operation is planned as far as is understood. In this survey, JICA Study Team considered the gas pipelines and the transmission facility as “not associated facilities”. Rades III switchyard was ascribed “associated facilities”.

8.4.1 Gas Pipelines

Rades A&B Power Plant and Rades II Power Plant are supplied with natural gas from the national gas supply network, which connect with south part of Tunisia, Algeria, and Sicily (Figure 8.4-1). Rades C Power Plant will also obtain its natural gas supply from the adjacent station of the same gas supply network. Installation of a gas pipeline connecting Rades C Power Plant to the gas supply network has been integrated in the planning of the Project, and the main pipeline has been in use prior to the construction of Rades C Power Plant. In this regard, the gas pipeline between the national gas supply network and the adjacent station is not considered to be an associated facility of the project.

[4] Central Research Institute of Electric Power Industry (2009); Evaluation of Power Generation Technologies based on Life Cycle CO_2 Emissions.



Source: http://www.docstoc.com/docs/50696250/TUNISIA-CONCESSION-MAP

Figure 8.4-1 National Gas Supply Network in Tunisia

8.4.2 Electric Transmission Facilities

(1) Rades III Swichyard

Rades C Power Plant will be connected to the national grid through the Rades III switchyard and existing Rades II sub-station within the plant site. This Rades III switchyard is used by only Rades C Power Plant and proposed by STEG to be constructed separately from Rades C Power Plant and with another source of funding. Rades C Power Plant not being able to function without this switchyard, the Rades III switchyard is considered to be an associated facility, necessitating the evaluation of its environmental impacts during construction phase and operation phase. Since Rades III switchyard is to be constructed in the same site as Rades C power plant itself (requiring no land acquisition) and its size is relatively small, we foresee no significant negative environmental impact for its construction as well as for its operation.

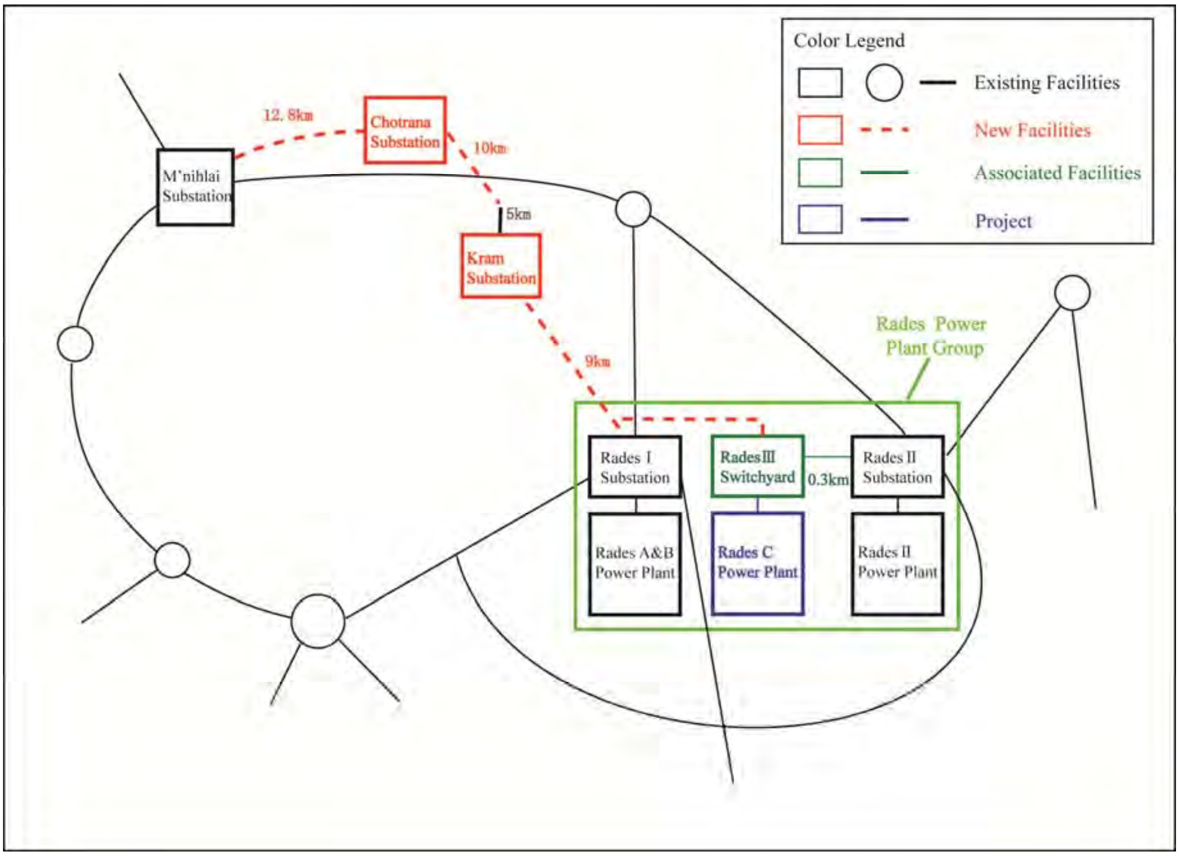
(2) Other transmission facilities

Current grid system in the great Tunis area is forming a cycle, making it prepared for an eventual transmission line accident. Our power system analysis shows that this double transmission line in the form of cycle has sufficient capacity to absorb additional electricity from Rades C Power Plant. Therefore, even without the new substations and the underground transmission line which are described below, electricity generated by Rades C Power Plant can be transferred to customers through existing grid.

The 12th national grid enhancement plan developed by STEG includes the installation of a third transmission line in order to better prepare for a transmission line accident as well as to serve areas where electric demande is growing. The construction of new substations and transmission line is also designed in the context of the plan, and Rades C Power Plant will be also connected to the national grid through this new route (Figure 8.4-2).

In the 11th national grid enhancement plan developed by STEG, construction of Kram Substation and an underground transmission line connecting the project site to the substation have almost been completed with a loan from EIB (European Investment Bank). The new planned transmission route includes construction of Chotrana Substation 15 km from Kram Substation and an underground transmission line connecting to the existing Mnihla Substation, also with a new loan from EIB. Chotrana Substation is located on government-owned land acquired by STEG, and there will be no resettlement of local inhabitants. The underground transmission line will be buried in a new trench 0.65 m wide and 1.5 m deep dug along the existing main road and highway, and acquisition of land is not necessary.

Consequently, the new substations and the underground transmission line will be used to transmit electricity from the three power plants and not only from Rades C Power Plant. Therefore, they are not considered to be associated facilities of the Project.



Source: JICA Study Team

Figure 8.4-2 Schematic View of the Rades Area and Transmission Network

We also have to mention that these two new substations (Kram and Chotrana) will mainly serve as subatations for securing safe and stable distribution of electricity in the surrounding residential or industrial areas.

8.5 Scoping and Terms of Reference (TOR) for the Survey on Natural and Social Environment

8.5.1 Expected Environmental Impacts

Table 8.5-1 shows the scoping results of the expected environmental impacts of the survey, which was conducted in accordance with the JICA Guideline on Environmental Social Consideration.

Table 8.5-1 Scoping results

Item	No.	Impact Source	Rating		Predicted Impact
			Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	**Construction phase:** - Production of dust is expected by land preparation and other construction work, but the impact will be temporary. - Generation of air pollutants (SOx, NOx, etc.) is predicted from the operation of heavy machinery and trucks, but the impact will be limited to only the surrounding area. **Operation phase:** - Natural gas is used as fuel and almost no SOx and dust will be generated. However, NOx is generated in the gas turbine operation.
	2	Water Quality	B-	B-	**Construction phase:** - Water turbidity is anticipated by excavation work, but the impact will be temporary. - It is expected that the impact of concrete wastewater and oil-containing wastewater is anticipated. **Operation phase:** - The impact of oil-containing wastewater, domestic wastewater, high salinity waste water, thermal wastewater, and other wastewater from the plant are expected by the plant operation.
	3	Wastes	B-	B-	**Construction phase:** - General waste and hazardous waste will be generated by the construction work. **Operation phase:** - General waste and hazardous waste will be generated
	4	Noise and Vibration	B-	B-	**Construction phase:** - Impact of noise and vibration is predicted caused by the operation of heavy machinery and trucks, but will be limited to the surrounding area. **Operation phase:** - Noise and vibration will be generated by the project operation. However, the nearest residential area is around 600m away, and STEG approves only the equipment satisfying the noise standard stipulated in Labor Law, and the environmental impact will be insignificant. - STEG approves only the use of equipment compliant to the noise generated standards, and the environmental impact of noise and vibration is not predicted within and around the project site.
	5	Subsidence	D	D	**Construction phase:** - Use of ground water is not in the plan. **Operation phase:** - Desalinated water will be used in the power plant.

Item	No.	Impact Source	Rating		Predicted Impact
			Pre- / construction Phase	Operation Phase	
	6	Odor	B-	B-	**Construction and Operation phases:** - If domestic waste from the workers' camp is not appropriately treated, foul odors may emanate from the rotten waste.
Natural Environment	7	Protected Areas	C-	C-	**Construction and Operation phases:** - The nearest protected area from the site is Chikly Island in Lake of Tunis located 6km east of the project site. There is also Bou kornin National Park 8km south-west of the site. As waste water is not discharged into Lake of Tunis, air pollution is the only possible environmental impact.
	8	Ecosystem	C-	C-	**Construction phase:** - The project relates to the installation of the additional power plantin the prepared vacant site which is not forest or marsh. There are no primary forests, natural forests and mangrove wetlands around the site. - The outlet of waste water faces shoaling beach, with no tidal flat or coral reef. - Zostera bed (Sea-grass bed), which is commonly seen in Tunisia, constitutes a nursing ground for marine organisms. If there is sea-grass bed located near the project site, it may be potentially affected by the water discharge from the construction work. - The existence of protected species around the project site is not identified, and if there are, potential impact of the construction work is predicted. **Operation phase:** - If there is sea-grass bed located near the project site, it may be potentially affected by the increased thermal effluent. - By cooling water intake, the intake of organisms, and potential impact of plant effluent and oil-containing effluent on aqua organisms is predicted. Although high-salinity effluent from sea water desalination system will be discharged, it is mixed with large quantity of circulation water at the discharge canal and impact on aqua organisms is not predicted.
Social Environment	9	Resettlement	D	D	**Pre-construction phase:** - Land acquisition and relocation of the affected people by the project implementation is not predicted.
	10	Poor People	D	D	**Construction and Operation phases:** - Rades A Power Plant started operation in 1985, Rades B PP in 1998 and Rades II PP in 2002. The existing power plants have about 30 years of history within the local community through operation and expansion. The project relates to the expansion of the existing power plant within the site, and significant impact on the local community will be avoided. Consequently, the life of

Item	No.	Impact Source	Rating: Pre- / construction Phase	Rating: Operation Phase	Predicted Impact
					poor people in the region, if any, will not be significantly affected.
	11	Ethnic Minority Groups and Indigenous People	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, the life of ethnic minority groups and indigenous people in the region, if any, will not be significantly affected.
	12	Local Economy such as Employment and Livelihood Means	B+/B-	B+/B-	**Construction phase:** - Construction work may produce increased job opportunity for the local people and increased purchase of local materials. - Local economy, especially fisheries, may be affected by the turbid water discharged from the construction site. **Operation phase:** - The operation of the power plant may produce increased job opportunity for the local people and increased purchase of local materials. - Local economy, especially fisheries, may be affected by the discharged wastewater from the power plant into the sea.
	13	Land Use and Utilization of Local Resources	D	D	**Construction and Operation phases:** - The project relates to an installation of an additional power plant in the vacant are of the existing project site. The site of the existing power plant is not used as a local resource and the operation of the project will not affect the use of the local land and resources.
	14	Water Usage, Water Rights, etc	D	D	**Construction and Operation phase:** - There is no water source for agricultural water, industrial water, and drinking water in and srounding the site and the operation of the project will not affect the water use and water rights.
	15	Existing Social Infrastructure and Services	B-	B-	**Construction phase:** - Marine and land traffic will be increased, because of material and equipment transportation, so that the traffic may disturb the existing local traffic and marine traffic. **Operation phase:** - Commuting of power plant workers will increase the traffic volume of the surrounding roads, possibly leading to traffic jams.
	16	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	D	D	**Construction and Operation phases:** - The project does not involve land acquisition and no damage of relation with the local decision-making institutions and other social institutions. - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on the relationship with the social institutions is not expected.
	17	Misdistribution of	B-	B-	**Construction and Operation phases:**

Item	No.	Impact Source	Rating		Predicted Impact
			Pre- / construction Phase	Operation Phase	
		Benefits and Loss			- If unfair employment and subcontracting occur between the local people, this may lead to misdistribution of benefits and loss.
	18	Local Conflicts of Interest	B-	B-	**Construction and Operation phases:** - If unfair employment and subcontracting occur between the local people, this may lead to misdistribution of benefits and loss. - Conflicts between local residence and construction workers and power plant staff may occur because of changes in local customs if the construction workers and the power plant staff cannot understand local customs.
	19	Cultural Heritage	D	D	- Historical, cultural and/or archaeological property and heritage does not exist around the site.
	20	Landscape	D	D	- The existing power plant is already integrated into the local scenery, and the project will not affect the local landscape. There is no scenic area around the project site.
	21	Gender	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on the gender is not expected.
	22	Children's Rights	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on children's right is not expected. - No child labor has been conducted in STEG, and will never be admitted in the future as well.
	23	Infectious Diseases such as HIV/AIDS	B-	D	**Construction phase:** - A temporary influx of migrant labor during the construction period may increase the risk of sexual transmitted diseases, etc.
	24	Work Environment (Including Work Safety)	B-	B-	**Construction phase:** - High risk rate of accidents is predicted in construction work. **Operation phase:** - Work accidents of workers may occur.
Others	25	Accidents	B-	B-	**Construction phase:** - Without the implementation of an appropriate traffic safety training, accidents in water traffic and land traffic may happen. **Operation phase:** - Without the implementation of appropriate traffic safety training, accidents in land traffic may happen. - There is a risk of potential oil seepage from the light oil tanks.
	26	Cross-boundary Impact and Climate Change	B-	B-	**Construction phase:** - CO_2 will be produced by the construction work. However, since the construction volume is limited, the

Item	No.	Impact Source	Rating		Predicted Impact
			Pre- / construction Phase	Operation Phase	
					environmental impact, such as cross-boundary pollution, is predicted to be insignificant. **Operation phase:** - CO_2 will be produced by the project operation. However, since the output of the power plant is not large, the environmental impact, such as cross-boundary pollution, is predicted to be insignificant.

Notes; A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

Source: JICA Study Team

8.5.2 TOR of the EIA Study

According to the scoping results, Table 8.5-2 shows the TOR which will be needed for the EIA study.

Table 8.5-2 TOR of the EIA Study

Environmental Items	Survey Items	Survey Method	Possible Countermeasures
Air Quality	- Relevant environmental standards - Meteorology - Current status of air quality	- Obtaining ambient air quality standards and emission gas standards. - Obtaining meteorological data (temperatures, moisture, wind directions, wind speeds, etc.) from the nearby weather centers. - Obtaining information of air pollutants (SO_2, NO_2, PM_{10}, etc.) - Predicting atmosphere diffusion by using simulation models and confirming that they meet air quality standards - Atmospheric diffusion simulation under unusual climate phenomenon, such as inversion layers and down drafts that may occur depending on the facility design and climate conditions, are also calculated in the above-described 5 cases.	**Construction phase** - Taking preventive measures against air pollution. **Operation phase** - Pollution-control equipment will be installed to meet the gas emission standard.
Water Quality	- Relevant environmental standards - Bathymetric feature	- Obtaining water quality standards and effluent standards. - Obtaining information of the bottom topography	**Construction phase** - Taking preventive measures against water pollution **Operation phase**

Environmental Items	Survey Items	Survey Method	Possible Countermeasures
	of the sea bottom - Current status of tidal current - Current status of water quality	- Obtaining information of tidal currents (tidal direction, current speed). - Obtaining information of marine water quality (temperatures, salinity, COD, nutrients) - Predicting thermal effluent diffusion by using simulation models and confirming the range of the diffusion. - Cumulative impacts of Rades A&B and Rades II	- Satisfying effluent standards by installing a wastewater treatment facility for domestic and other types of water.
Wastes	- Relevant environmental standards	- Obtain waste handling standards/ manuals/ guidelines.	**Construction phase** - Establishing a disposal plan for industrial, domestic and hazardous waste **Operation phase** - The same as above
Noise and Vibration	- Relevant environmental standards - Current status of noise and vibration	- Obtain noise level standards - Obtain the information of noise and vibration levels	**Construction phase** - Taking preventive measures for noise and vibration **Operation phase** - Taking preventive measures for noise and vibration
Subsidence	- None	- None	- None
Odor	- Relevant environmental standards	- Obtain environmental standards for smell sources (odor).	**Construction phase** - Taking preventive measures for handling domestic waste **Operation phase** - The same as above
Protected Areas	- Location of protected areas	- Obtaining information regarding protected areas	**Construction and Operation phases** - Estimating the degree of the impact on protected areas, and taking preventive measures if significant impact on the areas is expected
Ecosystem	- Current habitat status of ecologically valuable habitat (Sea-grass bed) - Current habitat status of flora, mammals, birds, reptiles, amphibians, fish, and protected species	- Obtaining distribution information of sea-grass bed - Obtaining distribution information of flora and fauna	**Construction phase** - Estimating the degree of the impact on ecologically important habitat (Sea-grass bed), and taking preventive measures if any impact on the habitat is expected. - In case any protected species are observed within the construction area or the affected area, appropriate mitigation measures will be developed and implemented. **Operation phase** - Estimating the degree of the impact on ecologically important

Environmental Items	Survey Items	Survey Method	Possible Countermeasures
			habitat (Sea-grass bed), and taking preventive measures if any impact on the habitat is expected. - In case any protected species are observed within the project-affected area with air pollution, water turbidity, or thermal effluent diffusion, the degree of the impact will be estimated and preventive measures shall be taken if any impact on the habitat is expected.
Resettlement	- None	- None	- None
Poor People	- None	- None	- None
Ethnic Minority Groups and Indigenous People	- None	- None	- None
Local Economy such as Employment and Livelihood Means	- Employment plan - Condition of fishery	- Check employment plan - Obtaining information regarding fishery	**Construction phase** - A fair and transparent employment plan shall be developed. - Fair standards for subcontract and material purchases shall be developed. - The same as those addressed in "Water Quality" - Estimating the degree of the impact on fishery **Operation phase** - The same as above
Land Use and Utilization of Local Resources	- None	- None	- None
Water Usage, Water Rights, etc	- None	- None	- None
Existing Social Infrastructure and Services	- Current traffic volume	- Obtain the information of the traffic volume	**Construction phase** - Taking measures for reducing the traffic volume **Operation phase** - The same as above
Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- None	- None	- None
Misdistribution of Benefits and Loss	- Employment plan	- Check employment plan	**Construction phase** - Taking fair employment plan - Local material shall be purchased and used to the possible extent

Environmental Items	Survey Items	Survey Method	Possible Countermeasures
			through fair method such as bidding system. **Operation phase** - The same as above
Local Conflicts of Interest	- None	- None	- The same as those addressed in "Misdistribution of Benefits and Compensation"
Cultural Heritage	- None	- None	- None
Landscape	- None	- None	- None
Gender	- None	- None	- None
Children's Rights	- None	- None	- None
Infectious Diseases such as HIV/AIDS	- None	- None	**Construction phase** - Taking mitigation measures for public health
Work Environment (Including Work Safety)	- None	- None	**Construction phase** - Taking mitigation measures for work safety **Operation phase** - The same as those addressed in "Construction phase"
Accident	- None	- None	**Construction phase** - Taking preventive measures for traffic accident **Operation phase** - The same as those addressed in "Construction phase" - Oil-seepage prevention measures shall be taken.
Cross-boundary Impact and Climate Change	- CO_2 will be generated from the existing power plants (1-2 stations) with the old facilities in the area	- The amount of reduced CO_2 amount will be calculated with the JICA Climate-FIT (Mitigation) calculation method	**Construction phase** - Taking measures for reducing the volume of CO_2 emissions **Operation phase** - Amount of CO_2 generation will be monitored

Source: JICA Study Team

8.6 Results of the Survey on Natural and Social Environment

8.6.1 Pollution Control

(1) Air Quality

The EIA report for Rades C Project does not state the current condision of airquality, water quality, and noise. However, the EIA report of Rades II CCPP, which is located in the same site of Rades Power Plant Group, states the current condition of them. According to the EIA Report for Rades II CCPP, the Ministry of Environment and Land Management measured the air quality in September 1995 in the surrounding area of the project site as part of the study entitled "Study of the Quality of the Air and Atmospheric Pollution in Tunisia" (Table 8.6-1). For reference, the "Tunisian Ambient Air Quality Standards" and the "IFC/EHS Guideline Value" (Genneral; 2007) is provided.

Compared with the standards of 1-hour average, the value of NO_2 and particulate matter does not exceed the standards at any locations. The air quality can be clean at that time, although Rades A Power Plant had already started operation in 1995. However, there was certain measure point where the value of NO_2 concentration was significantly higher than the average value.

Table 8.6-1 Summary of Ambient Air Quality (September, 1995)

(Unit: μg/m^3)

Parameter	Range (Average) (24hr averaging time)	Tunisian Ambient Air Quality Standards		IFC/EHS Guideline (General; 2007)
		Limit Value	Guide Value	
NO_2	2.7 - 92.9 (24.8)	600 (1hr)	400 (1hr)	200 (1hr)
SO_2	4.7 - 27.4 (14.9)	365	125	125
Particulate Matter	5 – 12 (8.6)	260 (1hr)	120 (1hr)	150 (PM_{10})

Source: EIA Report for Rades II CCPP

(2) Water Quality

JICA Study Team has conducted a water quality survey on February 14, 2014, on commission to a Tunisian local consultant (TEMA CONSULTING). 5 survey points, located in the front sea of Rades Power Plant Group (Figure 8.6-1), were selected and the result is shown in Table 8.6-2.

Salinity is in a high concentration due to little precipitation and inflow of river water, as well as high amount of radiation. Nutrients are also in relatively high level, indicating that the relevant sea area has eutrophic tendency.

Sea water in the relevant area is high in salinity, and the interference problems resulting from highly chloride ion made the COD value (71 - 168 mg/ℓ) a measurement mistake. Even in Tokyo Bay where eutrophication has become a problem, COD value does not exceeded 10 mg/ℓ. The project proponent is necessary to confirm in advance that determination of COD in the monitoring survey is conducted by an appropriate analyzing method.

Point	LAT.	LOG.
St-3	36°47'37.50"N	10°17'20.20"E
St-5	36°48'02.00"N	10°17'33.60"E
St-6	36°47'46.20"N	10°17'41.00"E
St-7	36°47'25.80"N	10°17'29.42"E
St-12	36°47'28.60"N	10°17'48.10"E

Source: JICA Study Team & TEMA CONSULTING

Figure 8.6-1 Location of Sea Water Quality Survey (14th February, 2014)

Table 8.6-2 Results of Sea Water Quality Survey (14th February, 2014)

Parameter	Unit	St.3	St.5		St.6		St.7	
		Surface	Surface	Bottom	Surface	Bottom	Surface	Bottom
Depth	m	1.9	2.3		3.7		3.5	
Temperature	^{o}C	17.2	14.9	15.3	15.3	15.4	17.3	15.7
Salinity	-	37.9	37.8	37.8	37.8	37.9	37.7	38.0
pH	-	8.26	8.28	8.29	8.27	8.30	8.26	8.29
BOD_5	mg/L	1.5	2.0	1.4	1.6	1.7	1.4	1.7
Suspended solid	mg/L	7.0	7.0	6.5	8.1	6.1	3.6	6.1
Total Hydro Carbon	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
NO_3-N	mg/L	0.342	0.169	0.132	0.290	0.516	0.496	0.293
NO_2-N	mg/L	0.046	0.017	0.016	0.021	0.015	0.058	0.020
NH_3-N	mg/L	0.187	0.037	0.025	0.055	0.032	0.169	0.063
T-N	mg/L	2.38	4.77	2.88	2.99	2.16	2.72	1.94
PO_4-P	mg/L	0.013	0.013	<0.005	<0.005	<0.005	0.006	<0.005
T-P	mg/L	0.029	0.048	<0.005	0.016	0.016	0.051	<0.005

Parameter	Unit	St.12		Average		Japanese Ambient Water Quality Standards (Environmental Protection)*
		Surface	Bottom	Surface	Bottom	
Depth	m	4.7		-		-
Temperature	^oC	16.1	15.4	16.2	15.5	-
Salinity	-	37.8	38.1	37.8	38.0	-
pH	-	8.27	8.30	8.27	8.30	7.0 - 8.3
BOD_5	mg/L	1.5	1.5	1.6	1.6	-
Suspended solid	mg/L	6.0	18.0	6.3	9.2	-
Total Hydro Carbon	mg/L	<0.2	<0.2	<0.2	<0.2	-
NO_3-N	mg/L	0.367	0.365	0.333	0.327	-
NO_2-N	mg/L	0.042	0.016	0.037	0.017	-
NH_3-N	mg/L	0.113	0.041	0.112	0.040	-
T-N	mg/L	2.11	0.61	2.99	1.90	1.0
PO_4-P	mg/L	<0.005	<0.005	0.008	<0.005	-
T-P	mg/L	0.005	<0.005	0.030	0.008	0.09

Note: * For reference
Source: JICA Study Team & TEMA CONSULTING

(3) Noise
In the Rades II CCPP Project, the level of noise was measured on March 27 and 28, 1998, at the boundary of Rades II Power Plant (Table 8.6-3). As described above, the noise level generated by a business day shall not exceed 50 dBA, measured at the facade of the closest house from the noise source. According to STEG, since the project site is in trafficy area, the noise level has exceeded the Noise level standards for noise by a car. For reference, the guideline values for noise of the IFC/EHS Guidelines is shown in Table 8.6-3.
The project site is on the premise of Rades A&B Power Plant, which is adjacent to Rades II Power Plant, and it is not in a residential area. The residential area is approximately 600m away from the project site. Noise level reduces around 55dB on the residence area from the noise source in the project site due to distance decay effect.

Table 8.6-3 Summary of Noise Mesurement

Noise Level (dBA)	IFC/EHS Guideline (General; 2007)	
	Residential; Institutional; Educational	Industrial; Commercial
54.0 - 67.0 (L_{50})	Day Time (07:00-22:00): 55	Day Time; 70
	Night Time (22:00-07:00): 45	Night Time: 70

Source: EIA Report for Rades II CCPP

8.6.2 Natural Environment

(1) Terrestrial Wildlife
According to the EIA Report for Rades II CCPP, The Rades II site was mainly unvegetated. The vegetation surrounding area was characterized by halophilic flora, the dominant species of which is salicorne arabica.
In addition, any protected fauna has not been recorded in the surrounding area of the Rades II site, excepting birds. Regarding birds observed at the Lake of Tunis, the scientific

name which was missing in the EIA Report for Rades II CCPP (only English name was described) and confirmed in Avibase[5] was described as well as conservation status (Table 8.6-4).

These birds are mainly migrant birds, which are typically observed on the coastal line of Tunisia. In the surrounding area of the Rades II site, these bird species were observed flying, but not nesting.

Table 8.6-4 Aves Found in the Lake of Tunis

English Name in the EIA Report	Appropriate Species in Tunisia listed in Avebase 1)	Conservation Status		
		National List	IUCN 2) 2013/Jan	Barcelona Convention 2012 3)
Heron	*Botaurus stellaris*		LC	
	Ixobrychus minutus		LC	
	Ardea cinerea		LC	
	Ardea purpurea		LC	
	Ardea alba		-	
	Egretta garzetta	O	LC	
	Egretta gularis		LC	
	Bubulcus ibis		LC	
	Ardeola ralloides		LC	
	Nycticorax nycticorax		LC	
Duck	*Tadorna ferruginea*		LC	
	Tadorna tadorna		LC	
	Anas strepera	O	LC	
	Anas penelope		LC	
	Anas platyrhynchos	O	LC	
	Anas discors		LC	
	Anas clypeata		LC	
	Anas acuta		LC	
	Anas querquedula		LC	
	Anas crecca		LC	
	Marmaronetta angustirostris		VU	
	Netta rufina		LC	
	Aythya ferina		LC	
	Aythya nyroca		NT	
	Aythya fuligula		LC	
	Aythya marila		LC	
	Somateria mollissima		LC	
	Melanitta nigra		LC	
	Clangula hyemalis		VU	
	Bucephala clangula		LC	
	Mergellus albellus		LC	
	Mergus merganser	O	LC	
	Mergus serrator	O	LC	
	Oxyura leucocephala	O	EN	
Lark	*Alaemon alaudipes*		LC	
	Chersophilus duponti		NT	

5 http://avibase.bsc-eoc.org/checklist.jsp?region=tn&list=clements

English Name in the EIA Report	Appropriate Species in Tunisia listed in Avebase [1)]	Conservation Status		
		National List	IUCN [2)] 2013/Jan	Barcelona Convention 2012 [3)]
	Ammomanes cinctura		LC	
	Ammomanes deserti		LC	
	Ramphocoris clotbey		LC	
	Melanocorypha calandra		LC	
	Calandrella brachydactyla		LC	
	Calandrella rufescens		LC	
	Galerida cristata		LC	
	Galerida theklae		-	
	Alauda arvensis		LC	
	Lullula arborea		LC	
	Eremophila bilopha		LC	
Gull	*Larus ichthyaetus*	O	LC	
	Larus melanocephalus	O	LC	
	Larus minutus	O	LC	
	Larus cirrocephalus	O	LC	
	Larus ridibundus	O	LC	
	Larus genei	O	LC	
	Larus audouinii	O	NT	
	Larus canus	O	LC	
	Larus fuscus	O	LC	
	Larus argentatus	O	LC	
	Larus cachinnans	O	LC	
	Larus hyperboreus	O	LC	
	Larus marinus	O	LC	
	Rissa tridactyla	O	LC	
Cormoran	*Phalacrocorax carbo*		LC	
	Phalacrocorax aristotelis		LC	
	Phalacrocorax pygmaeus		LC	
Flamingo	*Phoenicopterus rubber*	O	LC	
Avocet	*Himantopus himantopus*	O	LC	
	Recurvirostra avosetta		LC	
Curlew	*Numenius phaeopus*		LC	
	Numenius tenuirostris		CR	
	Numenius arquata		NT	
Spoonbill	*Plegadis falcinellus*		LC	
	Platalea leucorodia	O	LC	
Egret	Same Family as "Heron"			
Harrier	*Circus aeruginosus*	O	LC	
	Circus cyaneus	O	LC	
	Circus macrourus	O	VU	
	Circus pygargus	O	LC	
Plover	*Pluvialis squatarola*		LC	
	Pluvialis apricaria		LC	
	Pluvialis dominica		LC	
	Pluvialis fulva		LC	
	Vanellus vanellus		LC	
	Vanellus gregarius		CR	

English Name in the EIA Report	Appropriate Species in Tunisia listed in Avebase [1)]	Conservation Status		
		National List	IUCN [2)] 2013/Jan	Barcelona Convention 2012 [3)]
	Vanellus leucurus		LC	
	Charadrius leschenaultii	O	LC	O
	Charadrius alexandrinus	O	LC	O
	Charadrius hiaticula	O	LC	
	Charadrius dubius	O	LC	
	Charadrius morinellus	O	-	
Grebe	*Tachybaptus ruficollis*	O	LC	
	Podiceps auritus	O	LC	
	Podiceps grisegena	O	LC	
	Podiceps cristatus	O	LC	
	Podiceps nigricollis	O	LC	
Osprey	*Pandion haliaetus*		LC	
Coot	*Crex crex*		LC	
	Rallus aquaticus	O	LC	
	Porzana parva		LC	
	Porzana pusilla		LC	
	Porzana porzana		LC	
	Porphyrio porphyrio		-	
	Porphyrio alleni		-	
	Gallinula chloropus		LC	
	Fulica cristata		LC	
	Fulica atra		LC	
Sandpiper	*Xenus cinereus*		LC	
	Actitis hypoleucos		LC	
	Tringa ochropus	O	LC	
	Tringa erythropus	O	LC	
	Tringa nebularia	O	LC	
	Tringa stagnatilis	O	LC	
	Tringa glareola	O	LC	
	Tringa totanus	O	LC	
	Limosa limosa		NT	
	Limosa lapponica		LC	
	Arenaria interpres		LC	
	Calidris canutus	O	LC	
	Calidris pugnax	O	-	
	Calidris falcinellus	O	-	
	Calidris himantopus	O	LC	
	Calidris ferruginea	O	LC	
	Calidris temminckii	O	LC	
	Calidris ruficollis	O	LC	
	Calidris alba	O	LC	
	Calidris alpina	O	LC	
	Calidris minuta	O	LC	
	Calidris subruficollis	O	-	
	Lymnocryptes minimus		LC	
	Gallinago media		NT	
	Gallinago gallinago		LC	
	Gallinago stenura		LC	

English Name in the EIA Report	Appropriate Species in Tunisia listed in Avebase 1)	Conservation Status		
		National List	IUCN 2) 2013/Jan	Barcelona Convention 2012 3)
	Scolopax rusticola		LC	
	Phalaropus lobatus		LC	
	Phalaropus fulicariu		LC	
Tern	*Chlidonias niger*	O	LC	
	Chlidonias leucopterus	O	LC	
	Chlidonias hybrida	O	LC	
	Sterna albifrons	O	LC	
	Sterna bengalensis	O	LC	
	Sterna caspia	O	LC	
	Sterna dougallii	O	LC	
	Sterna fuscata	O	LC	
	Sterna hirundo	O	LC	
	Sterna nilotica	O	LC	
	Sterna sandvicensis	O	LC	

Notes: Categoly of IUCN; **LC** (Least Concern), **NT** (Near Threatened), **VU** (Vulnerable), **EN** (Endangered), **CR** (Critically Endangered)

Source: EIA Report for Rades II CCPP

1) http://avibase.bsc-eoc.org/checklist.jsp?region=tn&list=clements
2) http://www.iucnredlist.org/search
3) Annex II to Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Revised at the 17th COP meeting (UNEP/MAP, 2012)

(2) Marine Organism

On September 27, 2013, the water temperature was measured at 12 points as shown in Figure 8.6-2. At 8 points, i.e. St.4 to St.12 except for St.7, benthos was collected. The collection procedures were as follows: divers collected bottom mud to the depth of 5cm using a square-shaped frame sized 30cm by 30cm, and the collected mud was strained with a 2mm-mesh screen. The speed of current was so fast at St.7 that the divers couldn't go under the water to collect mud (which resulted in missing data).

The survey result of temperature is shown in Table 8.6-5 and the one of benthos is shown in Table 8.6-6. At most of the measuring points, the bottom was made up of sand and silt. The vegetation of *Cymodocea nodosa* as "Sea-grass bed", which is a species of sea-grass, was found only at St. 5 and St. 6 (Figure 8.6-3). *Cymodocea nodosa* is listed as endangered or threatened species of Barcelona Convention.

Source: EIA Report for Rades C Project

Figure 8.6-2 Loaction of Survey Point

Table 8.6-5 Depth and Water Temperature on the Survey Points

Station	Depth (m)	Temperature (°C)	
		Surface	Bottom
St.1	4.9	30.1	-
St.2	2.5	32.0	-
St.3	1.9	30.0	-
St.4	2.5	30.0	29.0
St.5	3.1	30.0	27.0
St.6	4.2	30.1	29.0
St.7	3.4	32.0	31.5
St.8	0.5	30.0	-
St.9	3.6	32.0	28.0
St.10	2.5	30.0	28.5
St.11	4.3	30.0	28.5
St.12	3.2	30.0	27.4

Source: EIA Report for Rades C Project

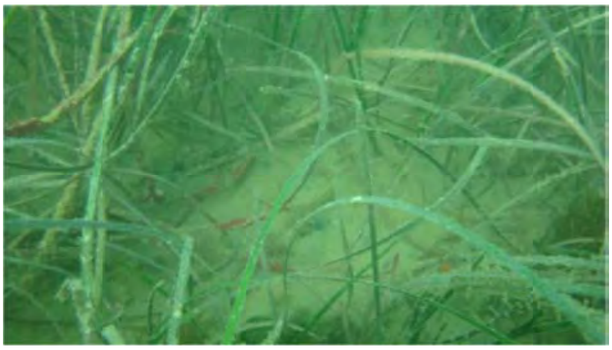
Table 8.6-6 List of Species on Each Survey Point

Station	Depth (m)	Species	Remarks
St.4	2.5	**[Flora]** None **[Fauna]** Polychaeta: *Myxicola* sp. Bivalvia: *Callista chione*	*Myxicola* sp. is indicative of sheltered muddy environments

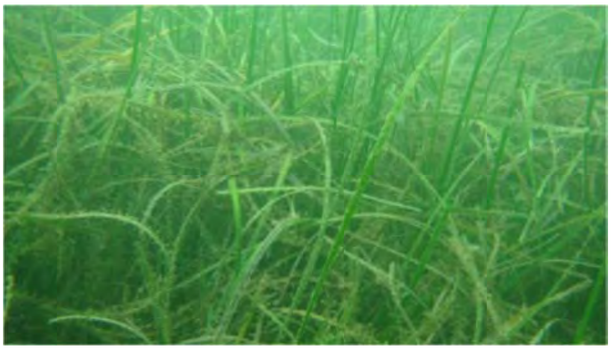
Station	Depth (m)	Species	Remarks
		Venerupis pullastra	
St.5	3.1	**[Flora]** Spermatophyta: *Cymodocea nodosa* **[Fauna]** Bivalvia: *Cerastoderma glaucum* *Kellia* sp. *Arca noe* *Mytilus galloprovincialis* *Pecten glaber* *Venerupis pullastra* *Ruditapes decussatus* *Loripes lacteus* Gastropoda: *Turitella turbona*	Although *Cymodocea nodosa* indicates facies without desalinization (normal biocenosis) the presence of *Cerasmoderma glaucum* shows the impact of freshwater because it characterizes euryhaline and eurythermal biocenosis lagoon, facing it in the presence of *Loripes lacteus*.
St.6	4.2	**[Flora]** Spermatophyta: *Cymodocea nodosa* **[Fauna]** Crustacea: *Carcinus aestuarii* Bivalvia: *Ruditapes decussatus* *Arca noe*	*Carcinus aesturii* indicate the presence of polluted water but also beneficiating a relatively larger hydrodynamics than other stations
St.8	0.5	**[Flora]** None **[Fauna]** Polychaeta: *Heteromastus filiformis* Bivalvia: *Callista chione* *Loripes lacteus* *Ruditapes decussates* *Venerupis pullastra* *Turitella turbona*	The presence of *Heteromastus filiformis*, which is a species which it contains important hemoglobin allows it to oxygenate, indicates the presence of a large muddy fraction indicating the containment of environment (*Loripes lacteus*, *Cerithium vulgatum*).
St.9	3.6	**[Flora]** None **[Fauna]** Polychaeta: *Heteromastus filiformis* Bivalvia: *Kellia corbuloides* *Ruditapes* sp. *Venerupis* sp. Gastropoda: *Littorina punctata*	*Heteromastus filiformis* indicates a important silt environment, the presence of *Kellia corbuloides* indicates that we are in the presence of a silt habitat calm type (calm protected water environment)
St.10	2.5	**[Flora]** None **[Fauna]** Polychaeta: *Heteromastus filiformis* Bivalvia: *Ruditapes decustatus* *Ensis minor* Gastropoda: *Cerithium vulgatum*	Confined environment characterized by the presence of *Heteromsatus filiformis* and *Cerithium vulgatum.*
St.11	4.3	**[Flora]** None **[Fauna]** Polychaeta: *Paradonereis lyra* *Heteromastus filiformis*	*Heteromastus filiformis* indicates important silt environment . The presence of *Donax trunculus* and *Ruditapes decustatus* might indiquate important contributions

Station	Depth (m)	Species	Remarks
		Bivalvia: *Ruditapes decustatus* *Venerupis pullastra* *Donax trunculus*	of tropics
St.12	3.2	**[Flora]** None **[Fauna]** Polychaeta: *Paradonereis lyra* *Heteromastus filiformis* Bivalvia: *Donax trunculus* Gastropoda: *Cerithium vulgatum*	Despite the large muddy fraction *Heteromastus filiuformis*, which is a species which hemoglobin is important, allows it to oxygenate

Source: EIA Report for Rades C Project



St.5



St.6

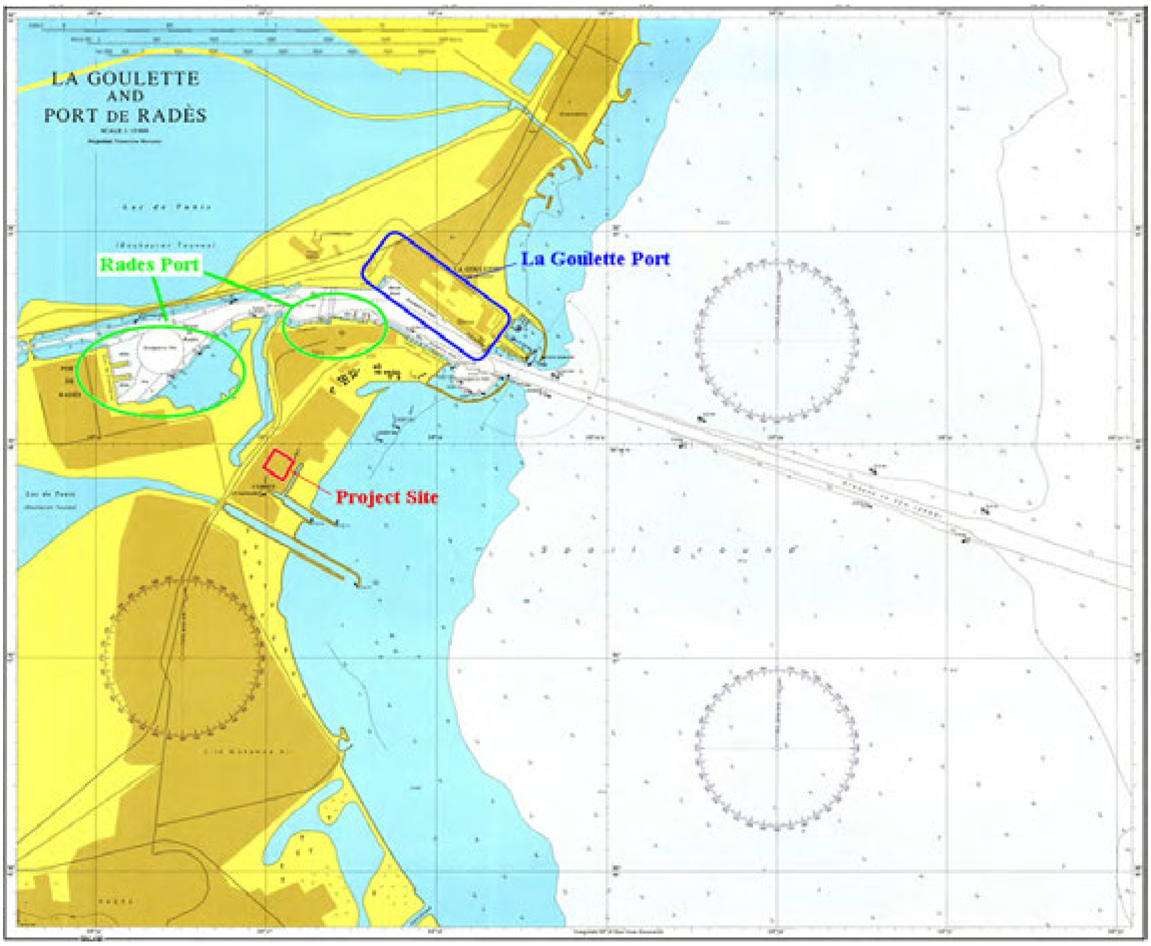
Source: EIA Report for Rades C Project

Figure 8.6-3 Scenery of Sea-grass Vegetation

8.6.3 Social Environment

(1) Marine Traffic

Rades port is the largest marine port in Tunisia with seven container berths, one oil berth, one dry bulk berth and one berth for general cargo, all separated in two main piers. La Goulette port, just opposite to Rades port, is mainly used for passengers, car ferry and cruise tourists (Figure 8.6-4). Due to the depth of sea, maximum tonnage of vessels accessible to these two ports is 30,000 tons. In recent years, a total number of approximately 3,000 vessels per year are using these two ports (Table 8.6-7). Annual volume of treated cargo by Rades port alone is around 6 million of tons. According to the Port Authority (Office de la Marine Marchande et des Ports), about 1,600 container trucks are working per day, to which tank lorries for oil and many trucks for dry cargo or general cargo should be added.



Source: JICA Study Team

Figure 8.6-4 Location of Rades Port and La Goulette Port

Table 8.6-7 Evolution of ships traffic

(Unit: Vessels)

Year	Rades Port	La Goulette Port
1990	980	799
1991	1,023	705
1992	1,221	792
1993	1,388	773
1994	1,273	776
1995	1,321	861
1996	1,367	896
1997	1,361	1,016
1998	1,417	940
1999	1,475	1,140
2000	1,672	1,179
2001	1,735	1,240
2002	1,727	1,277
2003	1,501	1,273
2004	1,567	1,358
2005	1,582	1,434

Year	Rades Port	La Goulette Port
2006	1,531	1,466
2007	1,583	1,483
2008	1,540	1,405
2009	1,689	1,278
2010	1,560	1,342
2011*	1,276	1,036

Source: http://www.ommp.nat.tn/page.php?code_menu=10&code_page=26
* Office de la Marine Marchande et des Ports; Annual Report 2011

(2) Fishery

According to the Union Tunisienee de l'Agriculture et de la Peche (UTAP), there is no professional fishery operators engaged in fishery in the sea area in front of the Rades Power Plant group. The reason thereof is that, due to shallow sea, no commercially valuable fish is available in that area. Therefore, they cannot obtain income to cover fishing cost.

There are approximately 2,000 fishermen in La Goulette, 80% of which operate gill net using a small boat. Remaining 20% are engaged in trawl net. The amount of catches is approximately 2,700 tons per year for trawl net, while that of for gill net is only 117 tons per year. Since trawl net in water shallower than 50m is restricted, the coastal area doesn't operate as a fishing ground. On the other hand, gill net is done on the coastal area to the north of La Marss (Figure 8.6-5). Target species of the gill net are shown in Table 8.6-8.

However, STEG explained that there are small size fisheries in front of the PROJECT site on the Bay of Tunis and they may not be recognized by the UTAP due to its scale and no registration to UTAP.

Source: Prepared by the JICA Survey Team based on a Google earth

Figure 8.6-5 Fishing Zone of Gill Net

Table 8.6-8 Target Species of the Gill Net

Einglish Name	Family	Einglish Name	Family
Fish		Meagre	Sciaenidae
Ell	Anguillidae	Picarel	Centracanthidae
Conger	Congridae	Wrasse	Labriade
Sardin	Clupeidae	Stargazer	Uranoscopidae
Lizarfish	Synodontidae	weever	Trachinidae
Hake	Merlucciidae	Blenny	Blenniidae
Cod	Gadidae	Barracuda	Sphyraenidae
Mullet	Mugilidae	Scabbard fish	Trichiuridae
Smelt	Atherinidae	Flatfish	Bothidae, Paralichthyidae
Garfish	Belonidae	Sole	Soleidae
Scorpionfish	Scorpaenidae	Cephalopoda	
Gurnard	Triglidae	Cuttlefish	Sepiidae
Seabass	Moronidae	Squid	Loliginidae, Ommastrephidae
Amberjack	Carangidae	Octopus	Octopodidae
Grunt	Haemulidae	Crustacea	
Seabream	Sparidae	Shrimp	Crangonidae
Goatfish	Mullidae	Prawn	Penaeidae

Source: Union Tunisienee de l'Agriculture et de la Peche

8.7 Environmental and Social Impact Evaluation

8.7.1 Construction Phase

(1) Pollution Control

1) Air Quality

Generation of dust is expected by land preparation, and generation of air pollutants (SOx and NOx, etc.) is predicted from the operation of heavy machinery and trucks, but the impact will be temporary.

Watering the construction site and using cover sheets on trucks for the transportation of soil will be undertaken to reduce dust generation.

Periodic maintenance and management of all the construction machinery and vehicles will be conducted to reduce exhaust gas discharged from construction machinery and vehicles.

2) Water Quality

There is water turbidity anticipated by land preparation, but the impact will be temporary. The impact of domestic wastewater, oil-containing wastewater, and chemical materials from construction activity is also expected.

Channels, ditches and a temporary settling pond will be dug and excavated around the construction area.

A wastewater treatment facility for workers, such as a septic tank and an oil separator for oily run-off water, will be installed in the construction area. Oil and chemical materials will be stored in an appropriate storage site to prevent permeation into the ground.

These measures will minimize the impact of contamination of sea water.

3) Waste

Waste generated from the construction work will include metal chips, waste plastic, wood shavings, waste glass and waste oil. Furthermore, household waste discarded from the workers will include cans, bottles and garbage. If such waste is inadequately handled, sea water may be contaminated, and sanitation problems may arise.

Segregating waste at collection, recycling and reusing waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to related regulations. To reduce the amount of solid waste discharged from the workers during the construction work, efforts will be taken to employ local workers wherever possible not to prepare worker’s camp, so that the amount of household waste at the construction site will be minimized. These measures will be taken to ensure that water pollution or sanitary problems resulting from waste will not arise.

Hazardous wastes, such as waste oil and batteries, will be treated by SOTULUB (Société Tunisienne de Lubrifiant) and ASSAD (L'accumulateur Tunisian ASSAD). These two companies are both accredited by ANGED.

4) Noise and Vibration

a. Noise

Noise and vibration occurs due to the operation of heavy machinery and trucks associated with the construction work. Table 8.7-1 shows the level of noise that occurs from major construction machinery. In order to reduce the noise generation, low-noise/low-vibration machinery will be used and the construction machinery and vehicles will be regularly maintained.

The distance to the nearest residential area (Mallaha) from the project site is approximately 600m and the noise level is decreased by approximately 55dB compared to the site (ex. 107 dB -> 52 dB). However, the noise level is decreased by the fence surrounding the construction area and the fence of the site boundary of the Rades Power Plant Group. Therefore, the noise level doesn't exceed the value of the Decree No. 84-1556 relating to the noise level, when single heavy machinery is operated. It may surpass these values when multiple units of heavy machinery are operated intensively. Therefore, the level of noise associated with the construction work can be reduced by avoiding intensive operations of construction machinery, not conducting construction work during the night and introducing low-noise type new machines. However, monitoring of noise level is necessary.

The source of noise is that vehicles will be used during equipment and material mobilization. When the vehicles drive near Mallaha residence area, it is necessary to take preventive measures, such as limiting truck speed.

Table 8.7-1 Noise Level of Major Construction Machinery

Machine	Unit Power (kW)	Noise Power level (dB)
Backhoe	P<55 55<P<103 103<P	99 104 106
Truck crane Crawler crane	P<55 55<P<103 103<P	100 103 107
Pile Driver	-	107
Concrete pump	P<55 55<P<103 103<P	100 103 107
Concrete Crusher	P<55 55<P<103 103<P<206 203<P	99 103 106 107
Concrete Cutter	-	106
Engine Compressor	P<55 55<P	101 105
Truck	P<150 150<P	89 92

Source: Japan Construction Mechanization Association (2001): Noise and Vibration Handbook measures associated with construction work

b. Vibration

The operation of heavy machinery and trucks create vibration. However, schedule management will be performed to maintain constant amounts of construction work and to ensure that low vibration equipment will be used as much as possible. Construction work will be performed during daytime, especially piling work.

5) Odor

In case domestic waste from the workers is not appropriately treated, the rotting waste may produce a foul odor. Before starting the construction work, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produced. These measures will be taken to minimize the generation of odor.

(2) Natural Environment

1) Protected Area

As waste water is not discharged into Lake of Tunis, Chikly Island where is the nearest protected area from the project site is not affected by waste water.

Since the air pollution due to the construction work is limited to the surrounding area of the construction site, it is assumed that there aren't any effects on Chikly Island and Bou kornin National Park, which are 6km and 8km distant from the project site respectively.

2) Ecosystem

The project is not forest or marsh. There is no primary forests, natural forests and mangrove wetlands around the site. According to Rades II EIA report, no fauna of significance, excepting birds, have been noted on the Rades II Power Plant site. Although migration birds are likely to fly to the coastline, the impact of the construction work on migration birds is minor, as there is no plan for changing the coastline. Therefore, the impact on the terrestrial ecosystem is minor and it is thought that the bird monitoring survey in the coastline is not necessary. However, workers will prohibit disturbance, harassment, and hunting.

The water outlet faces shoaling beach, with no tidal land or coral reef. Zostera bed (Sea-grass bed), which is commonly seen in Tunisia, was found in the north side of the sea area in front of the project site. Since the countermeasures against water contamination will be taken, the impact on the sea-grass bed will be reduced.

If protected species are observed, construction work will be stopped and the mitigation measure will be discussed in consultation with the expert.

(3) Social Environment

1) Local Economy

a. Fishery

As described above, small scale fishery is conducted in the sea area in front of the site. However, .wastewater by the construction work will be treated in order to meet the discharged wastewater standards and negative impact to the small scale fishery by the construction work will not be significant.

b. Local Employment

Positive impacts are expected by employment of local people for the construction as well as sales increase of the stores and restaurants in the Mallaha area nearby by people working for the construction. Since a large cement plant is located in Ben Arous Governorate, purchase of certain quantity of cement for the construction will stimulate the local economy. Other construction materials if procured locally will also stimulate the local economy.

2) Social Infrastructure

All materials, equipment and machinery to be imported to Tunisia for the Rades C project are estimated to be around 10,000 tons. As mentioned above, this represents less than 0.2 % of total volume treated by Rades port (6 million tons). Therefore, there should be no serious issue in terms of marine transportation. As for the land transportation, we need to examine three elements; materials and equipment from Rades port, materials to be purchased in Tunisia and increased number of workers during the construction period. Since Rades power plant site is located only 2 km from Rades port and the volume to be transported from port is equivalent to less than 1 day of annual volume treated by Rades port, no additional congestion of land transportation is foreseen for this category of materials and equipment.

Construction of a power plant needs a placing of considerable volume of concrete. It is up to the decision of final contractor to set up a concrete plant in the site and transport cement bags from outside or to use concrete mixer trucks coming from cement factory nearby. Impacts on the current land transportation are larger in the latter case. However, maximum number of concrete mixer trucks per hour being not more than five at the peak time of concrete placing, no serious problem expected to the current land transportation which accounts more than 200 heavy trucks per hour during day time.

Finally, vehicles transporting commuting workers may cause increased traffic and traffic jams around the project area.

In this regard, bus use will be promoted to reduce the increased number of vehicles on the roads. As prevention measures for accidents when large size truck will pass around the site to carry heavy vehicles and large size equipment into the site, people in the surrounding area will be informed by the Police

3) Misdistribution of Benefits and Loss

Since the construction of the project will not create any disappearance of existing job on one hand and all contractors or subcontractors will act in accordance with market mechanism on the other hand, no misdistribution of benefits and loss is expected.

4) Local Conflicts of Interest

Local people should be employed for the construction work to the maximum extent possible, and external workers should be taught to respect local customs in order to facilitate good relationships with local people and should promote communication to local people (e.g., join in local events).

All contractors or subcontractors will act in accordance with market mechanism, and no misdistribution of benefits and loss is expected.

5) Infectious Diseases such as HIV/AIDS

A temporary influx of migrant labor during the construction period may increase the risk of sexual transmitted diseases, etc. Local people should be recruited as much as possible so to minimize the risk of infectious diseases being transmitted from external workers. Pre-employment and periodic medical check-ups should be conducted for external workers (technical workers, etc). Construction companies will conduct an education and training on health care of workers.

6) Work Environment (Including Work Safety)

All construction work will be conducted within the area of Rades Power Plant Group surrounded with a fence to protect safety of the surrounding area. Rades A&B Power Plant site and the construction area will be divided with a solid wire-mesh fence to keep construction machines and vehicles away from the staffs and the facilities (machine rooms, boiler rooms, switchyard, hi-voltage transmission lines, etc.) of Rades A&B power plant. The construction vehicles shall access the project site only through the designated gate, and the use of the main gate will be forbidden.

A high risk rate of accidents is predicted for the construction work. Construction companies should establish work safety plans and submit them to STEG to obtain approval. Work safety plans should stipulate mitigation measures on soft aspects (safety training, etc.) and hard aspects (provide workers with appropriate protective equipment such as helmets masks, ear plugs, and, insulation protection equipments etc.).

In order to prevent health problems of workers, construction companies should observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc..

7) Accidents

Although no sea accident has been registered until now by STEG, a vessel transporting plant equipment for RADES C may encounter an accident. Even in such case, no sea pollution is foreseeable by the fact that such vessel does transport no liquid materials in substance but only heavy equipement like turbines. In addition, since all sea transport companies are required to a) keep their vessels in conformity with IMO (International Marine Organization) standards, b) be covered by sea accident insurance and c) operate their vessels in accordance with their manuals covering all aspects of marine operation, we can say that sufficient measures are taken to avoid negative impacts from sea accident. Land traffic accidents during construction work may occur. As prevention measures for land traffic accidents, observation of traffic regulations, and training and education on safe driving to the driver will be implemented by construction companies. People in the surrounding residence area shall be informed of the bus schedules.

8) Cross-boundary Impact and Climate Change

CO_2 will be produced by the construction machinery and vehicles. Periodic maintenance and management of all construction machinery and vehicles will be conducted.

8.7.2 Operation Phase

(1) Pollution Control

1) Air Quality

Prediction on environmental impact in Tunisia is supposed to be conducted by simulating the worst case scenario, even under the condition of natural gas containing sulfur. However, the result will be extremely over estimated and there is considered to have big gap between the estimated value and actual value.

JICA Study Team has conducted exhaust gas dispersion simulation for the case of short term (1 hour) instead, though it is not the same program of calculation as STEG because of lack of meteorological data.

Due to the limitation of the program of the simulation software, the culcration put the case that all emission sources were at the center of the project site. The result will also be considered over estimated, even with this method.

a. Method

Prediction method

Whether or not simulating exhaust gas dispersion models under special metrological conditions, such as inversion layers and downdrafts, was considered, in addition to the dispersion model under normal metrological condition.

Inversion Layers

In case that an inversion layer of the temperature occurred temporarily above the stack of the power plant, exhaust gas would stay under the inversion layer, possibly causing the concentration of pollutants becoming high. Here, the dispersion model was simulated with the worst case estimated.

Consideration according to the occurrence of downwash and down draft

Based on the Briggs formula[6], when gas emissions speed is lower than 1.5 times of the wind speed of stack height, downwash may occur (Figure 8.7-1). In this project, the gas emission speed is 20.4m/s, so that downwash will occur when wind speed at the stack outlet level is more than 30m/s. The gas emission speed of the existing Rades A Power Plant, Rades B Power Plant and Rades II Power Plant, on the other hand, is 11.5 - 14.5m/s, so downwash will not occur under the wind speed of 16m/s or more at stack outlet level. According to Figure 8.1-7, it is not frequent for the wind speed to become more than 16m/s, and the wind is usually west wind towards the ocean. Therefore, downwash was not considered to have occurred, and a dispersion model under downwash conditions was not simulated.

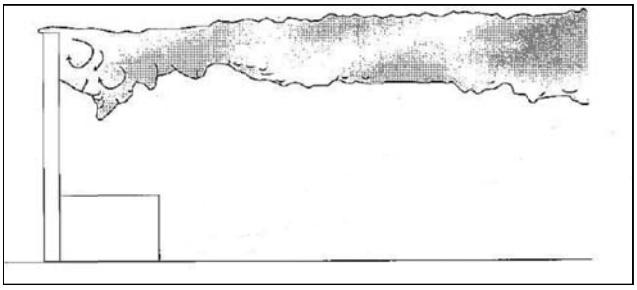


Figure 8.7-1 Outlook of the Downwash

Based on the Huber formula[7], when stack height is lower than 2.5 times of building height, downdraft may occur (Figure 8.7-2). In this project, stack height is 85 m. The building height in the vicinity of the stack for downdraft to occur would have to be more than 34 m. Since the height of all the proposed buildings will be under around 30m, downdraft will not occur.

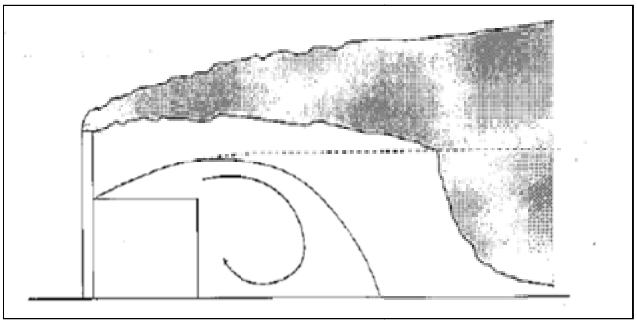


Figure 8.7-2 Outlook of the Down Draft

Dispersion Model of Exhaust Gas

Using the following Gaussian diffusion model, prediction of 1-hour value was calculated according to the time scale in conformity with the environmental standards of Tunisia and the IFC/EHS guidelines (General ,2008)..

6 Briggs, G.A. (1970): Some recent analyses of plume rise obeservation, International Clean Air Cong. Washington, D.C., 1970

7 Huber, A.H. (1984): Evaluation of a method for estimating pollution concentation downwind of inlfluencing buildings. Atmos. Environ., 18, 11., 2313-2338.

Normal Meteorological Condition

$$C = \frac{Q_p}{2\pi\ \sigma_y \sigma_z u} \cdot \exp(-2\frac{y^2}{2\sigma_y{}^2}) \exp\left\{-\frac{(z-He)^2}{2\sigma_z{}^2}\right\} + \exp\left\{-\frac{(z+He)^2}{2\sigma_z{}^2}\right\}$$

where

- C: Above-ground concentration at a leeward distance R (m)
- Q_p: Emission volume
- σ_y: Parameter in the horizontal direction (m)
- σ_z: Parameter in the vertical direction (m)
- u: Wind speed (m/s)
- R: Horizontal distance between smoke source and calculated point (m)
- z: Above-ground height
- He: Effective stack height (m)

He = H + ΔH

- H: Stack height (m)
- ΔH: Elevation height (m)

Occurrence of Inversion Layer

The occurrence of an inversion layer as a temporary metrological phenomenon, the dispersion model on a 1-hour value was simulated, using the Gaussian Model shown below.

$$C(x) = \frac{Q_p}{2\pi \cdot \sigma_y \cdot \sigma_z \cdot u} \cdot \sum_{n=-3}^{3}\left[\exp\left\{-\frac{(He+2n \cdot L)^2}{2\sigma_z{}^2}\right\} + \exp\left\{-\frac{(-He+2n \cdot L)^2}{2\sigma_z{}^2}\right\}\right]$$

Where;

Qp : Emission amount (g/s)
σ y : Parameter of horizontal direction (m)
σ z : Parameter of vertical direction (m)
u : Wind speed (m/s)
He : Effective stack height (m)
L : Height of mixing layer (m) (set as L=He, which is the worst case)
n : Reflection times (set as ±3)

b. Emission specifications

Natural gas, which is used as fuel, does not normally contain sulfur and ash; therefore, SOx and Particulate Matter were not calculated here. Table 8.7-2 shows the exhaust volume, temperature, speed, and emissions of the NOx on the Rades A Power Plant, Rades B Power Plant, Rades II Power Plant, and Rades C Power Plant. All the nitrogen oxide from the stack is assumed to become NO_2. Concentration of pollutants in emission gas will meet emission gas standards by adopting low-NOx combustion methods

Table 8.7-2 Emission Specifications

Parameter	Unit	Rades A	Rades B	Rades II	Rades C
Emission Volume (wet)	Nm^3/s	303.0	318.9	631.2	576.0
Exhaust Temperature	ºC	95.0	95.0	98.0	90.3

Parameter	Unit	Rades A	Rades B	Rades II	Rades C
Exhaust Speed	m/s	11.5	12.1	14.5	20.4
Actual Stack Height	m	100	100	70	85
Diameter of Stack Outlet	m	5.8	5.8	5.258 x 2	6.0
NOx	kg/h	58.0	283.5	162.0	33.9

Source: JICA Study Team

c. Results

Figure 8.7-3 shows the results of exhaust gas dispersion simulation on the 4 power plants and cumulative impact, showing the maximum ground concentrations based on the calculation under the condition of atmospheric stability B to F by wind speed. Tunisian Standards and IFC/EHS Guideline Value are also shown in the figure as reference. This result indicates that the impact caused by this project, Rades C Power Plant, is the lowest, whereas, the impact by the existing power plant, Rades B, is the highest.

Cumulative impact of all the 4 power plants is shown the black line in Figure 8.7-3. Mallaha (residential area), Chikly Island (protected area) and Bou- Kornine National Park are indicated at corresponded place from the project site in the figure. According to the figure, the maximum ground concentration is 53 $\mu g/m^3$ at about 2,300m from the project site. Although Mallaha (residential area) is located near the point of maximum ground concentration, the concentration value is still much below Tunisian Standards (Guideline Value) and IFC/EHS Guideline value. Also, there will be no air pollution impact on Chikly Island, 6km away from the project site, and Bou-Kornine National Park, 8km away from the project site.

Air quality has not been measured around the Rades Power Plant Group at this moment. The nearest measurement stations from Rades Power Plant are at Bab Saadoun and El Mourouj, located inland in an urban area. Since the project site is located in industrial area along the coast, the atmospheric environment around the power plant is different from the one at the measurement stations. Air quality data of September, 1995 is mentioned in the EIA report for Rades II CCPP.

The possible main NOx emission sources around the project site are Rades Power Plant Group, ports and vehicles. According to Table 8.6-7, ship traffic at Rades port and La Goulette port have been increased by 720 ships between 1995 and 2011, which is 30% from 2180 ships to 2902 ships. The number of vehicles is considered to be increased with the increase of ship traffic.

Fuel consumption amount of a container ship during anchorage at main ports in Japan (Tokyo, Yokohama, Kobe, Nagoya, Osaka) ranges from 1.7 to 2.5 ton/day[8]. NOx emission amount per ton of fuel consumption is estimated as 84kg[9]. 720 vessels being anchored per year, NOx emission amount per year is calculated 101 to 105 ton, which is 11.5 to 17.3 kg per hour, and it is about half of the total emission amount from Rades C power plant at maximum. NOx emission amount from a large-sized vehicle ranges from 0.3 to 0.9g/km[10]. Therefore, the largest NOx emission source around the project site is the Rades Power Plant Group.

In the comparison with the air quality standard, the maximum NO_2 value of

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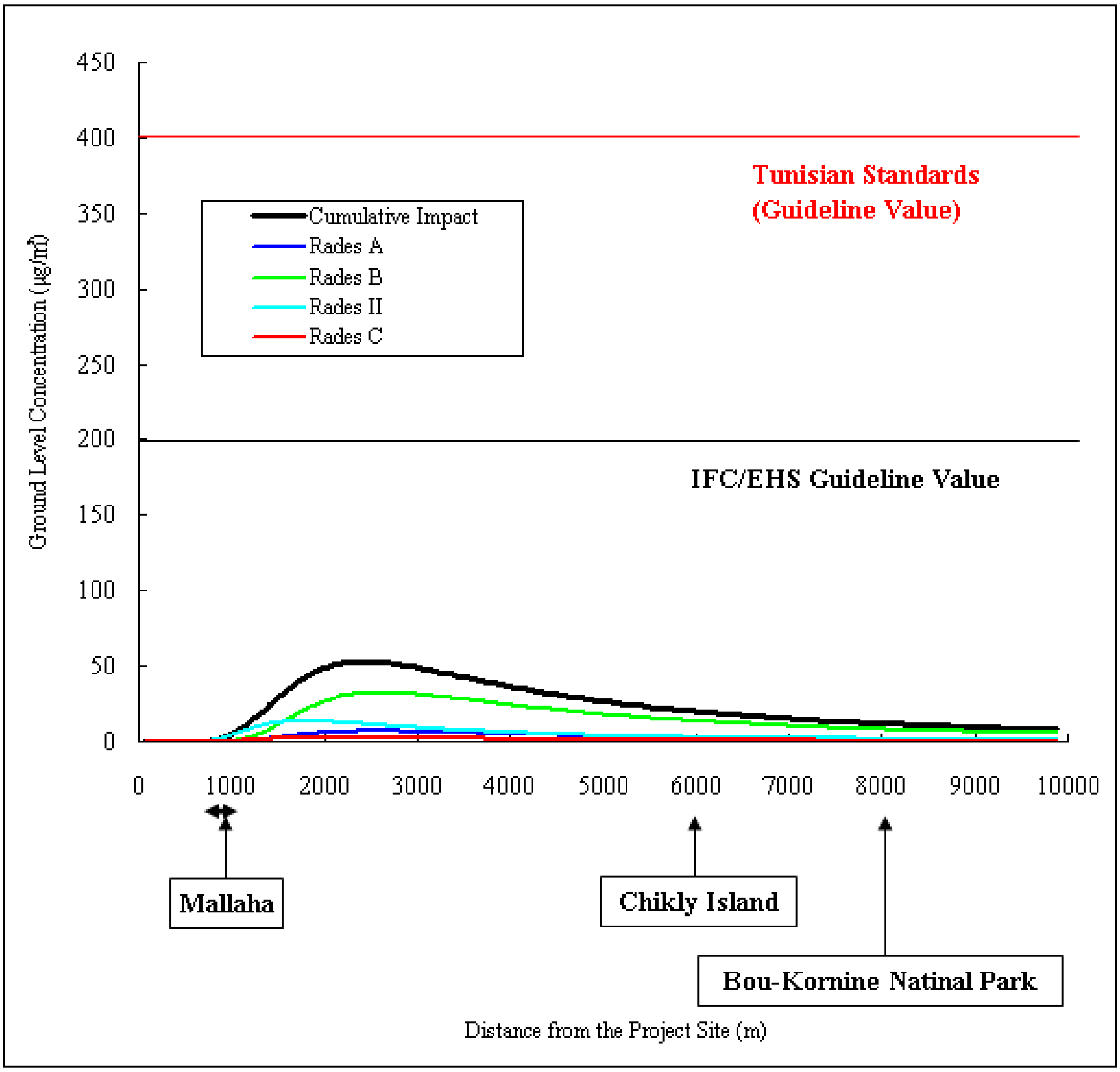
8 http://www.jterc.or.jp/kenkyusyo/product/tpsr/bn/pdf/no32-02.pdf

9 N. Awai, A. Hanajima and S. Yokozawa (1994): Fuel Oil for Medium and Large Diesel Engines. Sankai-do, Tokyo. (in Japanese)

10 Air Environment Division in the Ministry of the Environment (1995): Manual regulation of the total amount of nitrogen oxide. Environmental Research and Control Center, Tokyo. (in Japanese)

92.9µg/m^3 shown in Table 8.6-1 is set as background value. This is a 24-hour value and therefore cannot be compared with 1-hour value of the air quality standard. Assuming that 24-hour value of 92.9 µg/m^3 emerges every day and that the one-hour value of 53 µg/m^3 obtained by simulation result is added every hour, the yearly average is equivalent to 146 µg/m^3. The yearly standards of Tunisian Standrads (Guideline Value), which is150 µg/m^3, will not be exceeded even in this case.
The simulation result indicating the maximum ground concentration shown in the figure was obtained under the condition of atmospheric stability B with 1.0 -3.0 m/s of wind speed. According to Figure 8.1-8, the occurrence frequency of north or northeasterly wind, blowing towards Mallaha from the project site is about 10%. Therefore, predicting the long term impact by the 4 power plants, the maximum ground concentration will not likely exceed yearly standards of Tunisian Standards (Guideline Value).
However, NO_2 concentration may occur abnormally high in some part of this area, so that environmental monitoring will be needed.



Source: JICA Study Team

Figure 8.7-3 Cumulative Impact on the 4 Power Plants (NO_2: 1hr averaging time)

2) Water Quality

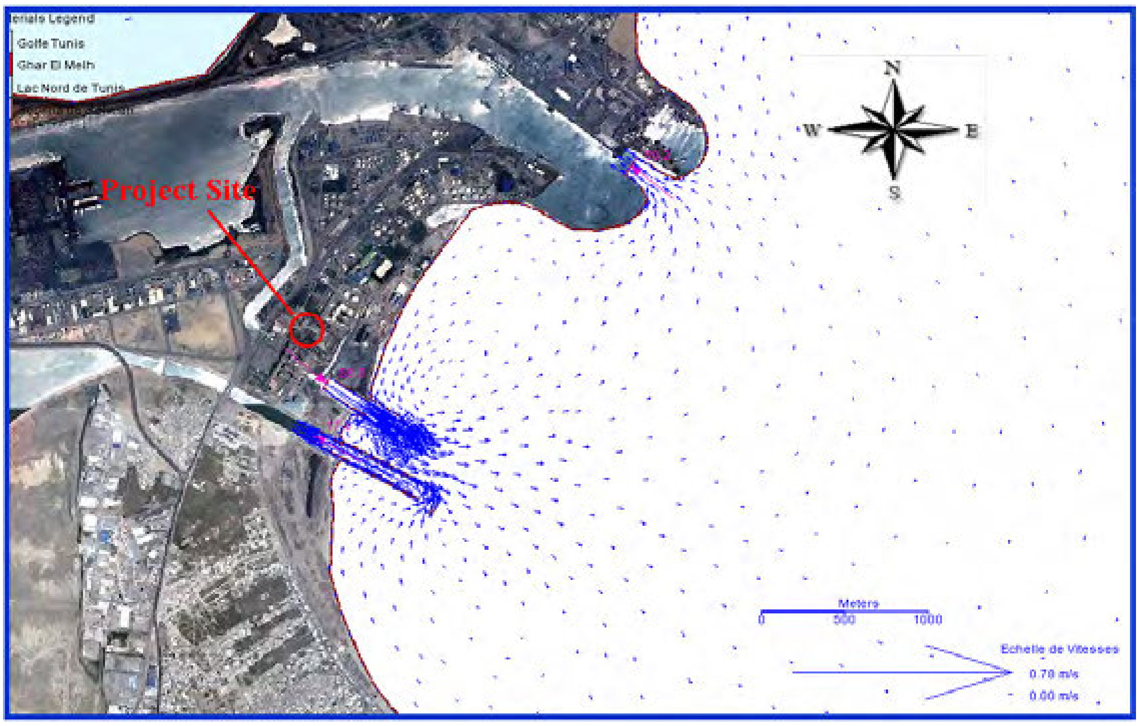
a. Thermal Effluents

(a) Water Flow in front of the Project Site

As describeed above, different flows of seawater occur in the Gulf of Tunis due to the impact of wind on the base surface current that is specific to Mediterranean Sea. Through Figure 8.7-5 to Figure 8.7-7 show the results of simulation of the flows of seawater for each wind direction in front of the project site. Taking the wind conditions in Tunis into consideration, simulation was conducted for the following three cases: Calm, East Wind with the wind speed of 6 m/sec, and West Wind with the wind speed of 9 m/sec.

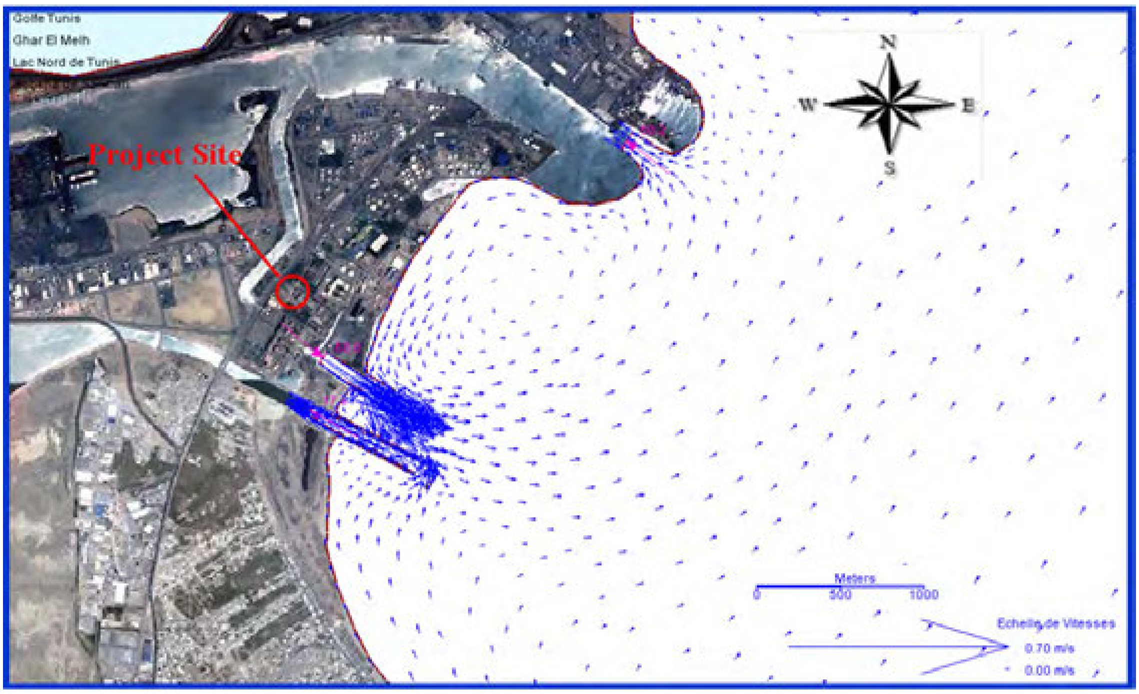
In the case of "Calm," the flow of seawater in front of the project site goes from north to south, and then heads out to sea after hitting the wash port.
Also in the case of "East Wind (6 m/sec)," there is an anticlockwise flow of seawater that flows from north to south in front of the project site.
In the case of "West Wind (9 m/sec)," the seawater in front of the project site flows from south to north, which is the reverse direction of those of the above two cases.

Since the project site is located in a short distance back from Gulf of Tunis, directions of seawater flows become complicated. As a result, the wind direction and the direction of seawater flow don't seem to coincide.



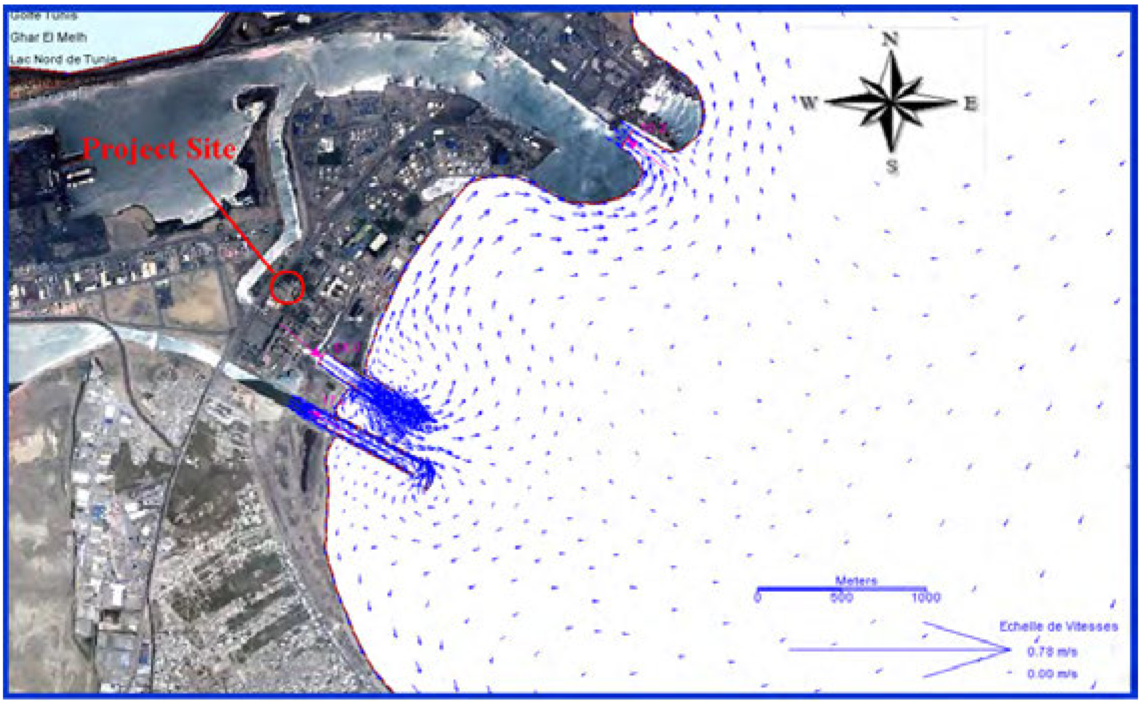
Source: EIA Report for Rades C Project

Figure 8.7-5 Water Flow in front of the Project Site (Calm)



Source: EIA Report for Rades C Project

Figure 8.7-6 Water Flow in front of the Project Site (East Wind: 6m/s)



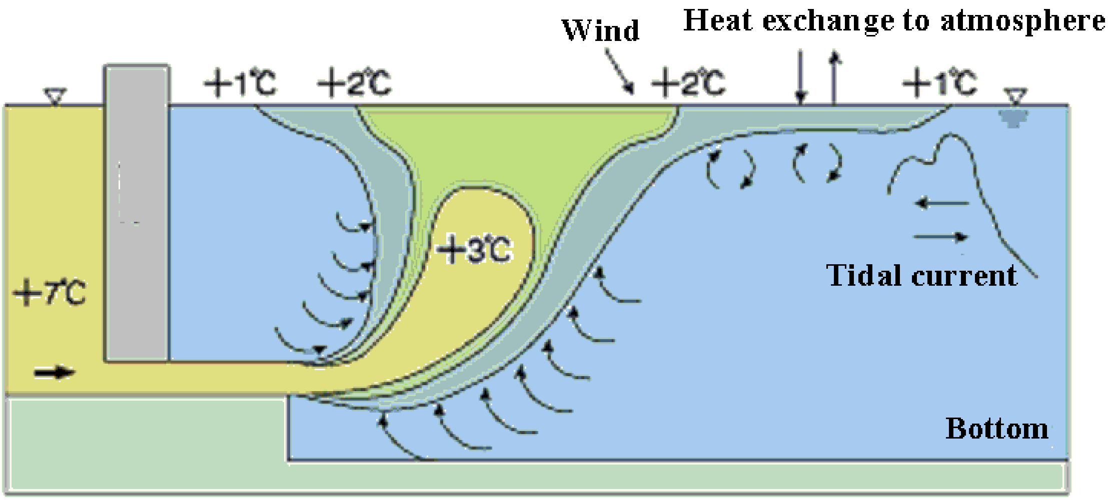
Source: EIA Report for Rades C Project

Figure 8.7-7 Water Flow in front of the Project Site (West Wind: 9m/s)

(b) Simulation of Thermal Effluents Diffusion

The thermal effluent diffuses horizontally around the outlet due to rushing power of discharge, moves upward by mixing with surrounding marine water and diffuses near the surface layer (Figure 8.7-8). As shown here, the impact of thermal effluent is predicted near the discharge outlet even in the bottom layer, but otherwise thermal effluent diffuses only near the surface layer.

Heat diffusion mechanism of thermal effluent includes “mixing with the surrounding sea water”, “heat transfer into surrounding sea water”, and “heat exchange to atmosphere”, of which “mixing with the surrounding sea water” is the most effective one. The mixing with sea water is only in a horizontal direction in two-dimensional model (2-D model), but it proceeds also in a vertical direction in a three-dimensional model (3-D model). In this manner, the 2-D model indicates smaller mixing effect compared to 3-D model, and consequently the area of rising temperature range calculated by the 2-D model tends to be larger than that of the 3-D model.



Source: http://www.kaiseiken.or.jp/study/study02.html

Figure 8.7-8 Diagram of Thermal Effluents Diffusion

a) Specifications of Thermal Effluents

According to the EIA report for Rades C project, since the outlet of thermal effluents is placed in one location, the simulation was conducted based on the two scenarios: Scenario 1 is the case in which Rades A&B Power Plant and Rades II Power Plant are in operation, and Scenario 2 is the case in which Rades C Power Plant of this project is operated in addition to the above two plants. The results of the simulation were calculated using 2-D model.

The specifications of thermal effluents in the simulation of the EIA report are as shown in Table 8.7-3.

Table 8.7-3 Specifications of Thermal Effluents

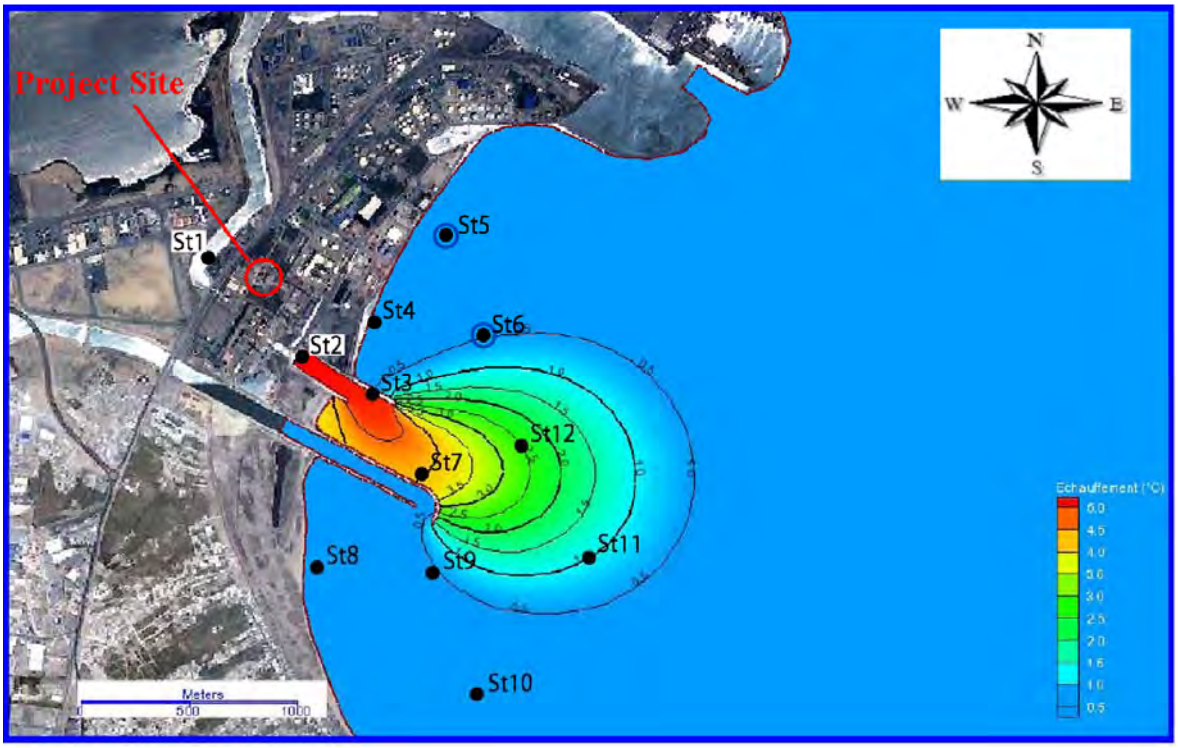
Parameter	Rades A&B	Rades II	Sinario 1	Rades C	Sinario 2
Maximam Discharge volume	33.3 m^3/sec	24.5 m^3/sec	56.8 m^3/sec	10.0 m^3/sec	68.8 m^3/sec
Rising Temperature from Intake Water Temperature	+5 °C	+5 °C	+5 °C	+5 °C	+5 °C

Source: EIA Report for Rades C Project

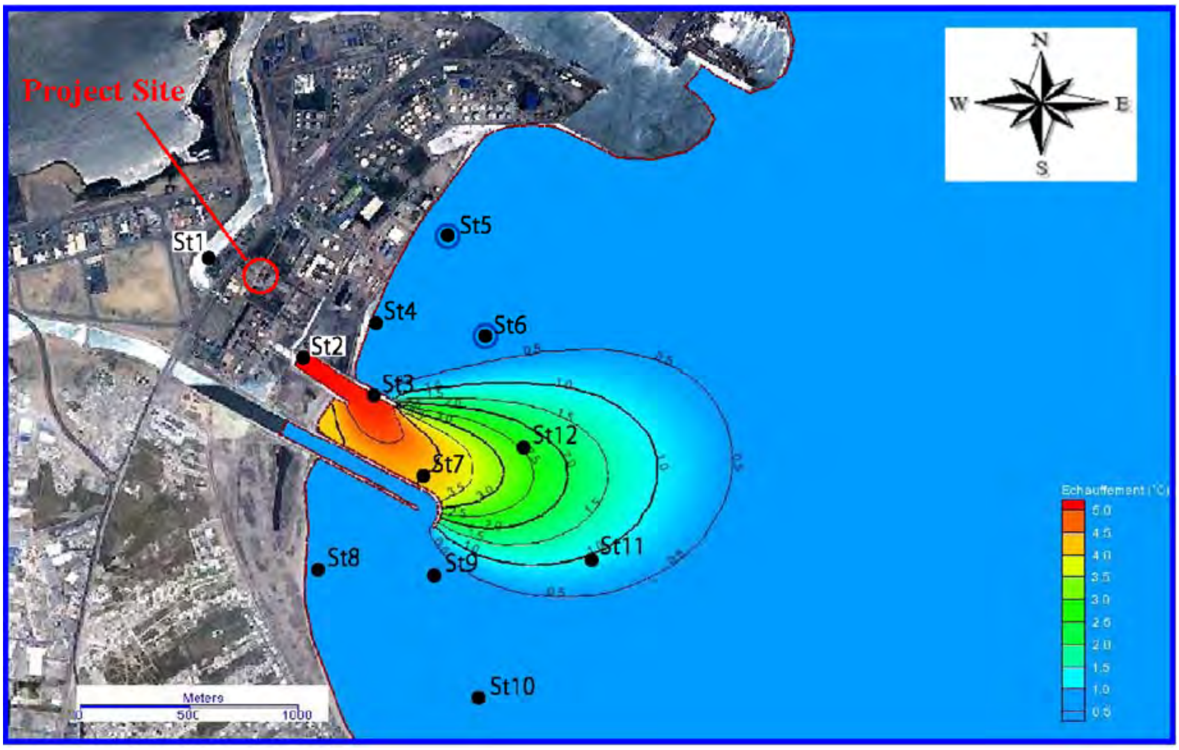
b) Results

The results of Scenario 2 in the EIA report are shown in through Figure 8.7-9 to

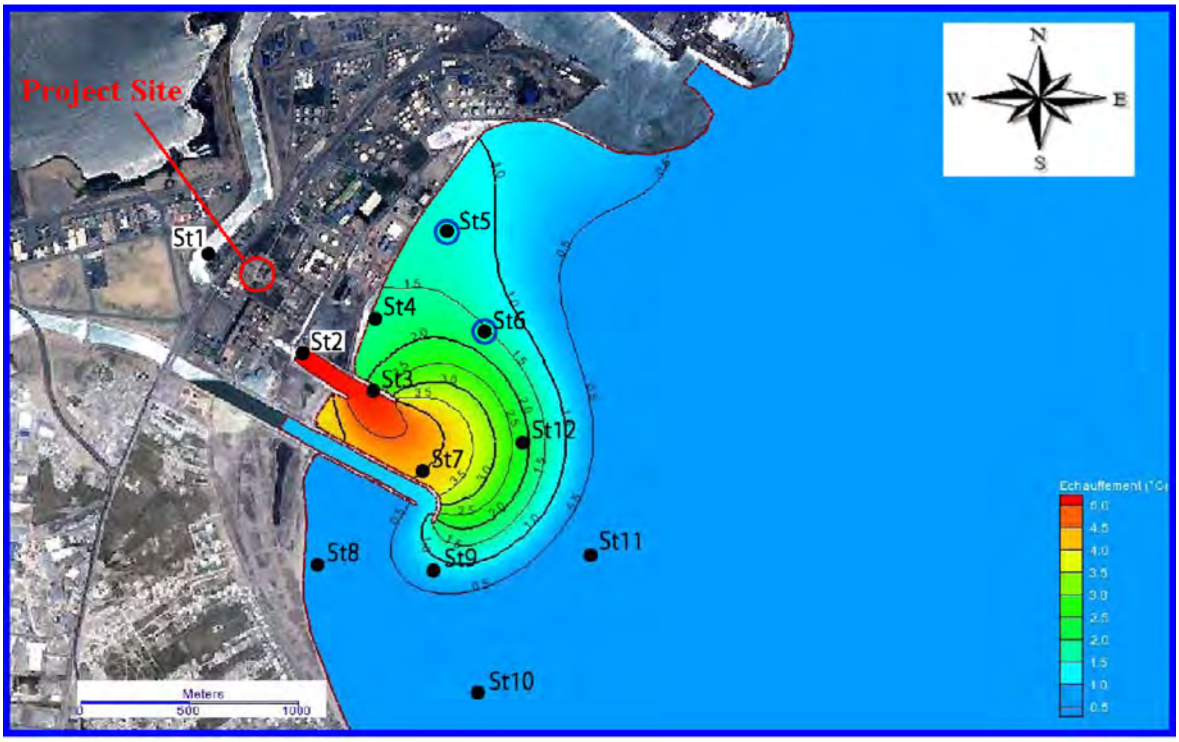
Figure 8.7-11. As the thermal effluents disperse with the flow of seawater, they spread concentrically from the wash port in the cases of “Calm” and “East Wind (6 m/sec).” To the contrast, the thermal effluents are flowed to the shore while dispersing in the case of “West Wind (9 m/sec).”



Note: Sea-grass bed was found at St.5 and St.6
Source: EIA Report for Rades C Project
Figure 8.7-9 Contour of Rising Temperature Range (Sinario 2: Calm)



Note: Sea-grass bed was found at St.5 and St.6
Source: EIA Report for Rades C Project
Figure 8.7-10 Contour of Rising Temperature Range (Sinario 2: East Wind 6m/sec)



Note: Sea-grass bed was found at St.5 and St.6
Source: EIA Report for Rades C Project
Figure 8.7-11 Contour of Rising Temperature Range (Sinario 2: West Wind 9m/sec)

The sizes of the Rising Temperature Area under Scenario 2 are as shown in Table 8.7-4. The dispersing scope of thermal effluents is the largest in the case of West Wind. It showed the tendency to even disperse toward the coast where the sea-grass bed was located.

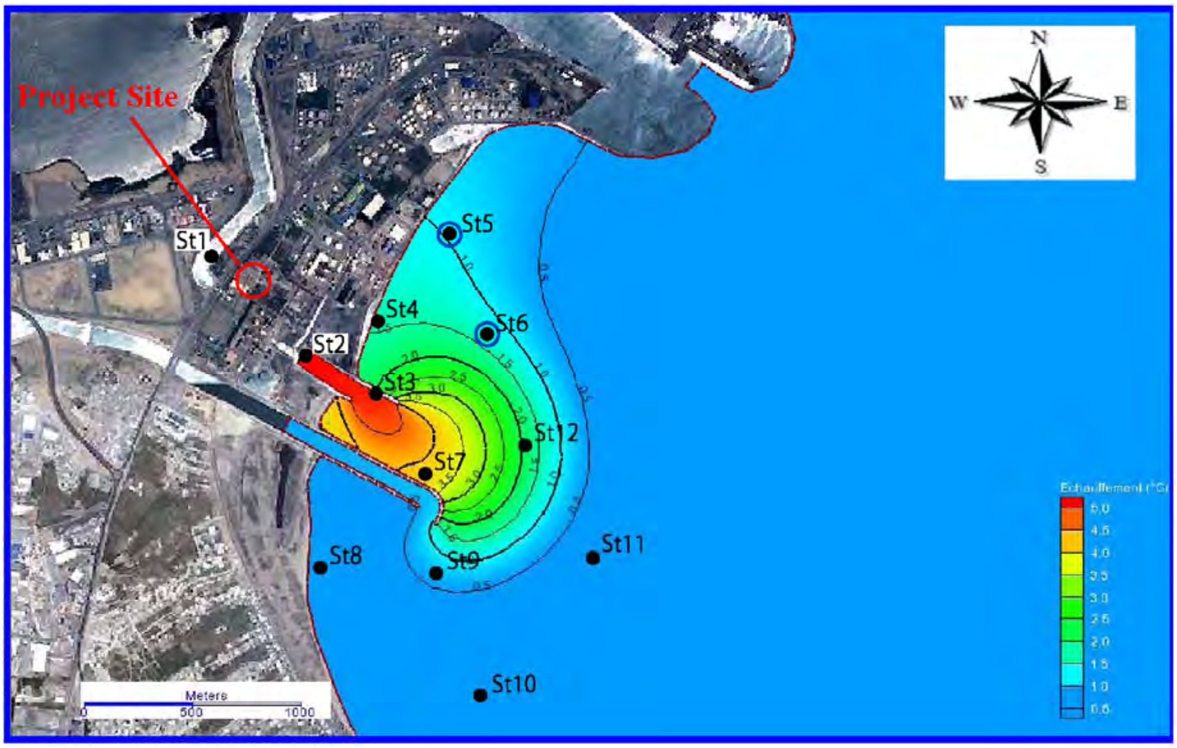
Table 8.7-4 Size of Rising Temperature Area (Sinario 2)

(Unit: ha)

Rising Temperature	Calm	East Wind	West wind
+4 °C	18	15	18
+3 °C	28	27	34
+2 °C	51	40	54
+1 °C	93	87	110

Source: EIA Report for Rades C Project

In the end, two results of Scenario 1 and Scenario 2 in the case of West Wind was compared that has an impact on the coast. Also in Scenario 1, the thermal effluents are observed to be flowed to the shore while dispersing (Figure 8.7-12). In addition, the diffusion area of thermal effluents was 100 ha when the rising temperature was +1 °C (Table 8.7-5). Therefore, the diffusion area of thermal effluents expanded by 10% only even under Scenario 2.



Note: Sea-grass bed was found at St.5 and St.6
Source: EIA Report for Rades C Project

Figure 8.7-12 Contour of Rising Temperature Range (Sinario 1: West Wind 9m/sec)

Table 8.7-5 Size of Rising Temperature Area (West Wind)

(Unit: ha)

Rising Temperature	Sinario 1	Sinario 2
+4 ^oC	18	18
+3 ^oC	30	34
+2 ^oC	51	54
+1 ^oC	100	110

Source: EIA Report for Rades C Project

c) Evaluation

With the start of the operation of Rades C Power Plant in addition to the current power plants, the dispersing scope of thermal effluents is expected to increase by 10% under Scenario 2. As a result, St.5 and St.6, where the sea-grass bed has been found, may fall within the scope of the temperature rise of 1 ^oC. However, the dispersing scope is estimated to be larger in this simulation, as the calculation was made with the 2-D model", in which thermal effluents are assumed to disperse only on the surface. In addition, the impact on the sea-grass bed that is located in the sea bottom is not assumed even if the thermal effluents disperse to the inside of the sea-grass bed, because the thermal effluents will diffused on the surface layer of the sea as their density is smaller than the surrounding seawater.

For the input data this time, the rising temperature is 5 ^oC. From 1st to 2nd July 2008, STEG measured water temperature at the water intake point and the discharge point every 15 minutes. As the results, the average water temperature difference between the water intake point and discharge point was 3.1^oC (maximum 4.2^oC and minimum 2.4^oC. Therefore, this simulation result is considered overestimate.

(c) Variation of Flow Rate due to Cooling Water Intake

Cooling water will be taken from the water canal within Rades port. As shown in Table 8.7-3, marine water is currently taken at the flow rate of 56.8m^3/sec for Rades A&B and Rades II power plant, and at 68.8m^3/sec including Rades C power plant. According to the marine chart (BA1184), the water canal in Rades port from which water is taken is 120m width and 3m depth. The current flow rate within the canal is 0.16 m/sec, whereas it will be 0.19m/sec after Rades C power plant starts operation, which is only 0.03m/sec increase.

According to EIA Report for Rades C Project, the discharge canal of thermal effluent is 70m width and 2.5m depth. The current flow rate within the canal is 0.32m/sec, whereas it will be 0.39m/sec after Rades C power plant starts operation. As indicated in comparing Figure 8.7-11 and Figure 8.7-12, the pattern of the rising temperature range is similar even the thermal effluent flow rate increases, which indicates that the increase in the flow rate of thermal effluent is not in a level to alter tidal current.

b. Cooling water, Make-up water, Rain water, and Domestic wastewater

The water flow of Rades A&B power plant is shown below. The similar water-flow is planned to be applied to Rades C power plant except domestic wastewater.

a) Cooling Water

Water Flow: Intake of sea water from the canal -> chlorine implantation -> (used as cooling water) -> discharging into sea as the thermal effluents

Chlorine residual within thermal effluent of Rades A&B power plant is below

0.05mg/ℓ. There is no standard value regulating chlorine residual in Tunisia, and IFC/EHS guideline value is 0.2mg/ℓ. Rades A&B power plant does not use "Coating Material for Preventing Adhesion of Aquatic Organism"

b) Make-up Water

Water Flow: Tap water -> Pure water production unit -> (used for the boilers) -> Water treatment process (sedimentation and neutralization [HCl and NaOH]) -> Discharge into rainwater drainage ditch -> Final separator -> discharging into sea with the thermal effluents (Figure 8.7-13)

Make-tp water is 100m^3/day as maximum, part of this amount may be discharged from the stack outlet as water vapour. No heavy metals will be discharged with make-up water. There is a possibility of discharge of acid or alkaline waste water, but due to the pH buffering action of sea water, pH change of the sea area by make-up water discharge is not predicted.

c) Rainwater

Water Flow: Flow into rainwater drainage network (ditch) -> pass through several separators -> Final separator -> discharging into sea

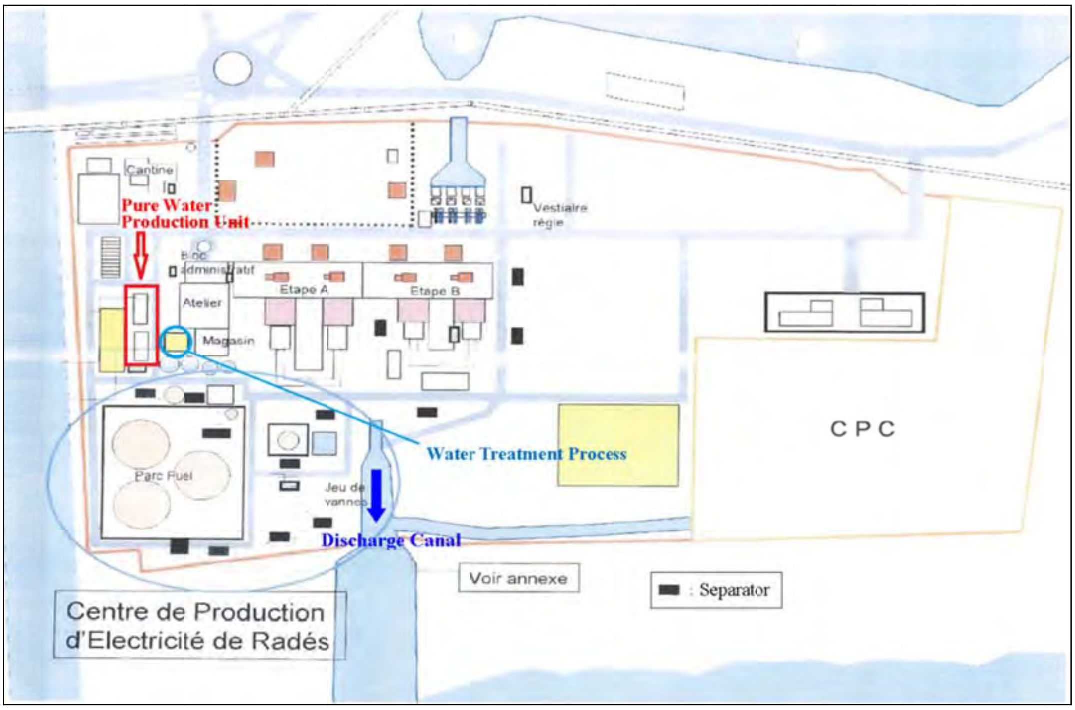
The sea area in front of Rades Power Plant Group is currently high in suspended solid (SS) concentration. Suspended matter such as mud contained in rainwater will be removed by use of separator as much as possible, and the occurrence of significantly higher concentration of suspended solid concentration of the relevant sea area due to rainwater discharge is not predicted.

d) Domestic wastewater

Water Flow: Stored into the tank in underground and collected by cesspool cleaner trucks. No discharging into sewage network

Domestic water will not be discharged into the sea area, and the further eutrophication of the sea area is not predicted.

Rades C power plant will be, similar to Rades A&B power plant, connected to the public sewage system in the operation phase, and domestic wastewater will not be discharged into marine area



Source: STEG

Figure 8.7-13 Location of Pure Water Production Unit and Water Treatment Process

The impact on water quality by the power plant operation is considered to be insignificant, because the impact intensity, duration and coverage area will be low, long term and limited, respectively.

3) Waste

Currently, Rades A&B are producing three kinds of solid wastes which need special care; used grease (3,000 ℓ/year), batteries (15 batteries/year) and sea-grass (30 tons/year) collected by the intake of cooling water (Table 8.7-6). These solid wastes are treated, in conformity with Tunisian regulations, as follows.

- Waste Oil: Tunisian company, named SOTULUB (Société Tunisienne de Lubrifiant), takes over all waste oil of STEG at Rades and reclaims it at its factory in order to resell it as new oil. SOTULUB is an accredited company by ANGED.
- Battery: Tunisian company, named ASSAD (L'accumulateur Tunisian ASSAD) under the Agency for the Promotion of Industry and Innovation, takes all old used batteries at Rades and regenerates them in order to sell them as a reclaimed battery. ASSAD is also an accredited company by ANGED.
- Sea-grass: STEG dries collected sea-grass in the site of Rades. VALORIA (an accredited company by ANGED) comes to collect them and transports them as raw material to a bio-related plant which was financed by the World Bank and is under operation by ANGED (Figure 8.7-14).

ANGED is acting mainly as a public accreditation body but also supervising regularly daily operations of theses accredited organizations.

As for the waste which is not dangerous, such as general waste (160 tons/ year), sediments from sea water treatment (150 tons/ year) or waste from restaurant for emplyees (50 tons/ year), collection is carried out by public services as ordinary waste.

Table 8.7-6 Solid Waste Management of Rades A&B power plant

Name of Waste	Amount (per year)	Origin	Storage at	Collection by	Disposal to
General Waste					
General Waste	160 tons	- Office works - Power Plant workers	Pumping station	VALORIA	Public authorized garbage dump
Ordinary Domestic Waste (canteen)	50 tons	- Canteen	Garbage bin near the canteen	SALTEN	Public authorized garbage dump
Solid Waste					
Oil	3,000 ℓ	- Power Plant work	Greasing oil room	SOTULUB	To be recycled by SOTULUB
Used batteries	15 batteries	- Power Plant work	Car garage	ASSAD	To be re-sold by ASSAD as a reclaimed battery
Sea-grass	30 tons	- Water Intake	Pumping station	VALORIA	Public authorized garbage dump
Solid residues	150 tons	- Sea water treatment process	Rades site	Rades City	Public authorized garbage dump
Oil contaminated sand	2 tons	- Power Plant work	Gasoil pump station	Rades site	Hazardous wastes dump (ANGED)
Oil contaminated dust cloth	1.5 tons	- Power Plant work	Gasoil pump station	Rades site	Hazardous wastes dump (ANGED)

Source: STEG

Source: Source: EIA Report for Rades C Project

Figure 8.7-14 Sediment, Sea-grass etc.. Retained in the Gates of the Pumping Station

4) Noise and Vibration

a. Noise

Machinery or equipment that generates large noise level in the plant operation is gas compressor, circulation water pump and water supply pump. Table 8.7-7 shows the specific noise level generated by machineries. As described in Chapter 8.7.1, the nearest residential area (Mallaha) from the project site is about 600 m away from the project site, and noise level is attenuated by about 55dB over 600m (ex. 100 dB -> 45 dB). However, all the machinery in the power plant will be operated over night, and it is still necessary to take appropriate mitigation measures to reduce noise level such as installing machinery and equipment in adequate enclosure, installing low noise/ low vibration type equipment and mainitaing the equipment regularly.

Table 8.7-7 Noise Level of Power Generation Facility

Machine Type	Noise Source Level(dB)
HRSG	75.0
Water Supply Pump	91.6
Stack	80.4
Circulation Water Pump	98.9
Gas Turbine	80.3
Steam Turbine	80.0
Gas Compressor	99.3

Note: Gas turbine and steam turbine are equipped with a cover.
Source: JICA Study Team

On the other hand, noise and vibration occurs due to the operation of vehicles. Vehicles for tranpotation of the workers will be regularly maintained.

b. Vibration

The impact of vibration is predicted to be caused by plant operation. Maintenance of equipment will be conducted, and low vibration type equipment and adequate enclosures will be installed.

5) Odor

In case domestic waste from the workers is not appropriately treated, bad odors from rotten waste may occur. Before starting plant operation, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produces. These measures will be taken to minimize the generation of odor.

(2) Natural Environment

1) Protected Area

As waste water is not discharged into Lake of Tunis, Chikly Island, which is the nearest protected area from the project site, is not affected by waste water.
In addition, impact to Chikly Island and Bou- Kornine National Park by this project is not anticipated since simulation result on the exhaust gas dispersion model indicates no impact on those protected areas by air pollutants emitted from the power plants.

2) Ecosystem

Simulation on thermal effluent diffusion model indicates no impact on the existing sea-grass bed. To meet Tunisian waste water standards, water treatment system will be installed in Rades C power plant. Therefore, significant impact on sea-grass bed is not predicted.

Although migration birds are likely to fly to the coastline, the impact of the power plant operation on migration birds is minor, as there is no plan for changing the coastline. However due to protect individual, workers will prohibit disturbance, harassment, and hunting. If protected species are observed, the mitigation measure will be discussed in consultation with the expert.

(3) Social Environment

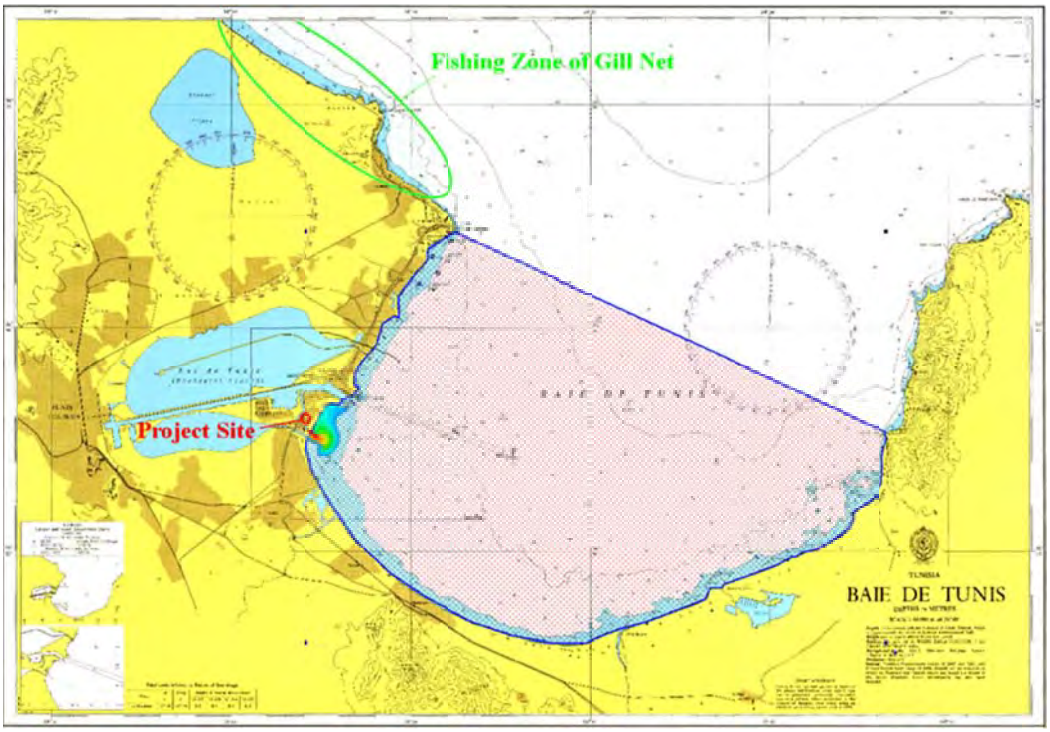
1) Local Economy

a. Fishery

As described above, small scale fishery is conducted in the sea area in front of the site. However, the sea area influenced by thermal effluent from the existing power plant is recognized as a good fishing area for the small scale fishery. Therefore, the adverse impact on the small scale fishery by thermal effluent from Rades C power plant will rarely occur.

On other hands, taking into account the migration of marine organisms, extension of rising temperature area (sea area of more than 1^{o}C of water temperature) due to the project may cause certain impact on fishery.

One of the plural patterns of predicted impact is the effect on the migration of marine organisms within Bay of Tunis. The migratory behavior of marine organisms in Bay of Tunis is not known. The maximum extension of rising temperature area is predicted to remain in 110ha (compared to 100ha before the project), accounting for as small as 252.25km^2 (25,225.3 ha) within the sea area Pte. Er Reis - Cap Carthage in Bay of Tunis (Fig. 8.7-15) .It indicates that the ratio of rising temperature area slightly increases from 0.40% to 0.44%, and the environmental impact will be very limited.



Source: JICA Study Team

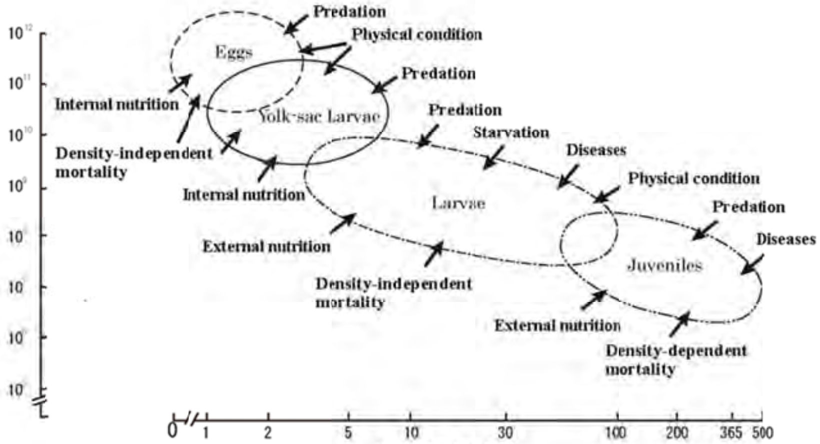
Figure 8.7-15 Rising Temperature Range in Bay of Tunis

Most of fish caught by gill net fishery are species that spawn pelagic egg. Pelagic eggs, as small as approximately 1mm diameter, are spawned in large amount and drift in the ocean. It hatches about 1day after being spawned and grow by consuming yolk (Yolk-sac Larvae). After consuming all yolk, it starts feeding (Larvae), and shifts from planktonic life stage to benthic life stage as it grows (Juvenile).

Figure 8.6-16 indicates a diagram of early life mortality of fish. The main cause of mortality in the early stage is predation of egg and yolk-sac larvae, constituting “density-independent mortality”. In addition to predation, starvation is another cause of mortality in juvenile, which also constitutes density-independent mortality. Predation and starvation are the main cause in juvenile as well, and in case of high density of settled individuals, fight over feed lead to “density-dependent mortality”. Density-dependent mortality is said to have compensation effect, which decreases the range of recruitment variation due to density-independent mortality in the planktonic life stage from egg to larvae[11]. In consequence, the potential impact of extension of rising temperature area on the planktonic life stage (from egg to larvae) is compensated in juvenile stage, and the impact on the adult fish resource is not predicted.

Juveniles settle on the sea bed of the shallow sea area. The sea area less than 5m depth within Pte. Er Reis - Cap Carthage is 25.2115km^2 (2,521.15 ha) (Figure 8.6-15), and the ratio of the rising temperature area slightly increases from 4.0% to 4.4%. In consequence, the adverse effect of extension of rising temperature area on juvenile in benthic life stage will be very limited.

Crustacea incubates egg till planktonic larvae come out. In this case, density-independent mortality in planktonic life stage is compensated by density independent mortality in benthic life stage and the impact on the fry shrimp in benthic life stage will be very limited.



Source: T. Minani (1994)[12]

Figure 8.7-16 Diagram of Early Life Mortality of Fish

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[11] Y. Yamashita (1994); 5. Predation, “Study on Early Life Mortality of Fishes”. p.60-71. Kohseisha Kohseikaku, Tokyo, Japan.

[12] T. Minani (1994): 1. Historical development of the research, “Study on Early Life Mortality of Fishes”. p.9-20. Kohseisha Kohseikaku, Tokyo, Japan.

Blenniidae and Cephalopoda spawn demersal egg on a base of sea grass or rock. Sea-grass bed is partly observed in a rising temperature area, but the impact of the thermal effluent does not reach the benthic environment. Revetment that serves as rock is already affected by thermal effluent. Juvenile hatched from these eggs is capable of swimming to avoid unsuitable water temperature area, and the impact of the extended temperature rising area is not predicted.

Some species with characteristic life story are described below.
Belonidae spawns eggs on floating sea-grass, and juvenile drifts with that sea-grass. As belonidae are dispersed in this manner in a wide area at their early life stage, the stock in Bay of Tunis assembles from a vast area and the impact of extended temperature rising area is not predicted.
Scorpaenidae spawns young fish in a rocky area. Considering the fact that, in the front sea area of the power plant, the revetment is already affected by thermal effluent, and that the juveniles are capable of avoiding unsuitable temperature area by swimming, the impact of extended temperature rising area is not predicted.
Bothidae does not settle on the sea bed at the juvenile stage, and disperses in a wide area during long planktonic life stage. In this way, the stock in Bay of Tunis assembles from a vast area and the impact of extended temperature rising area is not predicted.

From the reasons described above, the impact of the extended temperature rising area on the marine organisms targeted by gill net fishery will be very limited.

b. Local Employment

STEG has a clear policy that as for the technitians requiring certain qualification, recruitment will be carried out on national level, but as for unqualified personnel, priority will be granted to people living nearby the site. Since Rades C will need certain number of unqualified personnel for its daily operation, positive impact on local economy can be expected.

2) Social Infrastructure

Commuter bus is in operation between the site of the existing power plants Rades A&B and the city center. In consequence, the increase of 90 staffs for Rades C will not cause significant increase of traffic and traffic jam.
STEG stated that it is restricted to enter sea area in front of the Rades Power Plant Group site on the Bay of Rades due to current of the sea and they have already conducted appropriate measures for security such as putting sign boards and security cameras to avoid accident.

3) Misdistribution of Benefits and Loss

With a certain number of people recruited locally and no disappearance of existing job, as well as with certain purchase increase of the same materials as for the existing power plants, there will be no misdistribution of benefits and loss.

4) Local Conflicts of Interest

Local conflicts of interest may occur between employers and local residence. Local people should be employed at the power plant to the maximum extent possible, and external workers should be taught to respect local customs in order to facilitate good relationships with the local people and should promote communication to local people (e.g., join in local events).

5) Work Environment (Including Work Safety)

Work accidents involving workers may occur at the power plant site. STEG shall establish a work safety plan. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc.) and on hard aspects (such as helmets masks, ear plugs, and, insulation protection equipments etc.).).

In order to prevent health problems of workers, “Control/Instrument Group”, which may take responsibility in the implementation of the environmental management plan, should observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc..

STEG will take appropriate measures to prevent security violation by the security guard on the project staffs and local people, and cooperative system with the police and the military forces to protect the security of the power plant.

6) Accidents

Observation of traffic regulations, installation of traffic signs, and training and education on safe driving to drivers shall be conducted for land traffic vehicles by “Control/Instrument Group”.

Fire prevention measures shall be conducted such as installation of fire protection equipment in the power plant and organization of fire-fighting team and fire-fighting training.

For oil leakage from oil tanks, it is necessary to establish a counter measures, such as cover the bottom of the tank-installation area with cement and installation of oil-separation tank in the drainage around the tank-installation area.

7) Cross-boundary Impact and Climate Change

CO_2 will be produced by the operation of the power plant. Combined Cycle technology will be adopted at the power plant, producing less CO_2 of approximately 632 thousand tons/year compared to a exsiting thermal power plant.

The total global CO_2 emission in 2012 is 34.5 billion tons, 90% of which is from fossil fuel combustion, and power generation sector is the largest generation source. Annual CO_2 emission of the project is assumed 1.161 million tons, constituting 0.004% of the total CO_2 generation from fossil fuel combustion.

8.7.3 Summary of Environmental and Social Impact Assessment

Table 8.7-8 Results of Environmental Impact Assessment

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	B-	B-	**Construction phase:** - Watering the construction site and using cover sheets on trucks for the transportation of soil will be undertaken to reduce dust generation. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions.

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							Operation phase: - The results of NOx in the exhust gas dispersion simulation are much below the ambient air quality standards (Guideline Value). - There wil be no air pollution impact on Mallaha (residentioal area), Chikly Island, and Bou-Kornine National Park. - Concentration of pollutants in emission gas will meet emission gas standards by adopting low-NOx combustion methods - Duct will be provided with CEMS (Continuous Emission Monitoring System) with the supported infrastructure as required under the gas emission standards
	2	Water Quality	B-	B-	B-	B-	**Construction phase:** - Channels, ditches and a temporary settling pond will be dug and excavated around the construction area. - A wastewater treatment facility for workers, such as a septic tank and an oil separator for oily run-off water, will be installed in the construction area. - Oil and chemical materials will be stored in an appropriate storage site to prevent permeation into the ground. **Operation phase:** - The diffusion area of thermal effluents expanded by approximately 20% only. The diffusion of thermal effluents is occurred only in the surface of the sea. The impact on the sea-grass bed that is located in the sea bottom is not assumed even if the thermal effluents disperse to the inside of the sea-grass bed. - Plant wastewater will be treated at a wastewater treatment facility in order for pollutants in the water to meet the discharged wastewater standards and the impact on the sea-grass bed will be reduced.
	3	Waste	B-	B-	B-	B-	**Construction phase:** - Construction waste and general waste will be re-used, recycled or disposed following related regulations. - Hazardous wastes, such as waste oil and batteries, will be treated by the appropriate companies in Tunisia **Operation phase:** - Rades C will also produce the same kinds of wastes on Rades A&B. These wastes are treated, in conformity with Tunisian regulations. - Hazardous wastes, such as waste oil and batteries, will be treated by the appropriate companies in Tunisia
	4	Noise and Vibration	B-	B-	B-	B-	**Construction phase:** - Construction machinery and vehicles will be regularly maintained. - Performing construction work during daytime

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Low-noise/ low-vibration machinery will be used. - The distance to the nearest residential area (Mallaha) from the project site is approximately 600m and the noise level is decreased by approximately 55dB compared to the site (ex. 107 dB -> 52 dB). However, the noise level is decreased by the fence surrounding the construction area and the fence of the site boundary of the Rades Power Plant Group.. Therefore, the noise level doesn‘t exceed the value of the Decree No. 84-1556 relating to the noise level. Since such as avoiding intensive operations of construction machinery, counter measures will be taken. - When the vehicles drive near Mallaha residence area, it is necessary to take preventive measures, such as limiting truck speed. **Operation phase:** - The distance to the nearest residential area (Mallaha) from the project site is approximately 600m and the noise level is decreased by approximately 55dB compared to the site (ex. 100 dB -> 45 dB). However, counter measure, such as installing machinery and equipment in adequate enclosure, will be taken. - Low-noise/ low-vibration machinery will be used. - Vehicles for tranpotation of the workers will be regularly maintained.
	5	Subsidence	D	D	D	D	**Construction phase:** - Use of ground water is not in the plan. **Operation phase:** - Desalinated water will be used in the power plant.
	6	Odor	B-	B-	B-	B-	**Construction and Operation phases:** - Before starting the construction work and power plant operation, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. - Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produced.
Natural Environ -ment	7	Protected Areas	C-	C-	D	D	**Construction and Operation phases:** - The nearest protected area from the site is Chikly Island in Lake Tunis located 6km east of the project site. There is also Bou-Kornin National -Park 8km south-west of the site. As waste water is not discharged into Lake Tunis, there is not water pollution impact to Chikly Island. - As the results of exhaust gas dispersion simulation, there will be no air pollution impact on Chikly Island and Bou-Kornine National Park
	8	Ecosystem	C-	C-	B-	B-	**Construction phase:** - The project is not forest or marsh. There is no primary forests, natural forests and mangrove wetlands around the site.

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							− No fauna of significance, excepting birds, have been noted on the Rades II Power Plant site. Although migration birds are likely to fly to the coastline, the impact of the construction work on migration birds is minor, as there is no plan for changing the coastline. - However due to protect individual, construction workers will prohibit disturbance, harassment, and hunting. - The water outlet faces shoaling beach, with no tidal land or coral reef. - Zostera bed (Sea-grass bed), which is commonly seen in Tunisia, was found in the north side of the sea area in front of the project site. Therefore, since the countermeasures against water contamination will be taken, the impact on the sea-grass bed will be reduced. - If protected species are observed, construction work will be stopped and the mitigation measure will be discussed in consultation with the expert. **Operation phase:** - Simulation on thermal wastewater diffusion model indicates no impact on the existing sea-grass bed. To meet Tunisian waste water standards, water treatment system will be installed in Rades C power plant. Therefore, significant impact on sea-grass bed is not predicted. - The current flow rate within the water canal of Rades port will be increased due to cooling water intake of Rades C power plant, but the increasing degree of the flow rate is little. The current flow rate of the discharge canal will also be increased, but the increase in the flow rate is not in a level to alter tidal current. - Although migration birds are likely to fly to the coastline, the impact of the power plant operation on migration birds is minor, as there is no plan for changing the coastline. - However due to protect individual, workers will prohibit disturbance, harassment, and hunting. - If protected species are observed, the mitigation measure will be discussed in consultation with the expert.
Social Environ-Ment	9	Resettlement	D	D	D	D	**Pre-construction phase:** - Land acquisition and relocation of the affected people by the project implementation is not predicted.
	10	Poor People	D	D	D	D	**Construction and Operation phases:** - Rades A Power Plant started operation in 1985, Rades B PP in 1998 and Rades II PP in 2002. The existing power plants have about 30 years of history within the local community through operation and expansion. The project relates to the expansion of the existing power plant within the site, and significant impact on the local community will be avoided. Consequently, the life of poor people in the region, if any,

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							will not be significantly affected.
	11	Ethnic Minority Groups and Indigenous People	D	D	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, the life of ethnic minority groups and indigenous people in the region, if any, will not be significantly affected.
	12	Local Economy such as Losses of Employment and Livelihood Means	B+/B-	B+/B+	B+/B-	B+	**Construction phases:** - Small scale fishery is conducted in the sea area in front of the site. However, .wastewater by the construction work will be treated in order to meet the discharged wastewater standards and negative impact to the small scale fishery by the construction work will not be significant. - Positive impacts are expected by employment of local people for the construction as well as sales increase of the stores and restaurants in the Mallaha area nearby by people working for the construction. **Operation phase:** - The sea area influenced by thermal effluent from the existing power plant is recognized as a good fishing area for the small scale fishery. Therefore, the adverse impact on the small scale fishery by thermal effluent from Rades C power plant will rarely occur. - Even though the migration of marine organisms is considered、the impact of the extended temperature rising area on the marine organisms targeted by gill net fishery will be very limited. - Rades C will need certain number of unqualified personnel for its daily operation. Positive impact on local economy can be expected.
	13	Land Use and Utilization of Local Resources	D	D	D	D	**Construction and Operation phases:** - The project relates to an installation of an additional power plant in the vacant are of the existing project site. The site of the existing power plant is not used as a local resource and the operation of the project will not affect the use of the local land and resources.
	14	Water Usage, Water Rights, etc.	D	D	D	D	**Construction and Operation phase:** - There is no water source for agricultural water, industrial water, and drinking water in and srounding the site and the operation of the project will not affect the water use and water rights.
	15	Existing Social Infrastructure and Services	B-	B-	B-	B-	**Construction phase:** - All materials, equipment and machinery to be imported to Tunisia for the project are less than 0.2 % of total volume treated by Rades port. Therefore, there should be no serious issue in terms of marine transportation. - Vehicles transporting commuting workers may cause increased traffic and traffic jams around the project area. - For vehicles, bus use will be promoted to reduce increasing

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							the number of vehicles used. Bus use will be promoted to reduce the increased number of vehicles on the roads. - As prevention measures for accidents when large size truck will pass around the site to carry heavy vehicles and large size equipment into the site, people in the surrounding area will be informed by the Police. **Operation phase:** - Commuter bus is in operation between the site of the existing power plants Rades A&B and the city center. In consequence, the increase of 90 staffs for Rades C will not cause significant increase of traffic and traffic jam - STEG stated that it is restricted to enter sea area in front of the Rades Power Plant Group site on the Bay of Rades due to current of the sea and they have already conducted appropriate measures for security such as putting sign boards and security cameras to avoid accident.
	16	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	D	D	D	D	**Construction and Operation phases:** - The project does not involve land acquisition and no damage of relation with the local decision-making institutions and other social institutions. - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on the relationship with the social institutions is not expected.
	17	Misdistribution of Benefits and Loss	B-	B-	D	D	**Construction phase:** - All contractors or subcontractors will act in accordance with market mechanism, and no misdistribution of benefits and loss is expected. **Operation phase:** - With a certain number of people recruited locally and no disappearance of existing job, as well as with certain purchase increase of the same materials as for the existing power plants, there will be no misdistribution of benefits and loss.
	18	Local Conflicts of Interest	B-	B-	B-	B-	**Construction phase:** - Local people should be employed for the construction work to the maximum extent possible - All contractors or subcontractors will act in accordance with market mechanism, and no misdistribution of benefits and loss is expected. - External workers should be taught to respect local customs in order to facilitate good relationships with local people and should promote communication to local people (e.g., join in local event). **Operation phase:** - Local conflicts of interest may occur between employers and local residence.

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Local people should be employed at the power plant to the maximum extent possible, and external workers should be taught to respect local customs in order to facilitate good relationships with the local people and promote communication to local people (eg., join in local events).
	19	Cultural Heritage	D	D	D	D	- Historical, cultural and/or archaeological property and heritage does not exist around the site.
	20	Landscape	D	D	D	D	- There is no scenic area around the project site. - The existing power plant is already integrated into the local scenery, and the project will not affect the local landscape. There is no scenic area around the project site. However, STEG will conduct measures such as plantation of trees and bushes to minimize effect on the landscape.
	21	Gender	D	D	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on the gender is not expected.
	22	Children's Rights	D	D	D	D	**Construction and Operation phases:** - As described above, the project will avoid significant change on the local society. Consequently, any adverse effect on children's right is not expected. - No child labor has been conducted in STEG, and will never be admitted in the future as well.
	23	Infectious Disease	B-	D	B-	D	**Construction phase:** - A temporary influx of migrant labor during the construction period may increase the risk of sexual transmitted diseases, etc. - Local people shoul be recruited as much as possible. - Pre-employment and periodic medical check-ups should be conducted for external workers (technical wokers, etc.). - An education and training on health care of workers will be conducted.
	24	Work Environment (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - All construction work will be conducted within the area of Rades Power Plant Group surrounded with a fence to protect safety of the surrounding area. - Rades A&B Power Plant site and the construction area will be divided with a solid wire-mesh fence to keep construction machines and vehicles away from the staffs and the facilities (machine rooms, boiler rooms, switchyard, hi-voltage transmission lines, etc.) of Rades A&B power plant. - The construction vehicles shall access the project site only through the designated gate, and the use of the main gate will be forbidden. - High risk rate of accidents is predicted in construction work.

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Work safety plans and should be established and obtained the approval of STEG. - Work safety plans should stipulate mitigation measures on soft aspects (safety training, etc.) and hard aspects (provide workers with appropriate protective equipment such as helmets masks, ear plugs, and, insulation protection equipments etc.). - In order to prevent health problems of workers, construction companies should observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc.. **Operation phase:** - Work accidents involving workers may occur at the power plant site. STEG shall establish a work safety plan. - The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc.) and on hard aspects (such as helmets masks, ear plugs, and, insulation protection equipments etc.).). - In order to prevent health problems of workers, STEG should observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc.. - STEG will take appropriate measures to prevent security violation by the security guard on the project staffs and local people, and cooperative system with the police and the military forces to protect the security of the power plant.
Other	25	Accidents	B-	B-	B-	B-	**Construction phase:** - Even though a sea accident is happened, no sea pollution is foreseeable by the fact that such vessel does not transport any liquid materials but only heavy equipement like turbines. - Land traffic accidents during construction work may occur. As prevention measures for land traffic accidents, observation of traffic regulations, and training and education on safe driving to the driver will be implemented by construction companies. - People in the surrounding residence area shall be informed of the bus schedule **Operation phase:** - Observation of traffic regulations, installation of traffic signs, and training and education on safe driving to drivers shall be conducted for land traffic vehicles. - Fire prevention measures shall be conducted such as installation of fire protection equipment in the power plant and organization of fire-fighting team and fire-fighting training.

Item	No.	Impact	Assessment based Scoping		Assessment based Survey Results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Cover the bottom of the tank-installation area with cement - Installation of oil-separation tank in the drainage around the tank-installation area.
	26	Cross-boundary Impact and Climate Change	B-	B-	B-	B-	**Construction phase:** - CO_2 will be produced by the construction machinery and.vehicles. However, since the construction volume is limited, the environmental impact, such as cross-boundary pollution, is predicted to be insignificant. - To reduce CO_2 emission as much as possible, periodic mentenance and management of all construction machinery and vehicles will be conducted. **Operation phase:** - CO_2 will be produced by the operation of the power plant. Combined Cycle technology will be adopted at the power plant, producing less CO_2 of approximately 632 thousand tons/year compared to a exsiting thermal power plant. - The total global CO_2 emission in 2012 is 34.5 billion tons, 90% of which is from fossil fuel combustion, and power generation sector is the largest generation source. Annual CO_2 emission of the project is assumed 1.161 million tons, constituting 0.004% of the total CO_2 generation from fossil fuel combustion.

Notes: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

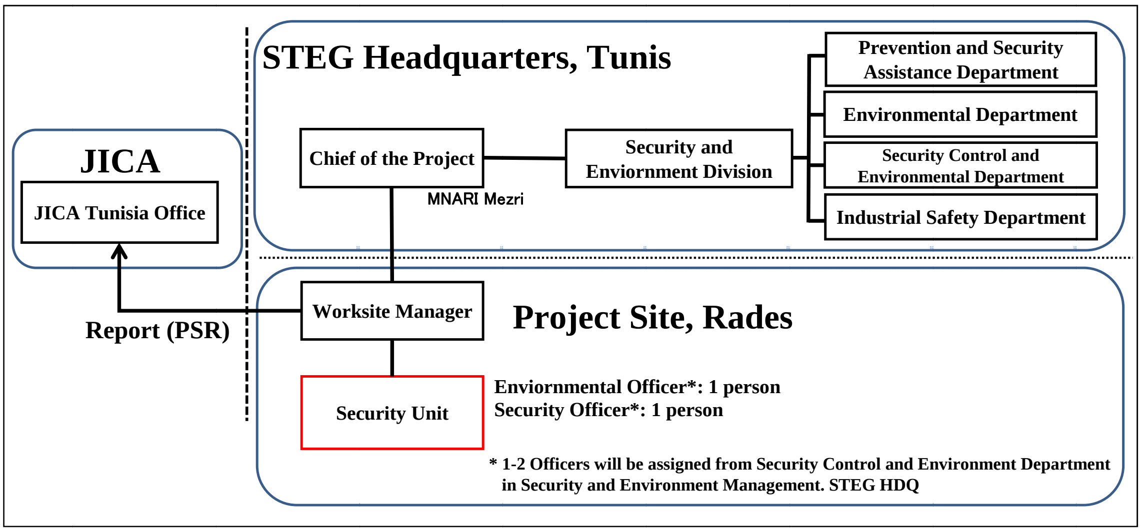
(Source: JICA Study Team)

8.8 Environmental Management Plan

8.8.1 Implementation System

(1) Construction Phase

Figure 8.8-1 shows the diagram of organizational framework during construction period of Rades C Power Plant. Security unit will take responsibility in the implementation of the environmental management plan.

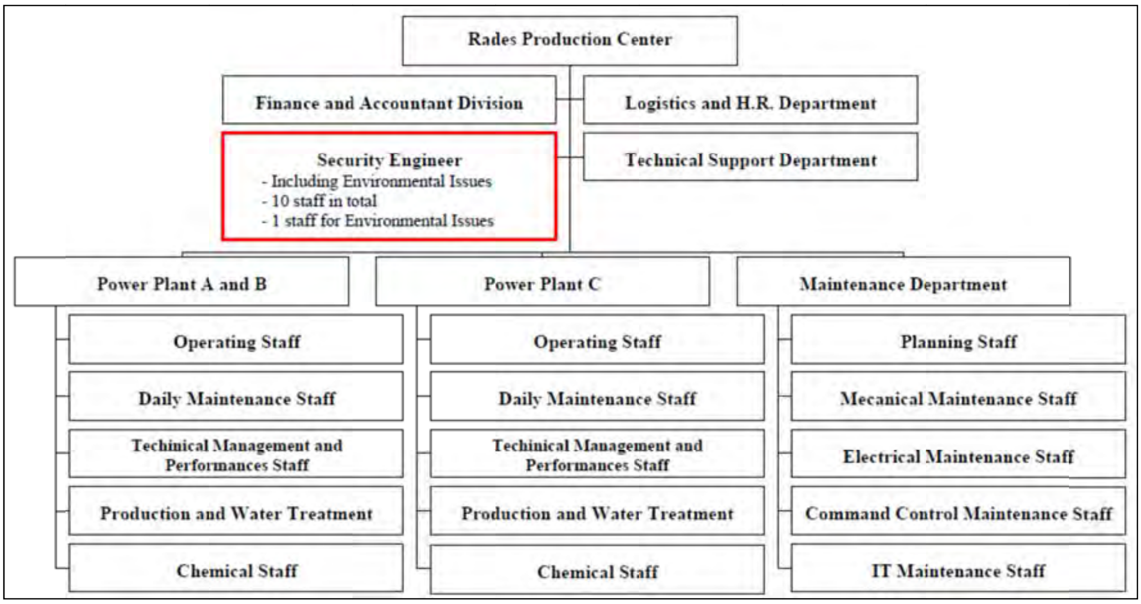


Source: STEG

Figure 8.8-1 Diagram of Organizational Framework during Construction Phase

(2) Operation Phase

Figure 8.8-2 shows the diagram of organizational framework during operation phase of Rades C Power Plant. Security Engineer will take responsibility in the implementation of the environmental management plan.



Source: STEG

Figure 8.8-1 Diagram of Organizational Framework during Operation Phase

8.8.2 Environmental Management Plan

Table 8.8-1 describes the environmental management plan proposed by JICA survey team to STEG and the consultant preparing EIA (TPE).

Table 8.8-1 Environmental Management Plan

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction phase									
1	Air Quality	1) Dust resulting from construction work	- Guideline values in Tunisian Standards related to Air (No. 106-04)	- Prevention of air pollution in surrounding area of the site	- Watering in the construction site - Using cover sheets on trucks for the transportation of soil - Setting up spaces for construction materials storage - Using an independent gate for the Construction site.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (10,000TND/ Construction phase)
		2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment			- Periodic maintenance and management of all the construction machinery and vehicles				
2	Water Quality	1) Run off water from construction area	- "Discharge to sea" in Tunisian Standard related to Effluent (No.106-02)	- Prevention of water pollution in surrounding area of the site	- Excavate channels, ditches and temporary settling pond around construction area - Install oil separator for treatment of oily wastewater - Construct silt basin	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (15,000TND/ Construction phase)
		2) Leakage oil and chemical materials from construction activity			- Storage of oil and chemical materials in an appropriate storage site and appropriate method to prevent				

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					permeation into ground				
		3) Domestic wastewater of workers			- Install wastewater treatment facility for workers such as septic tanks				
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers	- Law No. 96-14 (concerning management and disposal of solid waste)	- Prevention of inappropriate waste disposal	- Construction waste and general waste will be re-used, recycled or disposed following related regulations.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (10,000TND/ Construction phase)
		3) Hazardous waste such as dry batteries, etc.			- Hazardous waste should be treated by appropriate companies in Tunisia				
4	Noise and Vibration	1) Noise and vibration caused by construction machinery	- Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	- Reduction of noise levels from construction activities	- Construction machinery and vehicles will be regularly maintained. - Performing construction work during daytime - Using low-noise/ low vibration equipment	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (6,000TND/ Construction phase)
		2) Noise caused by vehicles used for mobilization of equipment and workers			- When the vehicles drive near Mallaha residence area, it is necessary to take preventive measures, such as limiting truck speed.				

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
5	Odor	- Domestic waste from workers	-----	- Prevention of generating odor	- Before starting the construction work, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. - Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produced.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	(Expenses included in the cost of waste management)
6	Ecosystem (Protected Species)	1) Construction works in the site (Impact on migration birds)	- Protected Species Lists of Flora and Fauna in Tunisia (19 July, 2006)	- Prevention of adverse impact on protected species	- Prohibit disturbance, harassment, and hunting - If protected species are observed, construction work will be stopped and the mitigation measure will be discussed in consultation with the expert.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (3,000TND/ Construction phase)
	Ecosystem (Marine Biota)	2) Potential impact due to the degradation of water quality caused by civil engineering work			- Same as those addressed in "Water quality"	- Construction site, especially at discharge of wastewater			(Expenses included in the cost of Water management)
7	Local Economy	- Adverse impact to small scale fishery d ue to water pollution	-----	- Prevention of water pollution	- Same as those addressed in "Water quality"	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor)	(Expenses included in the cost of Water management)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
								-Supervision: STEG	
8	Existing Social Infrastructure and Services	- Increased number of vehicles (cause of traffic jam)	-----	- Prevention of traffic disturbance	- Planning appropriate construction schedule - For vehicles, bus use will be promoted to reduce increasing the number of vehicles used. - The bus schedules shall be managed in consultation with related organizations.	- Roads near the construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) -Supervision: STEG	Expenses included in construction cost by the Contractor (2,000TND/ Construction phase)
9	Local Conflicts of Interest	1) Increase employment, subcontracting, the purchase of materials	-----	- Consideration of the attitudes of local residents to the project	- Local people should be employed for the construction work to the maximum extent possible - All contractor and sub-contractors will act in accordance with market mechanism, and no misdistribution of benefits and loss is expected.	- Community around the site	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor
		2) Conflicts between local residents and external workers			- External workers should be taught to respect local customs in order to facilitate good relationships with local people and should promote communication to local people (e.g., join in local event).				

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Infectious Diseases	- A temporary influx of migrant labor during the construction period may increase the risk of sexual transmitted diseases, etc.	-----	- Consideration for sanitation for local residents	- Pre-employment and periodic medical check-ups should be conducted for external workers (technical workers, etc.). - An education and training on health care of workers will be conducted.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (10,000TND/ Construction phase)
11	Work environment (including work safety)	1) Labor accidents	-----	- Prevention of labor accidents and health problems	- Work safety plans and should be established and obtained the approval of STEG. - Work safety plans should stipulate mitigation measures on soft aspects (safety training, etc.) and hard aspects (provide workers with appropriate protective equipment such as helmets masks, ear plugs, and, insulation protection equipment etc.).	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (18,000TND/ Construction phase)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		2) Diseases caused by air pollutants, water pollutants, and noise by construction work			- In order to prevent health problems of workers, construction companies should observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc..				
12	Site Security (Accidents)	- Work accidents and damage on existing equipment	-----	- Prevention of accidents by labors of the existing plant	- Setting up a protection mesh fence - Using an independent gate for the construction site. - The Contractor should provide enough qualified personnel and all needed means to insure a proper management of all works and emergency interventions.	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (15,000TND/ Construction phase)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
13	Accidents	- Traffic accidents	-----	- Prevention of traffic accidents	- As prevention measures for land traffic accidents, observation of traffic regulations, and training and education on safe driving to the driver will be implemented by construction companies. - As prevention measures for accidents when large size truck will pass around the site to carry heavy vehicles and large size equipment into the site, People in surrounding area of the site will be informed by the Police	- Roads near the construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (1,000TND/ Construction phase)
14	Cross-boundary impact and climate change	- CO_2 produced by construction machinery and vehicles	-----	- Reduce CO_2 emissions as much as possible	- To reduce CO_2 emission as much as possible, Periodic maintenance and management of all construction machinery and vehicles will be conducted	- Construction area	- During construction phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (7,000TND/ Construction phase)
Operation phase									
1	Air Quality	- Exhaust gas from the stacks	- Fixing Upper Limit of Polluted Air from Stationary Source (2010-2519) - Guideline values in Tunisian	- Prevention of air pollution in surrounding area of the site	- To reduce NO_2 emissions, firing system will use low combust technology - Duct will be provided with CEMS (Continuous Emission Monitoring System) with the supported infrastructure as required	- Stack	- During operation of power plant	- Implementation: STEG	(Expenses included in the construction cost, 400,000TND/ Low combust firing system, and Continuous Emission

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
			Standards related to Air (No. 106-04)		under the gas emission standards				Monitoring System)
2	Water Quality	1) Oil-containing wastewater, high salinity wastewater, boiler liquid waste, and other wastewater due to plant operation	- "Discharge to sea" in Tunisian Standard related to Effluent (No.106-02)	- Prevention of sea water pollution	- Installation of wastewater treatment system by neutralization, settling and oil separation so any wastewater produced complies with wastewater standards	- Power plant, especially at discharge of thermal effluents and wastewater treatment system	- During operation of power plant	- Implementation: STEG	(Expenses included in construction cost, 25,000TND/ water treatment system, temperature measurement system)
		2) Thermal effluent			- Installation of continuous temperature measurement system at the outlet				
		3) Domestic wastewater	-----	- Prevention of underground water contamination	- Construction of waterproof septic tank (underground tip); - Transportation (by truck) to treatment station or discharge into public sewage network	- Power plant	- During operation of power plant	- Implementation: STEG	(Expenses included in construction cost, 7,000TND/ septic tank) Disposal of domestic wastewater: 2,000TND/ year
3	Waste	1) Solid residue from wastewater treatment and waste oil from equipment, etc.	- Law No. 96-14 (concerning management and disposal of solid waste)	- Management of waste, especially hazardous waste - Prevention of inappropriate waste disposal	- Wastes are treated, in conformity with Tunisian regulations. - Hazardous wastes, such as waste oil and batteries, will be treated by the appropriate companies in Tunisia	- Power plant	- During operation of power plant	- Implementation: STEG	Waste disposal and transportation: 6,000TND/ year
		2) Sewage and garbage from workers							
		3) Waste of dredging	- Tunisian		- Conduct an impact				Conducting an

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		operation	regulation		assessment study. - Wastes are treated, in conformity with Tunisian regulations.				impact assessment study: 30,000TND/ 15 years Waste disposal and transportation: 6,000TND/ year
4	Noise and vibration	1) Noise and vibration from steam turbines, generators, and pumps, etc.	- Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	- Prevention of adverse impact from noise generated by the power plant	- Installation of low noise/ low vibration type equipment	- Power plant	- During operation of power plant	- Implementation: STEG	Expenses included in the construction cost: 10,000TND/ low noise and vibration equipment
		2) Noise caused by vehicles used for mobilization of equipment and workers			- Vehicles for transportation of the workers will be regularly maintained				Vehicles maintenance: 5,000TND/ year
5	Odor	- Domestic waste from workers	-----	- Prevention of generating odor	- Before starting the power plant operation, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. - Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produced.	- Power plant	- During operation of power plant	- Implementation: STEG	(Expenses included in the cost of waste management)
6	Ecosystem	1) Disturbance,	- Protected Species	- Prevention of	- Prohibit disturbance,	- Power plant	- During	- Implementation:	No expense as long

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
	(Protected Species)	harassment, and hunting by worker (Impact on migration birds)	Lists of Flora and Fauna in Tunisia (19 July, 2006)	adverse impact on protected species	harassment, and hunting - If any protecetd species are observed, the mitigation measure will be discussed in consultation with the expert.		operation of power plant	STEG	as any protected species are observed
	Ecosystem (Marine Biota)	2) Water discharge from the site			- Same as those addressed in "Water quality"	- Power plant, especially at discharge of thermal effluents and wastewater treatment system			(Expenses included in the cost of Water management)
7	Local Conflicts of Interest	1) Increase employment, subcontracting, the purchase of materials	-----	- Consideration of the attitudes of local residents to the project	- Local people should be employed for the work in STEG to the maximum extent possible	- Community around the power plant	- During operation of power plant	- Implementation: STEG	No expense
		2) Conflicts between local residents and workers			- External workers should be taught to respect local customs in order to facilitate good relationships with local people and should promote communication to local people (e.g., join in local event).				
8	Landscape	- Site landscape deterioration.	-----	- Prevention of Site landscape deterioration.	- Plantation of trees and bushes; - Continuous weeding; - Use of ecological colored paint.	- Power plant	- During operation of power plant	- Implementation: STEG	Expenses included in construction cost: 6,000TND/ plantation and painting

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
									Weeding: 3,000TND/ year
9	Work environment (including work safety)	1) Labor accidents	-----	- Prevention of labor accidents and health problems	- Establishing a work safety plan. - Soft aspects (safety training, etc.) - Hard aspects (such as helmets masks, ear plugs, and, insulation protection equipment etc.).	- Power plant	- During operation of power plant	- Implementation: STEG	Protective equipment: 15,000TND/ year
		2) Diseases caused by air pollutants, water pollutants, and noise by power plant operation			- In order to prevent health problems of workers, STEG will observe related working environment standards and provide workers with appropriate equipment, such as masks, ear plugs, etc.				
		3) Failure of security equipment		- Prevention of security equipment failure	- Periodic control and tests.				Control and tests: 10,000TND/ year
10	Accidents	1) Traffic accidents	-----	- Prevention of traffic accidents	- Observation of traffic regulations, installation of traffic signs, and training and education on safe driving to drivers shall be conducted for land traffic vehicles.	- Community around the power plant	- During operation of power plant	- Implementation: STEG	Safety training: 2,000TND/ year
		2) Fire accident		- Prevention of fire accident	- Organization of fire-fighting team and fire-fighting training	- Power plant			Training of firefighting team: 2,000TND/ year

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					- Installation of fire protection equipment in the power plant *CO_2 protection; *Portable and mobile extinguishers ; *Water protection; *Foam protection ; *Fire Alert Plan; *Evacuation signs; *Protection system control				(Expenses included in construction cost: 3,000TND/ all equipment)
		3) Gas Oil		- Prevention of Gas oil leakage, failure and fire	- Installation of these equipment for the gas oil tank *On site waterways for fire; *Oil blocking embankment around the tank *Cooling system for tank surface *Foam extinguisher system inside of the tank ; *Foam extinguisher system outside of the tank *Periodic control.				(Expenses included in construction cost: 10,000TND/ all equipment)
		4) Natural Gas		- Prevention of Natural gas leakage, failure and fire	- Installation of these equipment for the gas oil tank *Control room; *Gas Sensor; *On site fire extinguisher; *Periodic Control.				(Expenses included in construction cost: 10,000TND/ all equipment)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		5) Oil and Chemicals		- Prevention of Oil/ Chemicals leakage and fire	- Adequate storage; - Periodic inspections.				- Storage and inspection: 2,000TND/ year
11	Cross-boundary impact and climate change	- Emissions of CO_2	-----	- Reduce CO_2 emissions per electric generate (kW)	- Adoption of high-efficiency CCPP.	- Power plant	- During operation of power plant	- Implementation: STEG	(Expenses included in construction cost)

Source: STEG

8.9 Environmental Monitoring Plan

Table 8.9-1 describes the environmental monitoring plan proposed by JICA survey team to STEG and the consultant preparing EIA (TPE).

Table 8.9-1 Environmental Monitoring Plan

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method: Method of Collecting and Analyzing Data	Monitoring Method: Location	Monitoring Method: Duration and Frequency	Responsible Organization	Cost
Construction Phase									
1	Air Quality	- Dust resulting from construction work	- Implementation of mitigation measures towards air pollution	- To ensure concrete implementation of mitigation measures towards air pollution which will be conducted by the Contractor	- Patrolling the construction site	- Construction site	- Once every three months	- Supervision: STEG	Expenses included in normal inspection cost by STEG
2	Water Quality	1) Run off water from construction area 2) Leakages of oil and chemical materials from construction activity	**Refer to "Monitoring Form"** - Tunisian Standard related to Effluent (No.106-02)	- Evaluation of effect of the mitigation measures towards water pollution	- Collecting samples before discharging water and analyzing at a lab	**- 1 point:** Foreside of the drain outlet	- Once a month during structural work phase - Once three months during Finishing phase	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (Sampling and Analyzing: 4,000 TND/ Structural work phase 2,000 TND/ Finishing phase
3	Wastes (Odor)	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	**Type and quantity of waste, and the disposal method** - Law No. 96-14 (concerning management and disposal of solid waste)	- Evaluation of effect of the mitigation measures for waste	- Record of type and quantity of waste, and the disposal method	- Contractor's office	- Once a year	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (1,000TND/ 3month)
4	Noise	1) Noise and vibration	**Noise level**	- Evaluation of	- Measurement	**- 2 points:**	- Once every	- Implementation:	Expenses

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	- Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	effect of the mitigation measures towards noise levels	using noise level meter	Boundary of the power plant -**1 point:** Boundary of the closest house	three months	The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	included in construction cost by the Contractor (Measurement: 7,000TND/ year)
5	Ecosystem (Protected Species)	- Construction works in the site (Impact on migration birds)	**Species, Number** - Protected Species Lists of Flora and Fauna in Tunisia (19 July, 2006)	- Evaluation of existence of migration birds	- Observation	**1 point** - Construction area	- Once a week in migration season for **first two years** after starting the construction	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor (Observation: 2,000TND/ researcher・year)
	Ecosystem (Marine Biota)	2) Potential impact due to the degradation of water quality caused by civil engineering work	**Species, Cover degree** - Sea-grass bed	- Evaluation of effect of the mitigation measures towards water pollution	- Observation	**5 points** - Sea area in front of construction area	- Once a year		(Observation: 2,000TND/ researcher・year)
6	Existing Social Infrastructure and Services	- Increased number of vehicles (cause of traffic jam)	- Number of vehicles used by construction	- Evaluation of effect of construction schedule	- Record of numbers of cars being used	- Entrance of construction site	- Daily	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor
7	Local Conflicts of Interest	- Conflict between local residents and external workers	- Change in local customs	- Confirmation of the attitudes of local residents to the	- Number and contents of received grievance	- STEG	- Once every 3 months	- STEG	Expenses included in normal

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
				project	and the response				inspection cost by STEG
8	Infectious Diseases	-Temporary influx of migrant labor during construction may increase risk of infection	- Number of pre-employment medical check up - Number of periodic medical check up	- Evaluation of sanitation for labor	- Labor health records	- Related institutions	- Once every 3 months	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor
9	Work Environment (Including Work Safety)	- Labor accidents	- Record of accidents	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Once every 3 months	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor
10	Accidents	- Traffic accidents	- Record of accidents	- Evaluation of mitigation measures for prevention of accidents	- Record of accidents	- Contractor's office	- Once every 3 months	- Implementation: The Contractor/ Environmental Consultant (hired by the Contractor) - Supervision: STEG	Expenses included in construction cost by the Contractor
11	Cross-boundary Impact and Climate Change	- CO_2 will be produced by construction work	- Number of car registration check	- Efforts to reduce CO_2	- Record of car registration (as a proof of machinery maintenance)	- Contractor's office	- Once every 3 months	- Implementation: The Contractor/ Environmental Consultant (hired by the	Expenses included in construction cost by the Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								Contractor) - Supervision: STEG	
Operation Stage									
1	Air Quality	- Exhaust gas from the stacks	**SO_2, NO_2, CO** - Fixing Upper Limit of Polluted Air from Stationary Source (2010-2519)	- Evaluation of effect of the mitigation measures towards air pollution	- CEMS (Continuous Emission Monitoring System)	- Stack outlet	- Continuous measurement	- Implementation: STEG	Expenses by STEG
2	Water Quality	1) Oil-containing wastewater, high salinity wastewater, boiler liquid waste, and other wastewater due to plant operation 2) Thermal effluent	**Refer to "Monitoring Form"** - Tunisian Standard related to Effluent (No.106-02)	- Evaluation of effect of the mitigation measure towards water pollution	A:Drain outlet - Collecting samples at the site, analyzing at a lab - Continuous measurement using a sensor B: Seawater - Collecting samples at the site, analyzing at a lab - Measuring vertical sea water temperature profile with CTD meter	A; Drain outlet **-1 point:** Drain outlet of the wastewater treatment facility **-2 points:** Intake and Outlet B: Seawater **-6 points:** Sea area around intake and outlet	A: Drain outlet -**SS, Oil, BOD etc**.(Sampling and analyzing): Once every 3 months -**pH, temperature**: Continuous measurement B: Seawater - Once a year	- Implementation: STEG/ Environmental Consultant	A: Sampling: 100 TND/ day Analyzing: 1,000 TND/ sample B: Sampling: 500TND/ day Analyzing: 1,000TND/ sample
3	Waste (Odor)	1) Solid residue from wastewater treatment and waste oil from equipment, etc. from power plant operation. 2) Sewage and garbage from workers	**Type and quantity of waste, and the disposal method (refer to "Monitoring Form)** - Law No. 96-14 (concerning	- Evaluation of appropriate handling of Solid residue, sewage, garbage, and waste from dredging operation	- Record of the amount of wastes generated from power plant operation	- Power plant office	- Once a year	- Implementation: STEG	Expenses by STEG

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		3) Waste of dredging operation	management and disposal of solid waste)				- Once a year (if dredging operation is conducted)		Expenses by STEG
4	Noise	1) Noise from steam turbines, generators, and pumps, etc. 2) Noise caused by vehicles used for mobilization of equipment and workers	**Noise level** - Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	- Evaluation of effect of the mitigation measures towards noise levels	- Measurement using noise level meter	**-2 points:** Boundary of the power plant **-1 point:** Boundary of the closest house	- Once a year	- Implementation: STEG	Measurement: 1,500TND/ year
5	Ecosystem (Protected Species)	- Disturbance, harassment, and hunting by worker (Impact on migration birds)	**Species, Number** - Protected Species Lists of Flora and Fauna in Tunisia (19 July, 2006)	- Evaluation of existence of migration bird	- Observation	**1 point** - around the site	- Once a week in migration season if any precious species are observed during the construction phase	- Implementation: STEG	Observation: 2,000TND/ researcher
	Ecosystem (Marine Biota)	-Degradation of water quality caused by operation of power plant	**Species, Cover degree** -Sea-grass bed	- Evaluation of effect of the mitigation measure towards water pollution	- Observation	**-5 points:** Sea area in front of the site	- Once a year		Observation: 2,000TND/ researcher
6	Local Conflicts of Interest	- Conflict between local residents and workers	- Local residents' feelings	- Confirmation of local residents' feelings	- Number and contents of received grievance and the response	- Power plant office	- Once every 3 months	- Implementation: STEG	Expenses by STEG
7	Work Environment (Including Work Safety)	- Labor accidents	- Record of accidents	- Evaluation of effect of mitigation measurements	- Record of accidents	- Power plant office	- Once every 3 months	- Implementation: STEG	Expenses by STEG

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
8	Accidents	1) Traffic accidents 2) Fire 3) Gas Oil 4) Natural Gas 5) Oil and Chemicals	- Record of accidents	- Evaluation of effect of mitigation measurements	- Record of accidents	- Power plant office	- Once every 3 months	- Implementation: STEG	Expenses by STEG
9	Cross-boundary Impact and Climate Change	- Emissions of CO_2	- Amount of CO_2 emissions	- Efforts to reduce CO_2	- Calculate the CO_2 emissions from fuel consumption	- Power plant office	- Once a year	- Implementation: STEG	Expenses by STEG

Source: STEG

8.10 Stakeholders` Meeting

In Tunisia, a public consultation is not mandatory during the process of the EIA. For the Project of Rades C CCPP, STEG in its contract with Tunisie Protec Environnement (TPE: a local contracting consultant) in charge of EIA implementation, requested to carry out one public consultation, but not before starting the EIA on the subject of the scoping of the EIA.
In consultation with STEG and TPE and as requested by JICA Study Team, a first stakeholders` meeting was organized on September 20, 2013 in order to explain the outline of the project to the people concerned and to obtain their opinions on the proposed scoping as well as on the terms of reference (TOR) of the EIA. A second stakeholders` consultation to hear their opinions on the draft final report of the EIA was organized on November 13, 2013, but due to some reasons explained below, this second stakeholders` consultation was not successful. The third stakeholder meeting was decided to be held upon the request from the participants of the second stakeholder meeting.
By organizing the two stakeholders` meetings as above (as a result three stakeholders` meetings were organized), this is expected to be consistent with the JICA's Guidelines for Environmental and Social Considerations.

8.10.1 1st stakeholders` meeting

(1) Participants

For those who requested to be able to participate in the stakeholders` meeting, an invitation letter was sent in advance. In addition to STEG and the consulting firm in charge of the EIA, representatives from various organizations participated in the discussions. The participants were as follows (Figure 8.10.1).

- Administration authorities (i.e., the Ministry of Agriculture, National Agency for Environmental Protection (ANPE)
- Agency for Coastal Protection and Development (APAL),
- Ben Arous Prefecture and Rades City
- Local economic organizations (i.e., Tunisian Union of Agriculture and Fishery (UTAP), Ben Arous Prefecture industrial and commercial association, Rades City industrial and commercial association and the Rades City petroleum association)
- Non Governmental Organizations (NGOs) (i.e., Association de sauvegarde de l'Urbanisme et de l'Environnement (ASUE))
- Residents from the vicinity of the proposed power plant
- A female architect living in the vicinity of the proposed power plant

Source: JICA Study Team

Figure 8.10-1 Scenery of the 1st Stakeholder Meeting

(2) Summary of the meeting

Prior to the meeting, the governor of the Ben Arous Prefecture came to the venue and had discussions with various participants.

Summary of proceedings is as follows.

Date and time:	September 20, 2013 (Friday), 10:00 to 12:00.
Location:	Prefectural government facility of Ben Arous.
Number of participants:	34 people (including 7 ladies) in total (as detailed above).
Used Language	Mainly Arabic mixed with French

Proceedings:

a. Welcome speech and description of the project (STEG)
b. Explanation of scoping and TOR of the EIA study (TPE)
c. Questions and answers session (STEG and TPE answered the questions)
d. Explanation on the expected date for the completion of the EIA draft final report and programmed date for the second stakeholders` meeting as well as expressing gratitude to the participants (STEG)

The main questions were as follows.

- Estimated volume of emission of CO_2, NOx, and SOx, and possible impacts on the neighborhood (local NGO)
- Estimated volume of warm water effluent and possible impacts on the sea, coast and fisheries (local NGO)
- Necessity of APAL approval for warm water effluent into the public sea (APAL)
- Landscape issues around the power plant (local architect)
- Adverse effect on local and national economy in case of the zero option (Rades city industrial and commercial association)
- Relationship between environmental standards and emission levels for air and water (multiple participants)
- Combined effects when considering Rades C and the currently operating Rades II A&B, together with IPP (multiple participants)

To these questions, STEG and TPE answered wherever possible and promised to give

answers, based on the results of the EIA study, on the occasion of the next stakeholders` meeting in November.
It is also to be noted that female participants were very active in the discussion and sevral residents of Rades County took part of the meeting.

8.10.2 2nd stakeholders` meeting

(1) Participants
An invitation letter was sent in advance to those people and organizations who were invited in the first stakeholders' meeting. In addition, taking into account the advice of JICA's advisory committee for environmental and social considerations, a women's association (AFTURD: Association des Femmes Tunisiennes pour la Recherche sur le Développement) was invited and several notices were put in the nearest residential area of Mallaha (Figure 8.10-2). Due to very bad weather in the morning of the meeting day, however, less number of participants than the first meeting was unfortunately registered. In addition to STEG, TPE, JICA and TEPSCO, representatives of Ministry of Industry, APAL, Ben Arous Governorate, Rades County, UTAP, UTICA were in the meeting (Figure 8.10-3).

Société Tunisienne de l'Electricité et du Gaz
الشركة التونسية للكهرباء والغاز

دعوة للعموم

في إطار مشروع إنجاز محطة جديدة لإنتاج الكهرباء برادس تعتزم الشركة التونسية للكهرباء و الغاز (STEG) تنظيم استشارة عمومية مع الأطراف المتدخلة لهذا المشروع بحضور ممثلي الهياكل و المؤسسات المجاورة و ذلك يوم الاربعاء 13 نوفمبر 2013 بقاعة الأفراح التابعة لبلدية مقرين على الساعة التاسعة و نصف صباحا.

و في هذا الإطار فإن الدعوة مفتوحة للعموم لحضور هذا الاجتماع و ذلك لإبداء الرأي و الاقتراحات حول هذا المشروع التنموي الهام.

Source: STEG

Figure 8.10-2 Bill of SHM Held Announcement


Source: JICA Study Team

Figure 8.10-3 Scenery of the 2nd Stakeholder Meeting

(2) Summary of the meeting

Prior to the meeting, ex-ambassador of the republic of Tunisia to Japan came to the venue and had discussions with various participants.

Summary of proceedings is as follows.

Date and time:	November 13, 2013 (Wednesday), 10:00 to 11:45.
Location:	Prefectural government facility of Ben Arous.
Number of participants:	26 people (including 6 ladies) in total.
Used Language	Mainly Arabic mixed with French

Proceedings:

a. Welcome speech (STEG)
b. Explanation of main results of the EIA study (TPE)
c. Discussions

The main points discussed were as follows.

- Since the draft final EIA report was not distributed before meeting, we can not formulate our comments. In other projects, draft report is made available sufficiently in advance and we can check it in detail before attending the meeting (APAL).
- Invitation letter was not sent to our site office. I came here today by the order of my head-office which received STEG's letter only at the beginning of this week. The invitation should be reached at least one week before and should be addressed to Rades site office (UTAP).
- The meeting should be held in Rades city, nearer than here to the project site (a resident in Rades city).
- We should invite Media and make our discussions open to those people who could not attend the meeting (UTICA Ben Arous).
- Considering above discussions without mentioning at all the contents of EIA draft report, STEG decided to organize another stakeholders' meeting in about two weeks and announced it to participants making it also clear that comments made today will be taken into account. Participants agreed with that idea and the meeting was adjourned.

It is to be noted that female participants expressed their opinions more actively than male participants in general and real local observations were made by participants who were resident of Rades County or representative of Rades office of national or regional organizations.

8.10.3 3rd stakeholders` meeting

(1) Participants

An invitation letter together with EIA report was sent by STEG one week before the meeting and newspaper announcement (in French language) was made twice by STEG (Figure 8.10-4). Ben Arous Governorate on the other hand informed other organizations concerned as well as media people. The place of meeting was changed to the Rades city hall, nearer place to project site than two previous meetings. Therefore, all requests expressed by participants in the second stake holders' meeting were respected (Figure 8.10-5).

- Representatives from administration (Minstry of Industry, Minstry of Finance, ANGed, Ben Arous Governorate, Rades County)
- Media (two Arab newspaper and one French newspaper)
- One private maritime company (Société maritime GENMAR)
- Economic organizations (JCI=Jeune Chambre Internationale Rades, UTAP Ben Arous)
- NGO (ASUE, ATAE (Association Art et Envoronnement), Association Yassmin, Association BIATI, BTBFBMecasol)
- Two citizen of Rades County

JOURNAL
LA PRESSE
Du 25 Novembre 2013

Consultation publique du projet de construction de la Centrale électrique de radès

Dans le cadre du projet de la construction de la centrale électrique à cycle combiné de Radès étape C (430-500 MW), la Société tunisienne de l'électricite et du gaz (Steg) se propose d'organiser une réunion pour la consultation publique des parties prenantes affectées à ce projet en présence des représentants des différents organismes nationaux et entreprises avoisinantes du site d'implantation de la centrale le **mercredi 27 novembre 2013 à 09h00** à la municipalité de Radès.

A cette occasion, les habitants de Radès et principalement ceux avoisinant le centre de production d'électricité, sont invités à assister à cette réunion pour discuter et donner leurs avis et suggestions sur les aspects environnementaux et sociaux liés à la réalisation de ce projet de developpement régional.

Source: STEG

Figure 8.10-4 Newspaper Advertisement of SHM Held Announcement

Source: STEG

Figure 8.10-5 Scenery of the 3rd Stakeholder Meeting

(2) Summary of the meeting

Summary of proceedings is as follows.

Date and time:	November 27, 2013 (Wednesday), 9:30 to 11:30.
Location:	City hall of Rades County.
Number of participants:	37 people (including 4 ladies) in total.
Used Language	Mainly Arabic mixed with French

Proceedings:

a. Welcome speech (STEG)
b. Explanation of main results of the EIA study (TPE)
c. Discussions
d. Resolution

The main points explained by TPE about the results of the EIA study are as follows.

- On September 27, 2013, 12 points of Tunis bay nearby the Rades central were investigated. It was confirmed that some of these points got direct impacts from port activities but none of them got negative impact from Rades central.
- According to the simulation of hot water, most significant impact may occur with wind from west. Even under such conditions, however, area to be reached by water of one to five degrees hotter than sea will not be very large compared with current situation and hot water will not reach the intake area of cooling water.
- Simulation of air diffusion from chimneys shows that air quality, namely Nox and SO_2 will never exceed national or international standards. This is thanks to high chimenies and high speed of emission gaz.
- Main recommendation is to monitor the noise and vibration level and their possible impact in the neighboring area.

Then discussions started. Main opinions and answers expressed are as follows.

- Wind direction is very important to determine the hot water diffusion. Main cause of current Rades seashore pollution is Oued Méliène River. We need to investigate more on this issue. Tall chimney can be very aggressive from aesthetic point (ASUE).
- Recommendation is also made to carry out an overall study on the pollution of Rades seashore. It is recommended to develop solar electric generation (JCI de Rades).
- Representative of the association regretted not to be able to see anymore migrating birds including flamingoes in the bay of Tunis. He is convinced that this is closely related to the pollution of Rades seashore. He is also interested in the number of jobs to be created by the Project (Association Art et Environnement).
- (STEG and TPE) The pollution of Rades seashore never comes from STEG's electric central but from Oued Méliène River. Combined cycle power plant is very clean and efficient. STEG is making efforts in wind power (240 MW developed until today) as well as in solar power with a project of 50 MW. It is estimated to create 90 new jobs by the Project, without talking about many indirect jobs during the construction stage. By the air and hot water simulation, accumulated impacts by existing two plants and the new Rades C project are measured and the result does not exceed the standard. The project will carry out an architectural competition. ASUE can be associated in the selection of such competition.
- In order to reduce the dependence on conventional energy, we should promote PROSOL project[13] and increase the portion of solar power (Association BIATI).
- (STEG) PROSOL project is also beneficial for STEG. The government of Tunisia is now preparing a law concerning electricity sales by small producers. STEG is willing to associate with the comprehensive study to determine the causes of the pollution of Oued Méliène River.
- Rades county should be engaged in that study (Association BIATI).
- (STEG) Rades county is willing to commit to identify the source of pollution and to reduce it. The pollution seems to come from the water evacuation of ONAS (Office Nationale d'Assainissement) into the Oued Méliène River. The county wishes to have more contributions from NGO to find out good solutions. It wishes also that STEG be engaged in that study.
- The solution will be the construction of water treatment plant in Séjoumi area and to stop water drainage into the Oued Méliène River (ASUE).
- (STEG) We need to have an approval of ANPE before starting the project. As for the comprehensive study, Rades county is kindly requested to make a formal request to the STEG president. Since we are participating to a similar study in Sousse region, we can certainly engage in such a study.
- We propose in a near future a symposium on the Rades region pollution (Association Art et Environnement).
- The gouvernorate approves the initiative of symposium and will propose it to the government of Tunisia. It regrets the absence of ANPE to the meeting, although ANPE was well invited (Representative of Ben Arous Gouvernorate).
- We propose to construct a green belt around Rades Power Plans Group (UTAP).
- (STEG) We can do it.
- Deputy Mayor of Rades county, seeing there remains no further question, asked whether

[13] Initiative taken by UNEP to subsidize Tunisian private banks in order to promote the installation of solar panels by citizens to get hot water. By the success of this project, the government of Tunisia decided to install 750,000 m^2 of solar panels in the period 2010 - 2014.

the stakeholders approve the EIA and the project. All participants agreed to approve the EIA prepared by TPE and the Rades C project.

Resolution:

- Some corrections should be made, namely the height of chimney which will improve the result of impacts.
- EIA should be presented to ANPE as soon as possible, because the project will have positive effects on regional economy as well as on the Tunisian economy in general.

It is worth noting that although STEG had made tremendous efforts in inviting directly a female association to the third stakeholders meeting and in advertising in newspapers and putting announcements in the residential area nearby the Rades Power Plants about the meeting, less number of female participants was registerd compared to the two previous meetings. In particular, STEG invited directly AFTURD like the second meeting and confirmed by telephone receipt of their invitation letter, AFTURD, however, did not send any representative to the meeting. On the other hand, three male citizens from Rades county, representing no organization, participated in the meeting and expressed their opinions.

8.11 Others

8.11.1 Environmental Checklist

Table 8.11-1 shows the result of environmental and social consideration reviewed according to the checklist attached to JICA Guideline.

Table 8.11-1 Check List of Rades C Power Plant

Cate gory	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) Y (b) Y (c) N (d) N	(a) The EIA report was prepared in December 2013 and submitted to ANPE (Agence Nationale de Protection de l'Environnement) on 10th of December, 2013. (b) The EIA report has been approved by ANPE on 13th of February, 2014. (c) STEG received 8 points of condition and has to provide an updated EIA that includes all those points to ANPE: * The cumulative impact of the power plants and the monitoring of the previous projects * The effect of increasing of the heat rejection's volume and the extentt task offshore * The management mode of the brackich. * The impact on the water during the construction phase of the power plant Rades C * The details of the dispersion modeling discards (the compass,the streams..) * A detailed environnemental monitoring plan * The revision of the environmental manegement plan * The presentation of the minutes of the public hearings as par of the project. The environmental engeneering office, TPE, will update the EIA as soon as possible. (d) The realization of the project Rades C doesn't require other environmental permits. STEG only needs the agreement of the EIA by ANPE.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
1 Permits and Explanation	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) The stakeholder meeting was held three times. The first meeting was held in 20th of September, 2013 and the overview of the project, the status of the site, environmental impact mitigation measures and environmental management plan were explained, with the participation of the local administration, NGOs and the local residents living around the project site. The second meeting was held in 13th of November, 2013, giving explanation on the environmental impact assessment, with only small number of participant due to bad weather. In response to the demand for rescheduling of the meeting from the participant, the third meeting was held in 27th of November, 2013 with the participation of the local administration, the NGOs, the local residents. The questions were posed from the participants concerning the renewable energy, air pollution, water pollution, contribution of the project to the local economy and other issues, and the participants finally supported the implementation of the project. (b) Comments are reflected to the environmental management plan.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) The alternatives were discussed regarding zero-option, site selection, fuel selection, and power generation method.

Category	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
2 Pollution Control	(1) Air Quality	(a) Do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust emitted by the power plant operations comply with the country's emission standards? Is there a possibility that air pollutants emitted from the project will cause areas that do not comply with the country's ambient air quality standards? Are any mitigating measures taken? (b) In the case of coal-fired power plants, is there a possibility that fugitive dust from the coal piles, coal handling facilities, and dust from the coal ash disposal sites will cause air pollution? Are adequate measures taken to prevent the air pollution?	(a) Y (b) N	(a) Natural gas used for fuel contains almost no sulfur, ash and SOx, therefore it generates very little SOx and particulate matter. NOx concentration in the gas emission is estimated within the emission gas standards (Fixing Upper Limit of Polluted Air from Stationary Source; 2010-2519). Atmospheric diffusion simulation of NOx emitted from Rades C Power Plant (in addition to the existing power plants Rades A＆B and RadesII) was conducted and the result indicated that NOx concentration satisfies the ambient air quality standards (Tunisian Standards related to Air; No. 106-04) at all the measurement points. (b) The project is not a coal-fired power plant.
	(2) Water Quality	(a) Do effluents including thermal effluents from the power plant comply with the country's effluent standards? Is there a possibility that the effluents from the project will cause areas that do not comply with the country's ambient water quality standards or cause any significant temperature rise in the receiving waters? (b) In the case of coal-fired power plants, do leachates from the coal piles and coal ash disposal sites comply with the country's effluent standards? (c) Are adequate measures taken to prevent contamination of surface water, soil, groundwater, and seawater by the effluents?	(a) Y (b) N/A (c) Y	(a) Waste water discharge from Rades C Power Plant into the surrounding sea area includes thermal effluent, make-up water and rainwater. Domestic waste water is sent to the sewage system and treated at the sewage treatment facility. The conformity of the effluent to the effluent standard is confirmed before discharged into sea area. Thermal effluent from Rades C Power Plant is discharged into the discharge channel used for the existing power plants Rades A＆B and RadesII. According to the result of the thermal effluent diffusion simulation, regarding the maximum assumed affected area (water temperature increase of more than 1℃) of the thermal effluent, the area will increase from 100ha to 110ha by the operation of Rades C Compared to the existing power plants, only 10 ha of increase, and the impact to the sea-grass bed is not predicted. (b) The project is not a coal-fired power plant. (c) The effluent is not discharged into surface water or ground water. Make-up water will be treated with neutralization, sedimentation of suspended solid, and oil separation before discharging into sea to meet the waste water standards (Tunisian Standard related to Effluent; No.106-02).

Category	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
2 Pollution Control	(3) Wastes	(a) Are wastes, (such as waste oils, and waste chemical agents), coal ash, and by-product gypsum from flue gas desulfurization generated by the power plant operations properly treated and disposed of in accordance with the country's regulations?	(a) Y	(a) The project relates to the gas-fired power plant and coal ash and byproduct of flue gas desulfurization is not generated. Waste from the existing power plant Rades A &B is collected and treated with specified treatment method by specified treatment company according to the type of waste. The treatment company is authorized by ANGED (Agence Nationale de Gestion des déchets).
	(4) Noise and Vibration	(a) Do noise and vibrations comply with the country's standards?	(a) Y	(a) The distance to the nearest residential area (Mallaha) from the project site is approximately 600m and the noise level is decreased by approximately 55dB compared to the site (ex. 100 dB -> 45 dB). In consequence, the noise standard of 50dB will not be exceeded.
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N/A	(a) Fresh water used in the power plant will be produced using RO (Reverse Osmosis Membrane). Ground water will not be used.
	(6) Odor	(a) Are there any odor sources? Are adequate odor control measures taken?	(a) N	(a) Garbage will be disposed on a periodic basis to ensure that odor by putrefaction is not produced.

Category	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) The nearest protected area from the site is Chikly Island in Lake Tunis located 6km east of the project site. There is also Bou-Kornin National Park 8km south-west of the site. As waste water is not discharged into Lake Tunis, there is not water pollution impact to Chikly Island. As the results of exhaust gas dispersion simulation, there will be no air pollution impact on Chikly Island and Bou-Kornine National Park.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms? (e) Is there a possibility that discharge of thermal effluents, intake of a large volume of cooling water or discharge of leachates will adversely affect the ecosystem of surrounding water areas?	(a) N (b) N (c) N (d) N (e) N	(a) The project is implemented within the site of the existing power plant, and no virgin forest or natural forest exists. No coral reef, mangrove marsh, or tidal flats around the project site. (b) The project is implemented within the site of the existing power plant and protected species are not inhabited. However, sea-grass bed is found on the north side of the sea (outside of the project site), and it is recognized as endangered or threatened species under Barcelona Convention which is for protecting the Mediterranean Sea against pollution. (c) Although migration birds are likely to fly to the coastline, the impact of the power plant operation on migration birds is minor, as there is no plan for changing the coastline. To meet Tunisian waste water standards, water treatment system will be installed in Rades C power plant. Therefore, significant impact on sea-grass bed is not predicted. (d) The current flow rate within the water canal of Rades port will be increased due to cooling water intake of Rades C power plant, but the increasing degree of the flow rate is little. The current flow rate of the discharge canal will also be increased, but the increase in the flow rate is not in a level to alter tidal current.. (e) Simulation on thermal wastewater diffusion model indicates no impact on the existing sea-grass bed.

Cate gory	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A (i) N/A (j) N/A	(a) The project is implemented within the site of the existing power plant. Land acquisition is not involved and resettlement does not occur. (b) - (c) - (d) - (e) - (f) - (g) - (h) - (i) - (j) -

Category	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is sufficient infrastructure (e.g., hospitals, schools, and roads) available for the project implementation? If the existing infrastructure is insufficient, are any plans developed to construct new infrastructure or improve the existing infrastructure? (c) Is there a possibility that large vehicles traffic for transportation of materials, such as raw materials and products will have impacts on traffic in the surrounding areas, impede the movement of inhabitants, and any cause risks to pedestrians? (d) Is there a possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (e) Is there a possibility that the amount of water used (e.g., surface water, groundwater) and discharge of thermal effluents by the project will adversely affect existing water uses and uses of water areas (especially fishery)?	(a) N (b) Y (c) Y (d) Y (e) N	(a) Rades A power plant started operation in 1985, Rades B power plant in 1998 and Rades II power plant in 2002. The existing power plants have about 30 years of history within the local community through operation and expansion. The project relates to the expansion of the existing power plant within the site, and significant impact on the local community will be avoided. (b) There are sufficient infrastructures around the project site; therefore there is no problem with implementation of the project. (c) There is possibility of transporting materials during the construction phase by heavy vehicles. It will be informed to local people by police/. (d) During construction phase, Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc.). And also, an education and training on health care of workers will be conducted. (e) Small scale fishery is conducted in the sea area in front of the site. However, the sea area influenced by thermal effluent from the existing power plant is recognized as a good fishing area for the small scale fishery. Therefore, the adverse impact on the small scale fishery by thermal effluent from Rades C power plant will rarely occur.. Even though the migration of marine organisms is considered、the impact of the extended temperature rising area on the marine organisms targeted by gill net fishery will be very limited.

Category	Environmental Item	Main Check Items	Yes: Y No: N	"Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) Historical, cultural and/or archaeological property and heritage does not exist around the site.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) The existing power plant is already integrated into the local scenery, and the project will not affect the local landscape. There is no scenic area around the project site. However, STEG will conduct measures such as plantation of trees and bushes to minimize effect on the landscape.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N/A (b) N/A	(a) In Tunisia, ethnic minorities do not exist. Therefore, any impact on ethnic minorities and indigenous peoples will not occur. (b) -
	(6) Working Conditions	"(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?"	(a) Y (b) Y (c) Y (d) Y	(a) STEG insisted on the compliance to the labor laws and regulations (b) STEG insisted they will take due consideration on the safety of workers on the hardware aspect such as installation of safety equipment and management of hazardous substances in order to prevent labor accident. (c) STEG insisted on the successive instruction on the software aspect such as implementation of work safety plan including training on traffic safety and public sanitation for staffs. (d) STEG will take appropriate measures to prevent security violation by the security guard on the project staffs and local people, and cooperative system with the police and the military forces to protect the security of the power plant.

Cate gory	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?"	(a) Y (b) N	(a) The following pollution-preventive measures will be taken. The obligation of compliance to the relevant laws and regulations by the construction company will be specified in the contract and confirmed in the process of the construction management. (a)-1 Noise The distance to the nearest residential area (Mallaha) from the project site is approximately 600m and the noise level is decreased by approximately 55dB compared to the site (ex. 107 dB -> 52 dB). However, the noise level is decreased by the fence surrounding the construction area and the fence of the site boundary of the Rades ower Plant Group. Therefore, the noise level doesn‘t exceed the value of the Decree No. 84-1556 relating to the noise level (a)-2 Water quality Channels, ditches and a temporary settling pond will be dug and excavated around the construction area. A wastewater treatment facility for workers, such as a septic tank and an oil separator for oily run-off water, will be installed in the construction area. (a)-3 Air quality Watering the construction site and using cover sheets on trucks for the transportation of soil will be undertaken to reduce dust generation. Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. (a)-4 Waste Construction waste and general waste will be re-used, recycled or disposed following related regulations. Hazardous wastes, such as waste oil and batteries, will be treated by the appropriate companies in Tunisia (b) The construction activity is conducted within the existing power plant site where no protected species are observed. Although migration birds are likely to fly to the coastline, the impact of the construction work on migration birds is minor, as there is no plan for changing the coastline

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
5 Others	(1) Impacts during Construction	(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	(c) Y	(c)-1 Fishery Small scale fishery is conducted in the sea area in front of the site. However, .wastewater by the construction work will be treated in order to meet the discharged wastewater standards and negative impact to the small scale fishery by the construction work will not be significant. (c)-2 Traffic All materials, equipment and machinery to be imported to Tunisia for the project are less than 0.2 % of total volume treated by Rades port. Therefore, there should be no serious issue in terms of marine transportation. For vehicles, bus use will be promoted to reduce increasing the number of vehicles used. As prevention measures for accidents when large size truck will pass around the site to carry heavy vehicles and large size equipment into the site, people in the surrounding area will be informed by the Police (c)-3 Local conflict External workers should be taught to respect local customs in order to facilitate good relationships with local people and should promote communication to local people. (c)-4 Infectious diseases Pre-employment and periodic medical check-ups should be conducted for external workers (technical workers, etc.). An education and training on health care of workers will be conducted.
	(2) Accident Prevention Measures	(a) In the case of coal-fired power plants, are adequate measures planned to prevent spontaneous combustion at the coal piles (e.g., sprinkler systems)?	(a) N/A	(a) The project is not a coal-fired power plant.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)"
5 Others	(3) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) N/A	(a) STEG has already prepared the environmental monitoring plan (EMoP). (b) The EMoP contains monitoring of air quality, water quality, noise, ecosystem, waste, and social aspects during construction and operation. All items, methods and frequencies of the monitoring are written on the EMoP and the Monitoring Form. (c) STEG confirmed they will establish an adequate monitoring framework for the project during construction and operation phase. (d) In Tunisia, the reporting of the monitoring result to the relevant authority is not regulated by law and regulation. However, STEG will inform periodically the result of monitoring to JICA.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). (b) Where necessary, pertinent items described in the Ports and Harbors checklist should also be checked (e.g., projects including construction of port and harbor facilities).	(a) N/A (b) N/A	(a) The project does not include transmission and/or distribution lines. (b) The project does not involve construction and expansion of the port facility.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, and global warming).	(a) N/A	(a) The total global CO_2 emission in 2012 is 34.5 billion tons, 90% of which is from fossil fuel combustion, and power generation sector is the largest generation source. Annual CO_2 emission of the project is assumed 1.161 million tons, constituting 0.004% of the total CO_2 generation from fossil fuel combustion.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are requested to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Source: STEG & JICA Study Team

8.11.2 Monitoring Form

Items that require monitoring shall be decided on according to the sector and nature of the project, with reference to the following list of items.

(1) Construction phase

1) Air quality (Site patrol to check the implementation of mitigation measures)

Mitigations	Place	Date	Time	Result of inspection (Conducted or Not Conducted)	Remarks
Watering					
Using cover sheet on trucks					
Others ( )					

Source: JICA & STEG

2) Water quality (Discharge point)

(Date:)

Parameter	Unit	Result	Tunisian Standard related to Effluent (No.106-02) (Discharge into sea)	Remarks
Temperature	°C.		35	
pH	-		6.5 - 8.5	
BOD_5	Mg/L		30	
COD	Mg/L		90	
Suspended Solid	Mg/L		30	
Total Aliphatic Hydrocarbons (Oil, Grease, Tar)	Mg/L		10	

Source: JICA & STEG

3) Noise

Date;   (Unit: dBA)

Location	Result (L_{50})	Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	IFC/EHS guidelines (General; 2007)	Remarks
Boundary of the power plant (1)		-	70	
Boundary of the power plant (2)				
Boundary of the closest house		50	Day (07:00-22:00): 55 Night (22:00-07:00): 45	

Source: JICA & STEG

4) Ecosystem

a. Migration birds: for first two years after starting the construction

(Date:)

Scientific name	Local name	English name	Total No. of individuals	Conservation Status		Remarks
				IUCN	Decision of Ministry of Agriculture and Water Resources dated July 19, 2006	

Source: JICA & STEG

b. Sea-grass bed

(Date;) (Unit: Cover degree (%))

Species		St.3	St.5	St.6	St.7	St.12	Remarks
1							
2							
·							
·							
·							

Note: Sampling point is same as sea water monitoring in operation phase

Source: JICA & STEG

5) Other

a. Waste

- Types and quantity of waste, and the disposal method

Duration: / / ~ / /

Type of Waste	Amount	Waste Generation	Storage	Collection	Disposal
General Waste					
General Waste		From office works and workers in the construction site			
Construction Waste*					
Metal chips					
Waste plastic					
Wood shavings					
Waste glass					
Waste oil					
Batteries					

*: Parameter of type of waste can be deleted and/or added in accordance with actual type of waste

Source: JICA & STEG

b. Social environment

- Social Infrastructure: Record of numbers of cars being used for the construction work

Duration: / / ~ / /

Item	Monitoring Results
Number of cars	

Source: JICA & STEG

- Local conflict: Number and contents of received grievance and the response

Duration: / / ~ / /

Date	Name	Contents	Response	Remarks

Source: JICA & STEG

- Infectious Diseases: Labor health records

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Number of pre-employment medical check up		
Number of periodic medical check up		

Source: JICA & STEG

c. Working environment and accidents

- Record of accidents

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Workers' accident		

Source: JICA & STEG

d. Accidents

- Record of traffic accidents

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Traffic accident		

Source: JICA & STEG

e. CO_2 emission

- Record of car registration (as a proof of machinery maintenance)

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Number of car registration check		

Source: JICA & STEG

(2) Operation phase

1) Air quality

a. CEMS (Continuous Emission Monitoring System)

Duration: / / ~ / /

Parameter	Unit	Period exceeding the standard	Fixing upper limit of polluted air from stationary source (2010-2519)	IFC/ EHC Guideline (Thermal Power Plant; 2008)	Remarks
SOx	mg/Nm^3		10	-	
NOx	mg/Nm^3		50	51	
CO	mg/Nm^3		85	-	

Notes: Dry Gas, The values are converted into 15% of O_2 concentration

Source: JICA & STEG

2) Water quality

a. Drain outlet

(Sampling)

(Date:)

Parameter	Unit	Result		Tunisian Standard related to Effluent (No.106-02) (Discharge into sea)	IFC/EHS guidelines		Remarks
		IN	OUT		Industry wastewater (Thermal Power Plant; 2008)	Sanitary sewage (General; 2007)	
Temperature	°C.			35	-	-	
pH	-			6.5 - 8.5	6 - 9	6 - 9	
BOD_5	mg/L			30	-	30	
COD	mg/L			90	-	125	
Suspended solid	mg/L			30	50	50	
Total Aliphatic Hydrocarbons (Oil, Grease, Tar)	mg/L			10	10	10	
Chlorine residual	mg/L			-	0.2	-	
NO_3-N	mg/L			90	-	-	
NO_2-N	mg/L			5	-	-	
NH_3-N	mg/L			30	-	-	
PO_4-P	mg/L			0.1	-	-	

Source: JICA & STEG

(Continuous measurement: pH, Temperature)

Duration: / / ~ / /

Parameter	Location	Period exceeding the standard	Tunisian Standard related to Effluent (No.106-02) (Discharge into sea)	IFC guideline (Thermal power: 2008)	Remarks
pH	Intake	hr	6.5 - 8.5	6 - 9	
	Outlet	hr			
Temperature	Intake	hr	35℃	-	
	Outlet	hr			

Source: JICA & STEG

b. Sea water

(Date:)

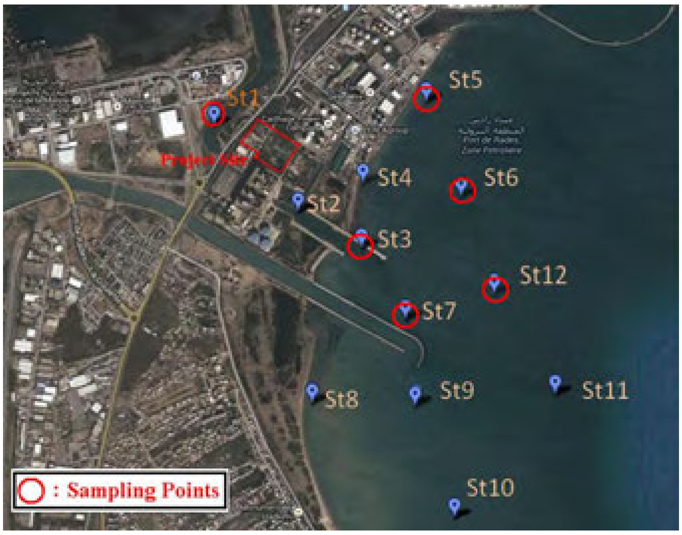
Parameter	Unit	St.1:Intake		St.3		St.5		St.6	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Depth	M								
Temperature	°C								
Salinity	-								
pH	-								
BOD_5	mg/L								
COD	mg/L								
Suspended solid	mg/L								
Total Aliphatic Hydrocarbons (Oil, Grease, Tar)	mg/L								
NO_3-N	mg/L								
NO_2-N	mg/L								
NH_3-N	mg/L								
PO_4-P	mg/L								

Parameter	Unit	St.7		St.12		Average		Japanese Ambient Water Quality Standards* (Environmental Protection)
		Surface	Bottom	Surface	Bottom	Surface	Bottom	
Depth	M							-
Temperature	°C							-
Salinity	-							-
pH	-							7.0 - 8.3
BOD_5	mg/L							-
COD	mg/L							< 8
Suspended solid	mg/L							-
Total Aliphatic Hydrocarbons (Oil, Grease, Tar)	mg/L							No detection (n-Hexane Extraction Substance)
NO_3-N	mg/L							-
NO_2-N	mg/L							-
NH_3-N	mg/L							-
PO_4-P	mg/L							-

Note: * For reference
Source: JICA & STEG

<Sea Water Sampling Point>

Station	Lat	Log
St1	36°47’58.00N”	10°16’49.50N”
St3	36°47’37.50N”	10°17’20.20N”
St5	36°48’02.00N”	10°17’33.60N”
St6	36°47’46.20N”	10°17’41.00N”
St7	36°47’25.80N”	10°17’29.42N”
St12	36°47’28.60N”	10°17’48.10N”



3) Noise

Date; (Unit: dBA)

Location	Result (L_{50})	Decree No. 84-1556 on the regulation of industrial estates relating to the noise level	IFC/EHS guidelines (General; 2007)	Remarks
Boundary of the power plant (1)		-	70	
Boundary of the power plant (2)				
Boundary of the closest house		50	Day (07:00-22:00): 55 Night (22:00-07:00): 45	

Source: JICA & STEG

4) Ecosystem

a. Migration bird**: <u>If any protected species are observed during the construction phase.</u>**

(Date:)

Scientific name	Local name	English name	Total No. of individuals	Conservation Status		Remarks
				IUCN	Decision of Ministry of Agriculture and Water Resources dated July 19, 2006	

Source: JICA & STEG

b. Sea-grass bed

(Date;) (Unit: Cover degree (%))

Species		St.3	St.5	St.6	St.7	St.12	Remarks
1							
2							
·							
·							
·							

Note: Sampling point is same as sea water monitoring

Source: JICA & STEG

5) Other

a. Waste

- Type and quantity of waste, and the disposal method

Duration: / / ~ / /

Type of Waste	Amount	Unit	Waste Generation	Storage	Collection	Disposal
General Waste						
General Waste		Tons	- Office works - Power Plant workers			
Ordinal household waste (canteen)		Tons	- Canteen			
Solid Waste						
Waste Oil		Litter	- Power Plant work			
Used Batteries		Batteries	- Power Plant work			
Sea-grass		Tons	- Water Intake			
Solid residue		Tons	- Sea water			

Type of Waste	Amount	Unit	Waste Generation	Storage	Collection	Disposal
			treatment process			
Oil contaminated sand		Tons	- Power Plant work			
Dust cloth contaminated with Oil		Tons	- Power Plant work			

Source: JICA & STEG

b. Social environment

- Local conflict: Number and contents of received grievance and the response

Duration: / / ~ / /

Date	Name	Contents	Response	Remarks

Source: JICA & STEG

c. Working environment and accidents

- Record of accident

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Workers' accident		

Source: JICA & STEG

d. Accidents

- Record of accidents

Duration: / / ~ / /

Item	Monitoring Results	Measures to be Taken (if any)
Traffic accident		
Fire		
Gas Oil		
Natural gas		
Oil and Chemicals		

Source: JICA & STEG

e. CO_2 emission

- Calculate the CO_2 emissions from fuel consumption

Duration: / / ~ / /

Item	Results (unit: ton/year)	Measures to be Taken (if any)
Amount of CO_2 emission		

Source: JICA & STEG

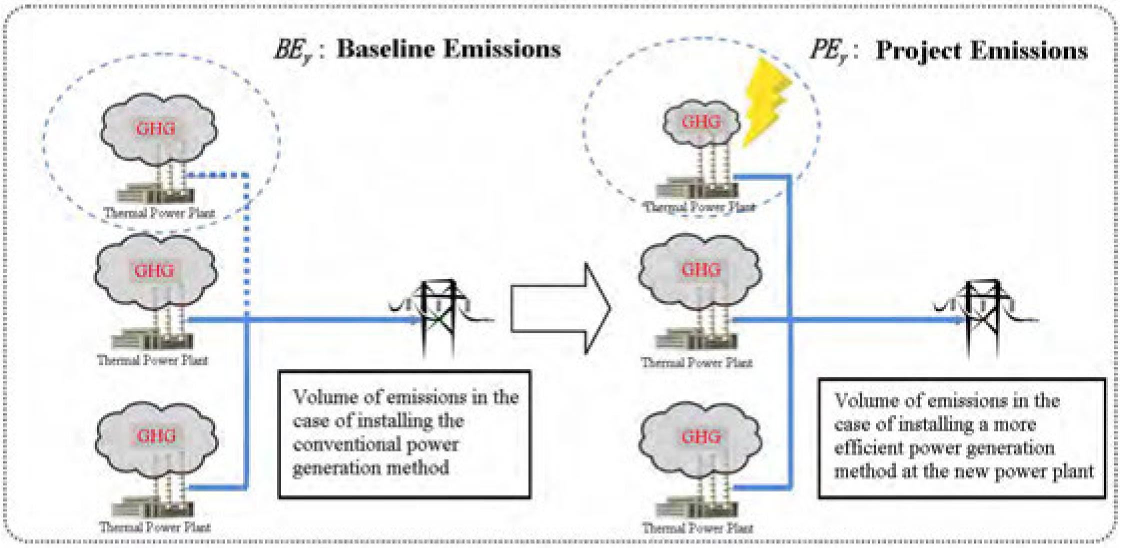
8.12 Estimation of Greenhouse Gas Reductions

8.12.1 Methodology

This project is identified as a climate change mitigation project, and its mitigation effect was calculated in reference to "JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011". The calculation method for greenhouse gas (GHG) emission reduction is shown below (Figure 8.12-1).

$ER_y = BE_y - PEy$

ER_y: GHG emission reduction in year y achieved by project (t-CO_2/y)
BE_y: GHG emission in year y with low-efficiency power generator (t-CO_2/y)
(Baseline emission)
PE_y: GHG emission in year y after efficiency improvement (t-CO_2/y)
(Project emission)



Source: JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011
Figure 8.12-1 Images of Emissions Reductions

(1) Baseline emission

Since the amount of power output in the grid before the start of the project is supposed not changed after the completion of the project, the power output reduced by the existing power plant shall be equivalent to the power out generated by the new power plant.

$BE_y = EG_{BLy} \times EF_{BLy}$

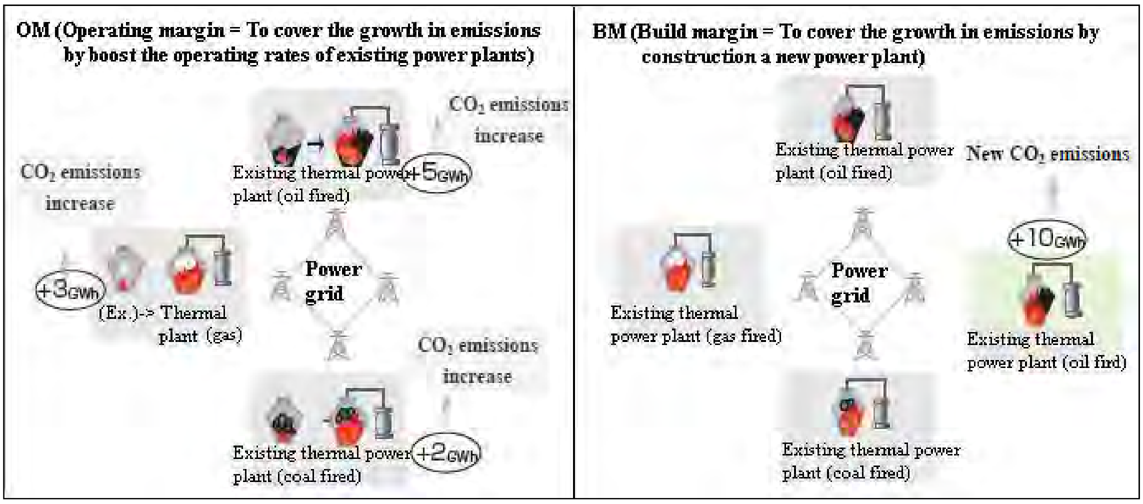
Where,
BEy: Baseline emission (GHG emission with low-efficiency existing power plants), (t-CO_2/y)
EG_{BLy}: Reduction of net electrical output by the existing power plants, which shall be equivalent to the power output of new power plant EG_{PJy}, (MWh/y)
EF_{BLy}: CO_2 emission factor of the electricity for the low-efficiency power plant, (t-CO_2/MWh)

There are three options for calculations of baseline emission coefficient (t-CO_2/MWh)

Option 1 : the build margin emission coefficient (t-CO_2/MWh)
Option 2 : the combined margin emission coefficient (using a 50/50 operating margin/build margin weight)

Option 3 : emission coefficient (t-CO_2/MWh) identified as the most likely baseline scenario

The images of operating margin (OM) and build margin(BM) emissions coefficient are shown in the Fig.8.12-2.



Source: http://gec.jp/gec/jp/Activities/cdm_meth/pACM0002-old-080414.pdf

Fig. 8.12-2 Images of OM and BM

(2) Project emission

Project emission shall be determined by multiplying the net power output produced by the new power plant and the CO_2 emission factor of electricity for the new power plants.

$$PE_y = EG_{PJy} \text{ x } EF_{PJy}$$

Where,

$PE_{PJ,y}$: Project emission (GHG emission after project activity (t-CO_2/y))

$EG_{PJ,y}$: Yearly electricity generating capacity after the project (transmission end efficiency) (MWh/y)

$EF_{PJ,y}$: CO_2 emission coefficient of electricity generation (t-CO_2/MWh)

Calculation of project CO_2 emission factor of electricity: EF_{PJy}

CO_2 emission coefficient of electricity for the new power plant is calculated using the planned data of CO_2 emission factor of fuel and generation efficiency and power output for the new power plant before the project starts, and the measured data shall be used after the project is completed.

CO_2 emission factor of fuel “i” shall be the same as of the baseline, since the fuel properties are the same for the both cases.

$$EF_{PJ,y} = \{COEFi / (\eta_{PJ,y/100})\} \text{x } 0.0036$$

Where,

EF_{PJy}: Project CO_2 emission factor of electricity, (t-CO_2/MWh)

$COEF_i$:CO_2 emission coefficient of fuel “i” per calorific value, (t-CO_2/TJ)

$\eta_{PJ,y}$: Planned value of generation efficiency after improvement, (%)
0.0036: Conversion factor of electric energy (mega watt hour) to thermal energy (tera-jule), (TJ/MWh)

8.12.2 Estimation of effect of greenhouse gas emissions reductions

(1) Baseline emission

IGES (Institute for Global Environmental Strategies) of Japan provides three emission factors as below for Tunisia. Table 8.12-1.

Table 8.12-1 Grid CO_2 Emission Factors in Tunisia

Margin	Unit	Average
Combined Margin (CM)	t-CO_2/ MWh	0.5536
Operation Margin (OM)	t-CO_2/ MWh	0.5711
Build Margin (BM)	t-CO_2/ MWh	0.5215

Source: http://pub.iges.or.jp/modules/envirolib/view.php?docid=2136

Since not only combined cycle power plants but also conventional thermal power plants are programmed for the future plan of STEG in Tunisia, using combined margin (CM) as baseline emission seems to be more conservative and appropriate than using build margin (BM). Therefore, we adopt here combined margin (CM) as baseline emission factor.

Baseline Emission Coefficient: 0.5536 (t-CO_2/ MWh)

(2) Project emission

Regarding Rades C CCCP, the CO_2 emission factor of fuel i: COEFi and CO_2 emission factor of electricity: $EF_{PJ,y}$ can be calculated using the same equations as for the old power plants by only changing the figure of generation efficiency from Table 8.12-1. The results are as shown in Table 8.12-2.

Table 8.12-2 Calculation of CO_2 emission coefficients for Rades C Project

Item	Unit	Value	Remarks
Kind of fuel	-	Natural gas	Note-1)
Higher heating value, HHV	kJ/kg	50,716	(ditto)
Lower heating value, LHV	kJ/kg	45,750	(ditto)
Carbon content in fuel, C%	weight%	70.37	(ditto)
CO_2 emission coefficient of fuel, COEFi	t-CO_2/TJ	56.36	Note-2)
Net generation efficiency of old power plant, $\eta_{PJ/y}$	%	56.6	Note-3)
Conversion factor of electric energy (mega watt hour) to thermal energy (tera-jule)	TJ/MWh	0.0036	
CO_2 emission coefficient of electricity generation, $EF_{PJ,y}$	t-CO_2/MWh	0.3585	Note-4)

Note:

1) the properties of fuel gas are cited from Table 6.1.1-1

2) CO_2 emission factor of fuel i,
COEFi = (C%/100) / LHV x (44.01/12.011) x 10^6
3) The net generation efficiency of new power plant is cited from
4) CO_2 emission factor of electricity, $EF_{PJ,y}$={COEFi / (η_{PJy} / 100)} x 0.0036
Source: JICA Study Team

(3) Trial calculation of GHG reduction

Table 8.12-3 shows a trial coalculation result of CO_2 emission reduction of the project based on the expected performance data for the combined cycle plant of M701 F4 gas turbine. The baseline emission BEy is 1,793,116 t-CO_2/y, and the project mission PEy is 1,161,185 t-CO_2/y, and consequently the reduction of emission is 631,931 t-CO_2/y.

Table 8.12-3 Production and CO_2 Emission by Rades C CCCP

Item	Unit	Value	Remarks
Gross power output of CCCP	MW	435.0	From Fig. 6.1.5-3
Gross thermal efficiency	%	56.6	(ditto)
Capacity factor	%	85	CF
Electricity generation	MWh	3,239,010	MWx8760x(CF/100)
Annual CO_2 emission	ton	1,161,185	Fx8760*(CF/100)x(C%/100)
Baseline CO_2 emission factor of electricity	ton/MWh	0.5536	ton/MHh
Project CO_2 emission factor of electricity	ton/MWh	0.3585	
Baseline emission, BEy	t-CO_2/y	1,793,116	
Project emission, PEy	t-CO_2/y	1,161,185	
Reduction of emission,	t-CO_2/y	631,931	

Source: JICA Study Team

APPENDIX

1. 1st Stakeholder Meeting

2. 2nd Stakeholder Meeting

3. 3rd Stakeholder Meeting

1. 1st Stakeholder Meeting

TUNISIAN - JAPANESE COOPERATION

PREPARATORY SURVEY FOR THE RADES COMBINED CYCLE POWER PLANT PROJECT IN TUNISIA - TEPSCO (TOKYO ELECTRIC POWER SERVICES CO., LTD.)

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

<table>
<tr><td colspan="4" align="center">Minutes of the Public Consultation of Stakeholders</td></tr>
<tr><td rowspan="2">Issued by: Abdeladhim ENNAIFER</td><td colspan="2" rowspan="2">Location: Festival Hall of Mégrine Municipality</td><td>Date: 20/09/2013</td></tr>
<tr><td>Time: 10:00</td></tr>
<tr><td colspan="3">RE: Public Consultation of Stakeholders for the Environmental Impact Assessment</td><td>Duration of meeting: 2 hours</td></tr>
<tr><td colspan="4">List of participants</td></tr>
<tr><td colspan="2" align="center">First name and Family name(s)</td><td colspan="2" align="center">Organization</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Document drawn up by Abdeladhim/ENNAIFER TEMA CONSULTING

COOPÉRATION TUNISO-JAPONAISE

THE PREPARATORY SURVEY FOR RADES COMBINED CYCLE POWER PLANT PROJECT IN TUNISIA - TEPSCO (TOKYO ELECTRIC POWER SERVICES CO., LTD.)

ENVIRONMENTAL AND SOCIAL CONSIDERATION

<table>
<tr><td colspan="3">Procès-verbal minute de la Consultation Publique des Parties Prenantes</td></tr>
<tr><td rowspan="2">Emetteur : Abdeladhim ENNAIFER</td><td rowspan="2">Lieu : salle des fêtes de la Municipalité de Mégrine</td><td>Date : 20/09/2013</td></tr>
<tr><td>Heure : 10h00</td></tr>
<tr><td colspan="2">Objet : Consultation Publique des Parties Prenantes pour l'Etude d'Impact sur l'Environnement</td><td>Durée de la réunion : 2H</td></tr>
<tr><td colspan="3">Liste des participants :</td></tr>
</table>

Noms et Prénoms	Organisme
1. Mr Kamel ECHARABI	Gouverneur de Ben Arous
2. Mme Sayaka TANIGUCHI	JICA
3. Mr Kaita TSUCHIYA	JICA
4. Mme Kérima KEFI	JICA
5. Mr Nizar JABEUR	JICA
6. Mr Amri OUANNES	Gouvernorat Ben Arous
7. Mme Meissoune BEN NSIRA	Commune de Radès
8. Mr Medi BEN YOUSSEF	Commune de Radès
9. Mme Hanen JAOUADI	Ministère de l'Agriculture
10. Mr Hazem YAHYAOUI	GMG Radès Pétrole
11. Mme Lamia BEN SALAH	ANPE
12. Mr Abdesselem FRIGA	UTICA Radès
13. Mr Ali FOURATI	UTICA Ben Arous
14. Mr Mongi SAIDANI	UTAP
15. Mr Ribai BEN HANA	APAL
16. Mr Hamza ATALLAH	ASUE
17. Mme Rania BADRI CHERIF	TPE
18. Mr Ahmed SIALA	TPE
19. Mr Salah SAYADI	STEG DEQ
20. Mr Mezri MNARI	STEG DEQ
21. Mr Néjib SAYARI	STEG DEQ
22. Mr Imed MKAOUAR	STEG CPR
23. Mr Ahmed TAAMALLAH	STEG CPR
24. Mr Hatem OUSLATI	STEG CPR
25. Mr Hichem ALLOUCHE	STEG DSE
26. Mr Slim DOUIK	STEG DSE
27. Mr Mourad AYED	STEG DES
28. Mr Moez KERFAI	STEG DSE
29. Melle Wala ALAYA	STEG DSE
30. Mohamed Mejdi HAMMOUDA	STEG
31. Mr Kunio HATANAKA	TEPSCO TEAM
32. Tadashi NAKAMORA	TEPSCO TEAM (Japan Nus)
33. Mr Abdeladhim ENNAIFER	TEPSCO TEAM (Tema Consulting)
34. Mr Ameur JERIDI	Interpète

A. MEETING AGENDA

1) Public Consultation of Stakeholders for the Environmental Impact Assessment

B. MINUTES OF INTERVENTIONS OF PARTICIPANTS

- The meeting was opened by the Governor who welcomed the persons present. He then gave the floor to the different stakeholders.
- The first presentation was given by Mr. Hichem ALLOUCHE, in charge of the Security and Environment Division. He gave the reasons for building the third plant in Rades. He also presented the preconditions for this public consultation required by the EIA (Environmental Impact Assessment) and the donors.
- Mr. Mezri MNARI, Chief of the Rades C Project, made a presentation about the project with its different phases. He also indicated the advantages of this combined cycle project as compared to single cycle projects, such as savings in energy and the reduction of emissions. He also presented the project implementation schedule. An invitation to tender must be launched in May 2014. Offers must be submitted in August 2014 for the signing of the contract in June 2015. Operations must be carried out in 2 phases: single cycle during the summer of 2017, and combined cycle during the summer of 2018.
- Mrs. Rania BADRI CHERIF then presented the EIA (environmental impact assessment) scope, according to the JICA guidelines and based on Tunisian regulations under Decree No. 1991-2005.
- After these three presentations, the floor was given to other stakeholders for their comments and proposals concerning the project;
- The principal interventions covered the following points:
    - NOx and Cox emissions
    - Effluents and discharges into the canal
    - Pollution of the Rades beach
    - Aesthetic aspects to improve un urban planning framework and the landscape around the power plant
    - Current impacts at the levels of emissions and pollution
    - Accumulated effects of existing power plants Rades A & B and Rades II.

- MRS. CHERIF and MR. SAYARI, MR. ALLOUCHE, MR. MNARI and MR. SAYARI gave the necessary clarifications for the questions posed. Mr. SAYADI also reassured those present that the study results will be presented during the major public consultation which must be held in the beginning of November.

C. <u>REPORTS AND VARIOUS DOCUMENTS DISCUSSED</u>

- The 3 presentations of the 3 participants.
- The scope

D. <u>RESOLUTIONS AND DECISIONS</u>

- Prepare the EIA report from now until the end of October 2013.
- Organize the next public consultation on the 1st week of November 2013

E. <u>APPROVED REPORTS AND PRODUCTS</u>

- None

2. 2nd Stakeholder Meeting

Tunisian Electricity and
Gas Company (STEG)

Security and Environment Division

Environmental Department

RE: Minutes of the public consultation meeting regarding the Rades C project

Memo presented by: Mr. Mourad AYED

ATT: DEQ / DCEPE

Following the second public consultation meeting regarding the construction project for the Rades C combined cycle power plant held on November 30th 2013, we are sending you enclosed herewith, the minutes of the meeting and the list of invited stakeholders, and the attendance list in this meeting.

Chief of the Environmental Department

Slim DOUIK

Tunisian Electricity and
Gas Company (STEG)

Minutes of the meeting

Public consultation for the Rades C combined cycle power plant construction project

RE: Holding of the second public consultation of external stakeholders relative to the construction project for the new Rades C combined cycle power plant (430 MW).

Date: Wednesday, November 13th 2013.

Location: Ben Arous Governorate/Mégrine Municipality Hall

Enclosed documents

- List of stakeholders invited to the meeting
- Attendance list of the meeting

Content

I- Subjects of presentations:

- Word of welcome and introduction of the project by Mr. Slim DOUIK (STEG/DSE)
- Presentation of the Environmental and Social Impact Assessment (EIES/ESIA) for the project by Mrs. Rania CHERIF (TPE, environmental engineering office) which included the following subjects:
  - General presentation of the project
  - Marine and coastal environment
  - Environmental impact of the project during the construction phase and the operational phase
  - Study of the dispersion of hot spots in the sea
  - Study of atmospheric dispersion of NOx and SO2 pollutants

II- Debates and discussions:

The principal interventions were as follows:

- The APAL representative asked for a copy of the initial EIES/ESIA report in order to have a clear idea of the study. This will allow him to give more reliable and well determined comments.

- The UTAP representative compared the project with the Sousse power plant project-stage C. In addition, he criticized the environmental effect of the project on the Gulf of Tunis and suggested the use of clean renewable energy technologies for electrical production. He also mentioned the health impacts of the project and the emission of NOx and SO2 waste in the Rades region. This waste will affect the health of the residents.
  The problem of compatibility of the new structures with the Rades residential and industrial landscape was also brought up.

- The UTAP representative asked for a copy of the EIA report for the Rades A plant, drawn up in 1984, and a copy of the EIA report for the Rades B, drawn up in 2006, in order to have an idea of the initial conditions for the Rades C project.

- The Ben Arous Governorate representative asked for a copy of the ESIA report for this project. The public consultation meeting for the project may have to be called again due to the limited attendance in this meeting.

In conclusion, the stakeholders present recommended the organization of a third public consultation for the project to assure wider participation of all organizations and citizens concerned. Furthermore, they asked that representatives of the Ministry of Public Health, the Ministry of Social Affairs be invited, with the presence of media.

3. 3rd Stakeholder Meeting

Tunisian Electricity and
Gas Company (STEG)

December 2nd 2013

Security and Environment Division

Environmental Department

RE: Minutes of the public consultation meeting regarding the Rades C project

Memo presented by: Mr. Safouan Kadri

ATT: DEQ / DCEPE

Following the third public consultation meeting of stakeholders relating to the construction project for the Rades C combined cycle power plant, stage C, held on November 27th 2013 at the Rades municipality, we are sending enclosed herewith, the minutes of this meeting, the list of invited stakeholders, and the attendance list in this meeting.

Chief of the Environmental Department
Slim DOUIK

Tunisian Electricity and
Gas Company (STEG)

<u>Minutes of the meeting</u>

Public consultation for the Rades C combined cycle power plant construction project

<u>RE</u>: Holding of the third public consultation of stakeholders relating to the Rades C combined cycle power plant construction project.

Date: Wednesday, November 27th 2013.

Location: Ben Arous Governorate/Rades Municipality

<u>Enclosed documents</u>

- List of stakeholders invited to the meeting
- Attendance list of the meeting

<u>Content</u>

I- Subjects of presentations

- Word of welcome and introduction of the project and the general context of the meeting
  - Mr. Hichem ALLOUCHE (STEG/Security and Environment Division).
- Presentation of the results of the Environmental and Social Impact Assessment (EIES/ESIA) and foreseeable environmental impacts of the project.
  - Mrs. Rania CHERIF (TPE, environmental engineering office)

II- Debates and discussions

The participants mainly addressed the following questions:

- The problem of sea water pollution principally caused by the Meliane River (Oued), the STEG and IPP power plants and The Rades maritime port.

- Sea water sampling and analysis were taken only from the Gulf of Tunis and did not include the Rades beach and coasts.
- Simulations of atmospheric emissions covered emissions from existing power plants Rades A & B, and not those of the neighboring IPP power plant.
- The project investment cost and the level of local integration in the employment of personnel from the Ben Arous region.
- The technology used by STEG must minimize the NOx and SOx waste.
- The introduction of renewable energies in the public electrical network.

Responses of the STEG management and the consultant covered the following aspects:

- The single waste to be produced by the STEG plant is hotter water with a maximum of 35˚C at the discharge point, as stipulated in the Tunisian regulations in force.
- Based on the hot spots dispersion study, the water temperature in the Rades beach will not be changed.
- Hot water will be directed to the open sea by the already existing dike and will have no direct effect on the beach. Negative impacts on the beach will be principally caused by water discharged from the Meliane River.
- Simulations of atmospheric dispersions were made, covering the existing power plants Rades A & B. These simulations will be repeated by the environmental engineering office and they will rather hold account the emissions of the IPP plant and the actual stack heights of the Rades power plants.
- Information on the winds and the climate are updated and issued by the National Meteorology Institute.
- The selected technology and the quality of natural gas required by STEG are optimal in order to minimize the NOx and SOx discharges.
- STEG is actively participating in promoting renewable energies in their electrical production system, based on two wind power plants already installed with 240 MW power and two scheduled solar projects (Solar PV plant in Tozeur, and CSP in Akarit, with total power of 60 MW).

List of persons invited to the Public Consultation Meeting for the Rades C Power Plant Project

Based on the Environmental and Social Impact Assessment for the construction project for the Rades C combined cycle power plant, enclosed is the list of persons invited to the third Public Consultation meeting of stakeholders held on November 27th 2013.

Liste des invités à la réunion de Consultation publique du projet de la Centrale électrique Rades C

Dans le cadre de l'Etude d'Impact Environnementale et Sociale du projet de construction de la centrale à Cycle combiné de Rades C, ci-joint la liste des invités de la 3ème réunion de Consultation publique des parties prenantes pour la date 27/11/2013.

Ministère de l'Industrie Tel : 71 905 132 Fax : 71 902 742

Ministère de l'Agriculture Tel : 71 786 833 Fax : 71 799 457/71 780 391

Ministère de Tourisme Tel : 71 341 077 Fax : 71 354 223

Ministère du Développement et de la Coopération Internationale Tel : 71 240 133 Fax : 71 351 666

Ministère des Finances Tel : 71 571 888 Fax : 71 563 959/ 71 572 390

Ministère de la Santé Publique Tel : 71 577 000 Fax : 71 577 000

Gouvernorat de Ben Arous Tel : 71 385 100 Fax : 71 387 343

Municipalité de Rades Tel : 71 441 800 Fax : 71 442 550

Agence Nationale de Protection de l'Environnement ANPE Tel : 71 233 600 Fax : 71 232 811

Agence Nationale de Protection et d'Aménagement du Littoral APAL Tel : 71 906 413 Fax : 71 908 460

Agence Nationale de Gestion des Déchets ANGed Tel : 71 791 595 Fax : 71 890 581

Union Tunisienne de l'Agriculture et de la Pêche UTAP Tel : 71 806 800 Fax : 71 809 181

UTICA Ben Arous Tel : 71 295 605 Fax : 71 297 455

Union Générale Tunisienne du Travail de Ben Arous UGTT Tel : 71 380 545 Fax : 71 386 521

Office de la Marine Marchande et des Ports OMMP Tel : 71 735 300 Fax : 71 735 812

ASUE- Ben Arous : Association de Sauvegarde de l'Environnement Tel : 71 290 988 Fax : 71 211 997

Bureau d'études TPE Tel : 71 841 801 Fax : 71 792 718

Groupement de Maintenance et de Gestion- ZI Rades Tel : 71 469 070 Fax : 71 469 060

Agence Japonaise de Coopération Internationale JICA- Tunis Tel : 71 786 386 Fax : 71 787 036

Association des Femmes Tunisiennes pour la Recherche sur le Dév AFTURD Tel/Fax : 71 870 580

Association Tunisienne pour la Santé et l'Environnement-Rades Tel : 71 841 200 Fax : 71 848 586

Direction Régionale des affaires sociales de Ben Arous Tel : 71 388 401/ 71 310 447 Fax : 71 338 401

TEMA Consulting Tel : 71 844 677/71 796 623 Fax : 71 845 583

District Ezzahra : Fax : 71 452 344

Centre de Production électrique Rades : Fax : 71 449 123

Attendance list for the third Public Consultation Meeting for the Rades C combined cycle power plant construction project

Wednesday, November 27th 2013

Liste des présents de la troisième consultation publique du projet de construction de la centrale à cycle combiné Rades C

Mercredi 27 Novembre 2013

Nom et prénom	Organisme	Tel	E-mail
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Lotfi Mbarki	Association Art et Environnement	98 901 571	mbarkilotfi@gmail.com
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Salah Sayadi	STEG/DEQ	98 999 405	ssayadi@steg.com.tn
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