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V1

Environmental Impact Assessment
(EIA)

Of the

Yemen Power Sector Project
(IDA Financed)

For the

Yemen Electricity Distribution Loss Reduction
Carbon Finance Project

Carbon Finance project: Yemen Electricity Distribution Loss Reduction (P110603)
------- Linkage to Yemen Power Sector Project (P086865)

This cover page serves to clarify the linkage between the Yemen Electricity Distribution Loss Reduction Carbon Finance Project and IDA financed Yemen Power Sector Project.

The Yemen Electricity Distribution Loss Reduction CF project aims to purchase the emission reductions created by the implementation of the substation upgrading and distribution investment in demarked areas in 18 regions of Yemen under the Power Sector Project. The carbon finance operation does not involve any modification of the existing Project or any additional activities out of the scope of the original Project, although the implementation schedule in the Project Design Documents reflects the updated project progress.

The idea of a potential carbon finance operation was extensively discussed and agreed with the borrower during project preparation, though the potential CF operation was not explicitly described in the PAD. The inclusion of the CF operation in the PAD would not have affected any aspect of the project design and preparation. The Power Sector Project was prepared and appraised in accordance with Bank policies and procedures, including Bank's safeguards procedures and policies. These procedures and policies meet the full requirement of the CF operation.

Prior to the signing of the Emission Reduction Purchase Agreement (ERPA), the Environmental Impact Assessment and Resettlement Policy Framework prepared under the Power Sector Project, which apply equally well to the Yemen Electricity Distribution Loss reduction CF Project, are being disclosed again as per the requirement of a carbon finance operation.

Ministry of Electricity
Public Electricity Corporation
Republic of Yemen

Power Sector Project

Environmental Impact Assessment (EIA)

Final Report

August 2005

CONSULTING ENGINEERING SERVICES (INDIA) PVT. LTD.
SANA'A
NEW DELHI

Acknowledgement

We, in Consulting Engineering Services (India) Pvt. Ltd., Sana'a, are thankful to all the officials and individuals met for their support and supplying information during this Environmental Impact Assessment (EIA) study which facilitated the work. Special acknowledgement is accorded to the officials of the Public Electricity Corporation (PEC) for their valuable suggestions, support & cooperation in successful completion of this assignment.

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List of Abbreviations

ARC	Aden Refinery Company
BOD	Biochemical Oxygen Demand
BSP	Bulk Supply Point
COD	Chemical Oxygen Demand
DM	Demineralized
DPS	Diesel Power Station
EA	Environmental Assessment
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environment Protection Authority
FAO	Food & Agricultural Organization
GCV	Gross Calorific Value
GLC	Ground Level Concentration
IEC	International Electricity Commission
NGO	Non Government Organization
O&M	Operation & Maintenance
OWS	Oil Water Separator
PCB	Polychlorinated Biphenyl
PEC	Public Electricity Corporation
PM	Particulate Matters
PM_{10}	PM less than 10 micrometers
RDS	Respirable Dust Sampler
ROW	Right of Way
RPF	Resettlement Policy Framework
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TOR	Terms of Reference
TPS	Thermal Power Station
TSS	Total Suspended Solids
TSS	Total Suspended Solids
US-EPA	United States EPA
WB	World Bank
WHO	World Health Organization

List of Units of Measurements

°C	Degree centigrade
$\mu g/m^3$	Micrograms per cubic meter
dB(A)	Decibel (A weighted)
h	Hour
ha	Hectare
km	Kilometer
KV	Kilovolts
m	Meter
m^3	Cubic meters
m^3/h	Cubic meters per hour
mg/l	Milligrams per liter
mg/Nm^3	Milligrams per normal cubic meter
mmhos	Millimhos
MVA	Megavolts ampere
MW	Mega Watt
ppm	Parts per million
t, ton	Metric tons
t/h	Metric tons per hour
tpd	Metric tons per day

EXECUTIVE SUMMARY

1.0 INTRODUCTION, BACKGROUND & EIA METHODOLOGY

1.1 Introduction & Background

The Public Electricity Corporation (PEC), a state corporation of the Republic of Yemen, requested the World Bank- IDA to finance the power sector project in Yemen. This proposed project consists of three sub-components, Generation sub-component, Transmission sub-component and Distribution sub-component. In compliance with the Bank's environmental safeguard policies, the World Bank has requested the PEC to conduct and submit an Environmental Impact Assessment (EIA) of the project to the Bank prior to project appraisal in order to provide a framework for identification, assessment and management of environmental and social concern of the project.

As per the Bank's Operation Policy 4.01on "Environmental Assessment (EA)", after the initial environmental screening it has been found that the proposed project falls into Category-B project for its limited environmental impacts. Therefore, a limited EIA is required for the project.

1.2 Project Components Covered in the EIA Study

The project has three sub-components- Generation, Transmission and Distribution. However, the EIA study covers only two sub-components viz. Generation and Transmission.

Generation Sub-component
This sub-component consists of supply & installation of a 160 t/h boiler al Al-Hiswa steam power station (Aden region).

Transmission Sub-component
This sub-component consists of:

- Expansion of existing Al-Hali substation in Al-Hodeidah
- New substation at Kilo 16 in Al-Hodeidah
- Expansion of existing Dhamar substation
- New substation at Yarim by tapping the existing lines between Ibb and Dhamar
- New 12 km 132 KV transmission line from Al-Hali to Kilo-16
- New 90 km 132 KV transmission line from Dhamar to Hizyaz in Sana'a parallel to the existing line.

1.3 Methodology of EIA

The entire EIA study has been carried out within existing policy, legal and administrative framework considering the applicable Environmental laws & standards of the EPA, Republic of Yemen, and applicable policies, directives & good practices guidelines of the World Bank. The EIA study methodology basically included:

- Identification & formulation of the policy, legal & administrative framework.
- Establishment of the baseline/present environmental scenario through:

  Secondary Data Collection: Besides inputs from the client on the relevant information about the project, other secondary data/ information/ records & published literature with respect to physical, biological and social environment of the study area have been collected.

  Primary Survey & Monitoring: Necessary primary field study/ survey/ monitoring have been conducted in the month of July 2005. Field monitoring has been conducted on soil, water quality, ambient air quality & noise.
- Study of the project activities having environmental impacts
- Identification & assessment of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Analysis of various project alternatives.
- Public consultation to understand the perception of local people about the project.

2.0 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

2.1 Relevant World Bank Policies & Guidelines

The applicable environmental and social policies, directives & good practices guidelines of the World Bank are mentioned below:

- Environmental Assessment Sourcebook & its Updates
- OP/BP 4.01 Environmental Assessment
- OP/BP 4.02 Environmental Action Plans
- OP/BP 4.04 Natural Habitats
- OP/BP 4.36 Forests
- OP/BP 4.12 Involuntary Resettlement
- OD 4.20 Indigenous Peoples
- OP 14.70 Management of Cultural Properties in Bank-Financed Projects
- Excerpt of Thermal Power Guidelines for New Plants

2.2 Legal Framework

The Environment Protection Law, No. 26 of 1995, is the most comprehensive law in the Republic of Yemen on the environment. The law grants power to the EPA in Central Government to take all measures necessary to protect and improve the quality of environment and to prevent pollution of the environment. The standards relevant to the EIA studies of this power sector project are:

- Environmental Standards of Republic of Yemen
- World Bank Guidelines for Environmental Assessment

2.3 Administrative Framework

The organizations responsible for ensuring environmental compliance of the project include:

- **Public Electricity Corporation (PEC)**, Republic of Yemen: Being the project promoter is responsible for ensuring environmental compliance with environmental laws & standards of the Republic of Yemen as well as with environmental & social safeguard policies & guidelines of the World Bank, the financer.
- **The World Bank**: Being the financer of the project has to ensure that all the environmental safeguards & mitigation measures are designed & implemented in the project as per the Bank's environmental & social safeguard policies & guidelines.
- **Environment Protection Authority (EPA)**, Republic of Yemen, (previously EPC): Is the principal central authority empowered to formulate & enact the environmental policies & strategies, environmental laws, rules & standards, and responsible for implementation of the laws and safeguarding the environment.

3.0 PROJECT DESCRIPTION

The project has three sub-components- Generation, Transmission and Distribution. However, the EIA study covers only two sub-components viz. Generation and Transmission which are detailed below.

3.1 Generation Sub-component

This sub-component is planned for expansion of existing Al-Hiswa oil-fired steam power station (5x25 MW) at Aden region. There are 5 steam turbines of 25 MW capacity each and 6 boilers of 160 tones/hour capacity each. Another 60 MW turbo-generator is under construction. The proposed expansion will consist of:

(1) Supply and installation of one new boiler of 160 tones/hour capacity (7^{th} boiler) in Al-Hiswa steam power station in Aden region for strengthening and augmenting the system and to increase the power station reliability.

3.1.1 Project Highlights of Al-Hiswa Power Station

Location	Al-Hiswa in Aden region (about 10 km north-west of Aden city)
Capacity	5 x 25 MW (existing) + 60 MW generator under construction
Existing main units	Boilers : 6 nos. 160 t/h each (oil fired) Generators : 5 nos. 25 MW each existing + 1 no. 60 MW under construction Desalination plant for production of DM water
Proposed units	Boilers : 1 no. 160 t/h (dual firing- oil and gas) & 1 no. associated stack.
Fuel system	Heavy fuel oil for the existing oil fired boilers is taken from the Aden Refinery Company (ARC) through pipeline.
Cooling system	Once through cooling system. Cooling water is taken from the sea & the return cooling water is discharged into the sea through channel.
Pollution control	Sewage is treated in the Sewage Treatment Plant & the oily plant wastewater is treated in the Oil Water Separator, and the combined treated effluent is discharged into the sea through the cooling water discharge channel. Flue gas of boilers is emitted into the atmosphere through 3 nos. 80 m tall stacks.
Land	Proposed boiler will be installed within the existing plant

requirement	premises and no additional land is to be acquired.

3.1.2 Expansion Proposal

For this project it has been assumed that the efficiency of the proposed 7th boiler will be about 85% and its fuel oil consumption rate will be about 7 t/h. Then its SO_2 emission rate will be 0.16 tpd per MW which is within the World Bank guideline of 0.2 tpd per MW. Moreover, the new boiler should be of dual firing system (fuel oil as well as natural gas).

3.2 Transmission Sub-component

This sub-component is planned for new transmission lines, new substations and expansion of existing substations related to two Bulk Supply Point (BSP) substations at Al-Hodeidah and Dhamar. The augmentation of the transmission facilities of Al-Hodeidah and Dhamar area will consist of:

3.2.1 Substations

(1) 132 KV new substation at Kilo 16 in Al-Hodeidah (with 1 no. 132/33 KV, 60 MVA & 1 no. 33/11 KV, 20 MVA transformers, and a 50 MVAR compensation plant).
(2) Expansion of Al-Hali existing 132/33 KV BSP (Bulk Supply Point) substation in Al-Hodeidah by installing a new interlinking single bus-bar 132 KV substation in the vacant land within the boundary of the existing substation.
(3) Extension of existing Dhamar 132 KV substation (in the vacant land within the boundary of the Dhamar substation) to link the proposed 132 KV double circuit transmission line from Dhamar to Hizyaz (Sana'a).
(4) 132 KV new substation at Yarim (with 2 nos. 132/33 KV, 45 MVA and 1 no. 33/11 KV, 20 MVA transformers) by tapping the existing 132 KV double circuit transmission lines between Dhamar and Ibb on Dhamar to Taiz transmission route.

3.2.2 Transmission Lines

(1) 12 km 132 KV double circuit new transmission line in Al-Hodeidah region from Al-Hali to Kilo 16 (i.e. from proposed interlinking single bus-bar 132 KV substation at Al-Hali to proposed 132 KV substation at Kilo 16).
(2) 90 km 132 KV double conductor double circuit new transmission line from Dhamar to Hizyaz in Sana'a (i.e from existing 132 KV BSP substation at Dhamar to proposed 132 KV Hizyaz substation. Hizyaz substation is proposed under the Marib transmission line project). Marib is located at a distance of 180 km from Sana'a and a Gas Power Project is going to be implemented at Marib by PEC.

Based on the International Standards, typical specifications for the new transmission lines and towers as given in **Table-E3.1** have been assumed as a guideline for this EIA Study.

Table-E3.1 Typical Specifications for the New Transmission Lines

Type of Tower	132 KV, Double Circuit
Material of Construction	Galvanized Steel Sections
Height of Tower	32.5 m (max.)
Base Area	7.2 m x 7.2 m (max.)
Distance between Towers	150 m – 200 m
Type of Conductor	ACSR ZEBRA

Arm Length for Conductor	4.8 m
Lateral Swing of Conductor	5.25 m
Maximum Conductor Sag	7.5 m
Minimum Clearance of Conductor from Building	5.1 m
Right-of-Way (ROW)*	30 m

*Right-of-Way shall vary depending on line design specification

4.0 ENVIRONMENTAL AUDIT AND BASELINE ENVIRONMENTAL SCENARIO

4.1 Environmental Audit of Al-Hiswa Power Station

Environmental audit of the Al-Hiswa power station has been conducted. Tools adopted for the environmental audit are:

- Meeting & interview with plant personnel
- Review of existing documentation and data records
- Process understanding, site inspections and environmental monitoring.

4.1.1 Capacity and Commissioning

The existing plant comprises of 6 nos. of boilers of 160 t/h capacity each and 5 nos. of turbo-generators of 25 MW capacity each, totaling to the installed capacity of 125 MW commissioned in 1985. One turbo generator of 60 MW capacity will be added by March 2006 for which construction is under progress. All the 6 boilers are interconnected to common header from where steam can be sent to any turbine. After commissioning of new turbine, the ultimate capacity will be 185 MW. It is proposed to add 160 t/h new boiler under this present project for strengthening and augmenting the system.

4.1.2 Cooling Water System

The condensers are cooled using once through cooling water system from the sea through sea water intake pump house & sea water intake channel. Sea water is also used for production of DM water in the desalination plant. The sea water pumping capacity is 40,064 m^3/h (5x4600 m^3/h cooling water pumps+ 3x5688 m^3/h desalination water pumps), while the present consumption rate is 33,355 m^3/h with surplus reserve of 6709 m^3/h.

4.1.3 Fuel Requirement, Source and Characteristics

Requirement: Heavy fuel oil 10.5 t/h for one 160 t/h boiler.
Source: Aden Refinery Company (ARC) through two nos. of 9 km long pipelines.
Storage: Three tanks of 5000 m^3.
Protection: Oil storage area & pump house are dyked properly to contain oil spillage and leakage, if any.
Characteristics: From the fuel oil analysis results collected from the plant for last two months (May & June 2005) it is evident that average sulphur content is fuel oil feed into the boilers is 2.9% by wt (range 2.2% to 3.26%).

4.1.4 Transformer and Turbine oil

There are 5 nos. step up transformers (10.5/33 KV) and 5 nos. step down transformers (4 nos. 10.5/6.6 KV and 1 no. 33/6.6 KV). There are 5 and 3 nos. storage tanks of 70 m^3

capacity each for turbine and transformer oil respectively. Storage area is dyked properly to avoid contamination of other water streams. Consumption of turbine oil is about 20 barrels per month and that of transformer oil is once in 5 to 6 years. Current practice for disposal of waste transformer and turbine waste oil is to mix it with main fuel oil and is burnt in the boiler.

4.1.5 Water System, Source & Requirement:

The plant water requirement consists of:

- Once through cooling sea water for condenser & auxiliary cooling system.
- Demineralized water for boiler make up from the Desalination Plant.
- Drinking water from the piped water supply from the Water Authority.
- Water for canteen, toilets & gardening from the waste DM water.

Table-E4.1 Break-up of Water Requirement

SN	Section	Quantity (m^3/h)	
		Sea Water	Drinking Water
1	Cooling water for condenser and auxiliary cooling	21985	-
2	Desalination Plant for boiler make-up water	1320	-
3	Chlorination Plant	50	-
4	Drinking Water	-	0.52
	Total	**23355**	**0.52**

The net raw water requirement is about 23355 m^3/h of sea water and 0.52 m^3/h of drinking water, the break up of which is given in **Table-E4.1.**

4.1.6 Wastewater Generation, Treatment & Quality

The plant wastewater streams consist of:

- Once through return cooling water.
- Boiler blow down.
- Waste/unsuitable DM water from the desalination plant.
- Oily drainage from fuel oil tank & pump area, boiler area & other plant drains.
- Sewage from the toilets & canteen.

The net quantity of finally disposable wastewater from combined discharge channel is about 22730 m^3/h (**Table-E4.2**). In addition to this, 5.25 m^3/h combined unsuitable DM water and boiler blow down is utilized within the premises of plant.

Table-E4.2 Break-up of Wastewater Generation

SN	Section	Quantity(m^3/h)	Discharge/Reuse
1	Brine water from desalination plant	740	Discharged into the sea through the cooling water discharge channel
2	Cooling water discharge	21985	
3	Clear water from oil trap	0.4	
4	Effluent from sewage treatment plant	4.6	

SN	Section	Quantity(m^3/h)	Discharge/Reuse
	Total	**22730**	
5	Unsuitable DM Water	2.85	Collected in storage sump and reused for gardening and sanitary water for toilets & canteen
6	Boiler Blow down	2.4	
	Total	**5.25**	

All the wastewater in the plant is treated properly in respective treatment plants. The wastewater treatment in the plant consists of:

- The return hot cooling water is directly discharged into the sea through a rectangular covered concrete discharge channel. The temperature of the return cooling water is about 4°C more than the intake cooling water temperature.

- The boiler blow down and the waste/unsuitable DM water coming from the desalination plant is collected in an underground tank where it gets mixed and the pH of the boiler blow down neutralizes. The water from this tank is then reused for gardening, toilet flushing, canteen & floor washing.

- The oily led to **oil water separator**. The oil & sediment free clear supernatant effluent is stored in a treated effluent sump and then intermittently pumped & disposed into the sea through the cooling water discharge channel where it gets huge dilution before its final disposal into the sea.

- The sanitary wastewater including any canteen wastewater is collected in a sewage sump & then intermittently pumped to the sewage treatment plant (STP) to assure necessary treatment. The STP consists of underwater bubble type aerators. The treated sewage is stored in the treated effluent sump (where treated oily wastewater is stored). The combined treated effluent is led out of the plant premises by intermittently pumping into the cooling water discharge channel where it gets huge dilution before its final disposal into the sea.

4.1.7 Wastewater Quality

Eight nos. of water and wastewater samples have been collected from various locations and analyzed. The monitoring results of the cooling water discharge at various points for salient water quality parameters are listed in **Table-E.4.3**.

Table-E.4.3 Salient Features of the Cooling Water Discharge & Treated Effluent

SN	Parameter & Unit	CW at Conden-ser Outlet	CW before dis. to Sea	Sea water after mixing with CW dis.	Combined Treated Effluent	Yemen Standards for Discharge into General Sewage Network	World Bank guidelines for effluents from Thermal Power Plants
1.	Temperature (°C)	41	39	35	35	45	□ 3°C[#]
2.	pH	7.9	8.0	7.9	6.5	5.5-9.5	6-9
3.	Conductivity (µmhos/cm)	54080	53040	53040	736	700-2000[$]	-
4.	Dissolved Oxygen (mg/L)	5.8	6.1	6.5	3.3	2[$]	-
5.	BOD (mg/L)	2.5	2.8	2.6	25	50	-
6.	Total Suspended Solid (mg/L)	18	42	26	72	500	50

7.	Total Dissolved Solid (mg/L)	44416	46500	45524	428	2000	-
8.	Oil and Grease (mg/L)	ND	1	ND	12.4	100	10
9.	Chloride (mg/L as Cl)	22759	23113	22617	99	600	-
10.	Sulphate (mg/L as SO_4)	1580	1680	1610	48	1000	-
11.	Nitrate (mg/L as NO_3)	2.4	2.5	2.7	0.5	20$^{\$}$	-
12.	Sodium (mg/L as Na)	5600	5800	6000	20	200$^{\$}$	-
13.	Copper (mg/L as Cu)	ND	ND	ND	ND	5	0.5
14.	Iron (mg/L as Fe)	0.23	0.25	0.27	0.2	50	1
15.	Zinc (mg/L as Zn)	0.32	0.3	0.35	ND	10	1
16.	Chromium^{6+} (mg/L as Cr)	ND	ND	ND	ND	5	0.5

@ standards for irrigational use
# at the edge of 100 m mixing zone

Cooling water discharge: Temperature of cooling water varied between 34°C at cooling water intake and 38°C at discharge point, only 4°C increments between the intake & outfall temperature. The sea water temperature after mixing with hot cooling water discharge measured at edge of 100m mixing zone was found to be 35°C which is only 1°C more than the sea water temperature of 34°C and therefore this increment is within the World Bank guideline limit of 3°C (Handbook on Industrial Pollution Prevention and Abatement, World Bank 1995).

Though, cooling water at final discharge point contained 1 mg/l oil & grease and 2.5 mg/l BOD due to the mixing of the treated effluent, oil & grease was nil and BOD was 2.6 mg/l in sea water after mixing with cooling water discharge measured at edge of 100m mixing zone. As no remarkable change in the sea water after mixing with cooling water discharge & treated effluent is noticed, it may be concluded that there is no significant pollution in sea due to plant discharge.

Combined Treated Effluent: The combined effluent was bit acidic (pH value 6.5) but was within the tolerance limit of 5.5-9.5. Conductivity (736 μmhos/cm), TDS (428 mg/l) & TSS (72 mg/l) all were within the permissible limits. Though oil & grease content of the oily wastewater was 28,470 mg/l, the same in treated combined effluent was only 12.4 mg/l indicating proper functioning of the oil water separator. The oil & grease level in the treated effluent is below the permissible limit of 100 mg/l. The BOD content of the raw sewage was 180 mg/l, but BOD in treated combined effluent was only 25 mg/l indicating proper treatment of sewage in the sewage treatment plant (STP). The treated effluent BOD level (25 mg/l) is within the permissible limit of 50 mg/l. All other parameters including heavy metals & toxic constituent in the treated effluent were found to be within their respective permissible limits. As all the parameters were within the permissible limits, it may be concluded that there is no significant pollution potential of the treated effluent discharge into the sea.

4.1.8 Air Emissions

There are three existing stacks of 80 m height connected to two boilers each for the flue gas dispersion. Based on the average sulphur content (2.9%) in fuel oil and average oil consumption (10.5 t/h per boiler), it is estimated that the plant emits 609 kg/h SO_2 per boiler i.e. 87.696 t/day at its full operating load which is far above the World Bank guideline level of 25 t/day.

4.1.9 Noise Pollution Level

Noise level monitored at 10 locations inside the plant showed that the in-plant noise level (8-hourly L_{eq}) varies from 66.1 dB(A) (near the Training Center) to 83.4 (inside the

Control Room) dB(A), which is within the permissible work zone area limit of 90 dB(A) for 8-hourly exposure of workers.

4.1.10 Solid Waste Management and Disposal Practices

Sludge from sludge drying beds is disposed to city landfill sites once in five years. Municipal garbage collection vehicle visits plant twice in a week and collects garbage from the bins kept at different locations within the plant premises.

4.2 Baseline Environmental Scenario around Al-Hiswa Power Station

4.2.1 Topography & Earthquakes

The Al-Hiswa power station is located 10 km north-west of centre of Aden City. The power station site is bounded by Aden to Little Aden road in the north, Gulf of Aden in the south and vacant lands on other sides. Topography of the area around Al-Hiswa power station is characterized by sandy barren flat terrain with gentle slope towards south with sparse vegetation, mainly palm and thorny bushes. The Gulf of Aden is located about 300 m south of the power station.

From the number of registered earthquakes it can be seen that the number of earthquakes in Aden in 2003 was only 1 compared to the total 1816 no. of domestic & regional events. Though earthquake is very common in Yemen, mostly is very weak in nature, only 3.9% of them touch 6 points mark in the Richter scale.

4.2.2 Soil

The physico-chemical characteristics of soils in the study area have been studied by analysis of soil samples from representative locations. Texture of the soil is sandy loam. Due to high percentage sand (76.5%) and silt (12.4%) the soil is highly permeable & less water retentive. Clay fraction being very less (6.6%) the soil is less fertile. The soil is alkaline with pH of 7.8. Sodium level in the soil sample (0.0032%) is low. But the soil is deficient in necessary nutrients like nitrogen (0.0013%), potassium (0.001%), phosphorous (0.0014%) and organic matter (0.56%) that indicates poor vegetative potential of the soil.

4.2.3 Land Use

Aden to Little Aden road runs parallelly to the northern boundary of the power station and beyond the road there exists the residential area Madinath Ashsha'b. Gulf of Aden exists in the south at about 300 m of the power station. Other sides i.e. eastern & western sides are vacant lands where some sparsely distributed palm trees mingled with thorny bushes are found.

4.2.4 Water Quality

In total, 8 representative water & effluent quality monitoring locations in the power station were selected for the purpose of monitoring, analysis and assessment of water quality. All the parameters are found conforming to stipulated standards and guideline of respective water use and disposal.

4.2.5 Climate

Available past meteorological data for Aden (Airport) has been summarized in **Table-E.4.4**. The maximum mean daily temperature of 39.0°C is observed in the hottest month June and the minimum of 20.0°C in the coldest month January. The average monthly relative humidity varies between 57% & 72% with annual mean of about 66%. Total annual rainfall is very low, about 57.1 mm, out of which about 91% rainfall takes place during the months of March & April, month of April being the rainiest (about 42.4 mm) and months of May to November being rainless. The annual mean wind speed, observed at Aden is around 10.1 Knots (18.2 km/h) which is high. Wind speed is high (>10 Knots) during December to March and in June & August, and in rest of the year it is moderate (4 to 10 Knots). Predominant wind direction is from east for most of year (for September to April) followed by south-west (for June to August).

Table-E.4.4 Summery of Climatological Data of Aden City

Parameter	**Monthly Range**	**Annual Mean/Total**
Mean daily maximum temperature (°C)	29.5°C (Jan) – 39.0°C (Jun)	
Mean daily mimimum temperature (°C)	20.0°C (Jan) – 28.2°C (Jun)	
Average relative humidity (%)	57 (Jul) – 72 (Apr)	
Total rainfall (mm)	0.0 (May to Nov) – 42.4 (Apr)	57.1
Wind speed (Knots)	7.7 (Sep) – 12.9 (Feb)	

4.2.6 Air Quality

For drawing up the baseline status of ambient air quality in the study area, ambient air quality monitoring in respect of PM, PM_{10}, SO_2, NO_x and CO has been conducted at 4 representative locations around the power station adopting a 24-hours schedule. The ambient air quality in the study area has been summarized in **Table-E.4.5**.

Table-E.4.5 Location Wise Summary of Ambient Air Quality Monitoring Results

Ln. No.	Station Location	PM (μg/m³)		PM_{10} (μg/m³)		SO_2 (μg/m³)		NOx (μg/m³)		CO (μg/m³)	
		Standard: 150		Standard: 70		Standard: 125*		Standard: 150		Standard: 10000	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Power Station Camp	275-447	344	100-143	121	44-55.5	49.7	13.7-16.4	15.4	280-316	302
2	FZP Guesthouse	615-786	704	118-145	134	22-40.5	32.6	26.6-43.6	33.6	620-940	760
3	Radio Station Office	443-693	572	88-135	117	40.5-46	42.6	7.1-21	14.6	286-425	354
4	University Campus	172-196	183	32-39	36	36-40.3	38.1	13.1-15.4	14.3	275-300	286
	Overall 4 locations	**172-786**	**451**	**32-145**	**102**	**22-55.5**	**40.7**	**7.1-43.6**	**19.5**	**275-940**	**425**

* WHO standard for SO_2, others are as per National Ambient Air Quality Standards of Yemen.

From the above table It is clear that in all the cases the 24-hourly average values of PM were observed to be above the permissible limit of 150 μg/m³ and in 75% cases (i.e. except the University Campus in all other locations) the PM_{10} levels were above the limit of 70 μg/m³ as stipulated in the National Ambient Air Quality Standards of Yemen. Boilers being oil fired, the particulate emission from the power plant is negligible. The area is barren & bare and the soils being loose sandy silt coupled with high speed coastal wind, huge wind blown dust is observed round the clock. And that is the reason for such high levels of PM & PM_{10}.

Though, the 24-hourly average SO_2 levels in all the locations were observed to be within the permissible limit of 125 μg/m^3 as per WHO standards (Yemen has no ambient air quality standard with respect to SO_2), the monitored levels (maximum 55.5 μg/m^3 and average 40.7 μg/m^3) were high. As there is no other industry or other source of SO_2 emission in the vicinity, it can be concluded that the high levels of SO_2 is due to the emissions from the Al-Hiswa power station. The 24-hourly average NOx levels in all the locations were observed to be within the permissible limit of 150 μg/m^3 as stipulated in the National Ambient Air Quality Standards of Yemen.

4.2.7 Noise

To assess the noise scenario in the study area ambient noise level monitoring was conducted at 7 representative locations very close to the power plant (**Table-E4.6**). Equivalent noise level (L_{eq}) just outside the plant varied between 65-68.5 dB(A) which are within the permissible limit of 70 dB(A) for industrial area. In the residential area of Madinath Ashaab the noise levels varied between 50-63.8 dB(A) which is within the limit of 65 dB(A) stipulated for residential area inside the city around industrial area.

Table-E4.6 Ambient Noise Levels in the Study Area

Locn No.	Location	Noise Level L_{eq} (dBA)
1	Outside the plant (about 40 m north of the plant main gate)	68.5
2	About 100 m north-east of the Desalination plant	65.6
3	Near a Mosque at about 140 m north of the plant	65.0
4	Madinath Ashaab area near a Shop (about 240 m north of the plant)	63.8
5	Madinath Ashaab area near a Residence (about 360 m north of the plant)	58.8
6	Madinath Ashaab area near a Residence (about 400 m north of the plant)	50.0
7	Radio station (about 500 m west of the plant)	57.0

Permissible ambient noise standards in dB(A):
a) Industrial & commercial area : 70
b) Residential area (inside the city around workshops & commercial area): 65

4.3 Baseline Environmental Scenario around Transmission Lines & Substations

4.3.1 Topography & Land Use in & around the Substations

Al-Hali: Generally flat terrain. The area around the boundary wall of the existing substation is urban with residential & commercial area except on the northern side where the present transmission line exists. The Al-Hali DSP is adjacent to the substation on the south. Necessary extension will be done in the vacant land within the existing boundary of the substation.

Kilo-16: Generally flat terrain. The site earmarked for Kilo 16 substation is a barren land and located away from inhabited area. The proposed site is located just north of the Al-Hodeidah to Sana'a main road. The eastern & western side of the site is vacant plots

allotted for development in near future. The northern side of the site is vacant & barren sandy land with no vegetation through which the new transmission line is proposed.

Dhamar: Undulating terrain. The substation is located on high land. The area around the existing substation is vacant undulating land with no agriculture or vegetation. Necessary extension will be done in the vacant land within the existing boundary of the substation.

Yarim: Undulating terrain. The substation is located in the valley. The site has already been acquired and the boundary wall has already been constructed. The area around the boundary wall of the proposed substation site is agricultural.

4.3.2 Topography & Land Use along the Transmission Line Routes

New Transmission Line from Hodeidah to Kilo-16

The route of the proposed 12 km long Al-Hali to Kilo 16 132 KV transmission line in Al-Hodeidah region has been proposed to avoid planned uses of land and inhabited area of Hodeidah city, following longer alignment almost in barren area. As such, much of the environmental problems have been minimized in corridor routing.

The landuse along the entire route is barren & sandy desert land with little or no vegetation. Rarely some thorny vegetation found in the route. No human settlement is found close to the route except the first few hundred meters. In the first 200 m (between the existing tower nos. 61 and 60) some squatters are found who are rag pickers. As they live within the ROW of the existing transmission line, PEC has the Govt. order to clear its ROW.

New Transmission Line from Dhamar to Sana'a

The alignment of the route of the proposed Dhamar to Hizyaz (Sana'a) 90 km long 132 KV transmission line has been proposed almost parallel and on the right side of the existing Dhamar to Asser (in Sana'a) 132 KV transmission line upto Hizyaz.

The proposed transmission corridor from Dhamar to Hizyaz, like the existing line, is passing through highly undulating hilly terrain. In most part of its 90 km travel it will pass through valleys and encounter some small patches of agricultural land like the existing line.

5.0 ANALYSIS OF ALTERNATIVES

A summary of the analysis of alternatives in terms of alternative expansion options of the power station, alternative sites for the new substations and alternative routes for the new transmission lines is presented in **Table-E5.1**.

Table-E5.1 Analysis of Alternatives

Alternatives	Merits	Demerits
	Expansion of Al-Hiswa Power Station:	
Alternative-1: No Action Alternative	No additional constructional & operational impacts.	Existing old units of low efficiency & old design will continue high fuel oil consumption & more air pollution and high O&M cost. Power shortage will continue hampering economical development. During load shedding people will use generators, kerosene lamps & candles resulting air & noise pollution.
Alternative-2: Expansion of Al-Hiswa Power Station	Infrastructures like land, water, fuel, offices, auxiliary units, power evacuation system etc. and staff already exists and no expansion of infrastructures or staff is required. It is close to the demand area.	None
Alternative-3: Small Power Facilities	Distributed generating capacity in demand areas	Cost effectiveness & peak-demand delivery limitations, more air pollution, acute dearth of water resources in most part of Yemen
Alternative-4: Gas Fired Boilers	Less pollution (no SO_2 & particulates emission), Cost effective	No gas is readily available in Aden at present.
Alternative-5: Oil Fired Boilers	Supply & storage facility readily exists.	More air pollution than gas fired boilers (SO_2 & particulates pollution).
	Route of Hodiedah - Kilo16 New Transmission Line	
Alternative-1: Shortest route	Shortest length, minimum transmission loss.	Passing through densely populated area. Land not available for towers & ROW. The line has to cross many buildings.
Alternative-2: Roadside alignment	Slightly loner route.	33 KV lines already exsit on both sides and it is not safe to take 132 KV line through city area. Minimum building clearance is not available.
Alternative-3: Long route outside city area	Passing out of city area through uninhabited and sandy barren land.	Longest route.
	Route of Dhamar - Hizyaz New Transmission Line	
Alternative-1: Upgrading Existing Line	No new route is required.	Existing line needs to remain operational as it is the only line supplying electricity between Dhamar and Sana'a.
Alternative-2: Proposed Alignment Parallel to Existing Line	Advantage of ROW of existing transmission line and closeness to the Sana'a to Dhamar highway from where it is easily accessible for construction, inspection & maintenance.	Crossing through some small agricultural lands.
Alternative-3: Shortest Alignment through Hills	Shortest alignment and avoid agricultural land.	Crossing more hills. Difficulty in access of construction & maintenance man & machinery and increases construction & maintenance cost. New access roads to be build that will increase the project cost tremendously.

6.0 ENVIRONMENTAL IMPACTS OF THE PROJECT & MITIGATION MEASURES

6.1 Environmental Impacts & Mitigation Measures

Identification of impacts is followed by recommendations of appropriate cost effective mitigation measures. The proposed project will have impacts on the environment in two distinct phases: construction phase (short-term impacts) and operation phase (long term impacts). A summary of the potential environmental impacts during construction and operation phase along with recommended mitigation measures is presented in matrix format in **Table-E6.1**.

Table-E6.1 Environmental Impacts and Mitigation Measures

Area	Impacts	Mitigation Measures	Scale of Impact
Construction	**Phase:**		
Earthquake	High earthquake frequency in the area	Suitable seismic design of the structures will be adopted to mitigate the earthquake impacts.	Negligible
Soil	Destruction of top soil	Construction activities would be confined to a very small area within the construction sites.	Negligible
Landuse, rehabilitation & resettlement	Loss of agricultural land, displacement of people & demolition of structures	*Expansion of power station:* Proposed expansion site is a piece of barren & vacant land existing within the plant premises, no additional land acquisition is necessary for the expansion. Therefore, no loss of agriculture, displacement of people or demolition of public properties.	Nil
		Substations: For expansion of existing Al-Hali and Dhamar substations necessary extension will be done in the vacant land within the existing boundary of the substation. The site earmarked for Kilo 16 substation is a barren land and located away from inhabited area. In case of Yarim substation the site has already been acquired and the boundary wall has already been constructed. Therefore, no loss of agriculture, displacement of people or demolition of public properties.	Nil
		Al-Hali to Kilo 16 new transmission line: The alignment passes through sandy barren area. No human settlement is found close to the route except the first 200 m where few squatters (rag pickers) are found. As they live within the ROW of the existing transmission line, PEC has the Govt. order to clear its ROW. Adequate compensation shall be given to the squatters as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.	Minor
		Dhamar to Hizyaz new transmission line: The alignment has been proposed almost parallel and on the right side of the existing Dhamar to Asser (in Sana'a) 132 KV transmission line upto Hizyaz. The proposed transmission corridor from Dhamar to Hizyaz, like the existing line, is passing through highly undulating hilly terrain. In most part of its 90 km travel it will pass through valleys and encounter some small patches of agricultural land like the existing line. The land required for footings of the transmission towers has to be acquired. As cultivation is permitted under the lines & within the base area of the towers, there will be only minor loss of agricultural land due to footings of the towers. As the ROW of the line will not pass through any human settlements, there is no impact like displacement of people. Adequate compensation shall be given to the owners of the agricultural land falling within the ROW as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.	Moderate
Solid wastes	Construction spoils	Small amount of construction spoils will be disposed of in suitable pre-identified dumping areas within the plant site.	Negligible
Construction camp	Construction camp	Construction camp with sanitary & health facilities will be provided to avoid indiscriminate settlement of construction workers.	Negligible
Drainage	Drainage of construction wastewater	Adequate drainage already exists in the plant to drain construction water.	Nil
	Water stagnation in construction site	Existing drains near the construction site will be regularly cleaned to avoid problems like formation of stagnant water pools, soil erosion & breeding of mosquitoes.	Negligible
Water use	Abstraction of groundwater	No ground water will be abstracted.	Nil
	Construction water demand	*Expansion of power station:* Construction water demand will be met from existing sources (piped supply) within the plant and, therefore, not likely to have impacts on other users.	Nil
		Substations & transmission lines: Construction water demand will be met from the existing local supply and, therefore, likely to have minor impacts on other users.	Minor
Water quality	Sediment load in	Sediment traps will be provided to reduce sediment load in	Negligible

Area	Impacts	Mitigation Measures	Scale of Impact
	construction wastewater	construction wastewater.	
	Water pollution due to sewage from construction camps	Proper sanitation facilities will be provided to the construction personnel to prevent water & sanitation related health problems.	Negligible
Air quality	Fugitive dusts from construction activities due to excavation, backfilling & concreting, and handling of earth & construction materials & construction spoils	• Construction materials will be stored in enclosed spaces to prevent fugitive emissions. • Truck carrying soil, sand and stone will be duly covered to avoid spilling. • Adequate dust suppression measures such as regular water sprinkling on haul & unpaved roads particularly near habitation will be undertaken to control fugitive dust. • Stringent construction material handling/overhauling procedures will be followed.	Minor
	Gaseous emissions from construction equipment & vehicular traffic.	• Low emission construction equipment & vehicles will be used. • It will be ensured that all construction equipment & vehicles are in good working condition, properly tuned & maintained to keep emissions within permissible limits.	Minor
Noise level	Noise due to construction activities like operation of construction equipment & vehicular traffic	• Construction camp will be located away from the immediate vicinity of the construction sites. • Protective gears such as ear plugs etc. will be provided to construction personnel exposed to high noise levels as preventive measure. • Low noise construction equipment will be used. • Construction machinery would be in good working condition and engines turned off when not in use.	Minor
Floral & fauna	Loss of flora and disturbance to fauna	Proposed sites are pieces of vacant land with no flora & fauna. Therefore, there will no loss of flora or disturbance to fauna. Plantation (only in power station) and landscaping in the available open spaces will be undertaken to enhance the floral resources.	Negligible
Social benefits	Employment opportunities	Most of the construction labourers will be recruited from local areas to alleviate social tension of migration.	Moderate
	Trading opportunities	Some of the construction materials like stone chips & sand will be procured locally.	Moderate
Occupational health & safety	Health & safety related problems to construction workers	Adequate safety & health measures complying the occupational safety manuals will be adopted to prevent accidents/hazards to the construction workers.	Negligible
Operation	**Phase:**	**Expansion of Power station:**	
Water use	Water requirement for the new boiler	The additional water requirement for the new boiler is only Demineralized water. As this additional water requirement for operation & maintenance will be met from the existing sources there will no impact on water use aspects outside the plant.	Nil
Water quality	Wastewater & cooling water discharge into the sea	• As all the effluents are completely treated in respective treatment plants (STP & Oil water separator) and their quality conforms to the prescribed discharge standards, no tangible impact is observed on the surface water quality in the study area due to the project. • The temperature of the return cooling water is only about 4°C more than the intake cooling water temperature. And when it discharged into the sea it gets huge dilution and no tangible negative impact on sea ecosystem has been observed near the discharge point.	Negligible
Air quality	Existing boilers emits 609 kg/h SO_2 per boiler i.e. 87.696 t/day at 125 MW load which is far above the World Bank permitted level of 25 t/day.	• As the SO_2 emission levels of the existing boilers is very high, it is desirable to use low sulphur fuel oil in the boilers to the maximum extent possible and switch over to natural gas when it is available. • Coastal high speed wind assists in a wide & quick dispersion of pollutants, thus lowering the GLCs, which is reflected in the relatively low monitored GLCs of SO_2 (maximum only 55.5 $\mu g/m^3$ which is permissible level of 125 $\mu g/m^3$) though its present emission rate is quite high.	Moderate

Area	Impacts	Mitigation Measures	Scale of Impact
	Additional emission due to new boiler	• Proposed 7th boiler will be of latest technology & high fuel efficiency (7 t/h) and will emit only 0.16 tpd SO_2 per MW which is within the World Bank guideline of 0.2 tpd per MW. • As observed from modelling results, the predicted 24-hourly maximum GLCs for the future stack will be about 3.8 $\mu g/m^3$. When it is added to the maximum present background level (55.5 $\mu g/m^3$), the resultant maximum ambient SO_2 level is expected to about 59.3 $\mu g/m^3$, which is within the permissible limit of 125 $\mu g/m^3$. • New boiler should be of dual firing system (fuel oil as well as natural gas). • Regular monitoring of stack emission & ambient air quality at specified locations will be conducted.	Minor
Noise level	Noise pollution due to machinery noise	• Impacts of noise on workers are minimized through adoption of adequate noise protective measures. • For expansion project low noise equipment should be installed.	Moderate
	Safety valves of the existing boilers creates loud noise nuisance to local residents	Safety valves of the existing boilers should be augmented to reduce the noise level.	Major
Fire & safety	Fire hazard due to fuel oil storage	Adequate safety measures already exist in the plant for use during the fire emergency that consists of: - Fire water storage tanks & pumps - Fire hydrants throughout the plant - Fire fighting tenders & crews round the clock - Portable fire extinguishers ate strategic locations - Automatic foam injection system for fuel oil area - Flame & smoke detectors at strategic locations	Negligible
Operation	**Phase:**	**Substations & transmission lines:**	
Land use	Encroachment of ROW of transmission lines	No construction of building or growing of trees will be permitted within the ROW to avoid accidents.	Negligible
Safety from electrical hazards	Electrical hazards from accidental snapping of conductors, electro-magnetic induction without minimum clearances, and unauthorized building or tree growth within ROW	• All the standard protection measures like circuit breakers, PLC based protection relay, routine maintenance and routine line patrolling by line walkers will be taken. Therefore, the chances of such accidents are very remote. • As minimum building clearance 5.1 m and ROW of 30 m will be maintained throughout the line length, there will be no hazards from electro-magnetic induction. • No construction of building or growing of trees will be permitted within the ROW to avoid accidents.	Negligible
Water use & water quality	Water requirement & wastewater disposal	Operation of substations needs water for staff and will generate sewage from toilet. As there will be only 1 control staff in a shift to operate & control the substations water requirement will be negligible. The water will be taken from the local supply. The sewage from the toilet will be led to septic tank followed by soak pit to assure necessary treatment and it may therefore be concluded that no impact is likely on the surface or ground water quality.	Negligible
PCB Oil	Health hazards due to improper disposal of PCB contaminated transformer oil	All efforts should be made to destroy PCB contaminated waste oil so that it does not escape into environment. The best way is to replace/ phase it out at the source by suitable substitute like Mineral Oil.	Negligible

6.2 Public Consultation

Public Consultation (socio-economic perception survey) jointly with PEC has been conducted to draw opinions about the project among the stakeholders around the power station, substations and the transmission lines. Emphasis has been laid on discussion with the plant personnel and local people in the impact zone. At the beginning of the

consultation process, the participants have been given a brief about objective of the study, about scope, objective & details of the project, and about environmental & social impacts of the projects.

Public consultations have been conducted at two places:

1) Public consultation near Al-Hiswa power station on the issue of the expansion of Al-Hiswa power station.
2) Public consultation in Hodeidah on issue of the expansion of Al-Hali substation, new substation at Kilo 16 and new transmission line from Al-Hali to Kilo 16.

The main outcomes of the public consultations are:

Expansion of power station:

- Disturbance of sleep in night due to safety valves operation of the existing boilers.
- Some participants expressed concern about their breathing trouble mainly of smokers, either due to SO_2 or due to high level of wind blown dust.
- More plantations in the vacant area within the plant.
- PEC should do some development of the existing school and hospital in their area.
- Some environmental awareness programs to be organized by the Hiswa plant management.
- All participants are in favour of the expansion of the power station because of the power crisis.

New substations & transmission lines:

- All the participants expressed their grave concern about the power cut, low voltage & faults in Al-Hodeidah. And they want immediate solution of the problems of power distribution.
- All the participants are in favour of the project (i.e. augmentation of substations and new substations to divert the load). Regarding location of the new substation they have no choice.
- Most of the participants are in favour of the Govt. order that the few illegal squatters occupying the ROW of the Al-Hali to Ras Katenib existing transmission line should be removed.

7.0 ENVIRONMENTAL MONITORING & ENVIRONMENTAL MANAGEMENT PLAN

The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. EMP has been prepared addressing the issues like:

- Environmental mitigation measures during construction and operation stages
- Institutional set up identified/recommended for implementation of the EMP
- Environmental monitoring during the construction and operation stages
- Expenditures for environmental protection measures.

7.1 Institutional Set Up

The responsibility for implementing the mitigation measures are delegated to the **PEC**, whose role in the present context, is to mobilize the appropriate expertise to mitigate the

adverse impact through implementation the mitigation measures contained in the EIA & EMP through the **Contractors** & the **Supervision Consultants** during the construction stage, and through PEC staff during the operation stage.

To look after the environmental aspects in the Al-Hiswa power station an **Environment Unit** has to be formed headed by the **Fire Fighting, Safety & Environment Manager (FSEM)**. A full time officer of the minimum rank of **Supervisor** will be given the charge of the Environment who will assist the FSEM. During operation, the responsibility of environmental management of the Al-Hiswa power station will lie mainly with the **FSEM** at plant site, who will act as a coordinator for environmental matters.

The responsibility of environmental management of the transmission lines & substations during operation will lie mainly with the **Department Manager, Technical Coordination (Environment) at PEC**, who will act as a coordinator for environmental matters.

The major responsibilities and functions of the **Fire Fighting, Safety & Environment Manager (FSEM)** are given below:

- Coordination with statutory bodies, various departments in the site & head quarters.
- Compliance with statutory guidelines and statutory requirements
- Coordinating the testing/monitoring of functions of the pollution control systems & environmental field monitoring & analysis during construction & operation
- Ensuring the proper functioning of the wastewater treatment plants.
- Maintenance of environmental database, preparation of report and to organize environmental training, workshops and seminars
- Environmental appraisal (internal) and environmental audit

7.2 Environmental Monitoring

7.2.1 Environmental Monitoring Programme

Summary of post project environmental monitoring program are presented in **Table-E7.1**.

Table-E7.1 Post Project Environmental Monitoring Programme

SN	Component	Parameter	Monitoring Location	Frequency
1.	Ambient Air Quality	PM, PM_{10}, SO_2, & NOx	3 locations outside the plant at distance of 1 to 1.3 km along three predominant wind directions north, east & west	Two months in a year (1 month in summer & 1 month in winter) at a frequency of twice in a week.
2.	Stack emission	Particulates, SO_2, NOx	All the 4 stacks in the power station during the full load operation of the connected boilers	Once in a month
3.	Noise Levels			
a)	Outside plant boundary	Day & night time L_{eq}	3 locations outside the plant (nearest residence, nearest school & nearest office)	Twice a year
b)	In work zones within the plant	8-hourly L_{eq}	5 locations inside the plant (Administrative office, Main gate security office, Training center, Main control room, & Boiler house)	Twice a year
4.	Liquid effluents			
a)	Boiler blow down	pH, TSS, TDS, Oil & grease, Copper, Iron, Residual chlorine		Once a month

SN	Component	Parameter	Monitoring Location	Frequency
b)	Oily effluent	pH, Oil & grease	At entrance to oil water separator	Once a month
c)	Treated oily effluent	pH, Oil & grease	At exit of oil water separator	Once a month
d)	Raw sewage	pH, BOD, COD, TSS	At entrance to STP	Once a month
e)	Treated sewage	pH, BOD, COD, TSS	At exit of STP	Once a month
f)	Combined cooling water discharge	Temp, TSS, Oil & grease, Total chromium, Copper, Iron, Zinc, Residual chlorine	Just before discharge point into the sea	Once a month
g)	Sea water	Temp, TSS, Oil & grease, Total chromium, Copper, Iron, Zinc, Residual chlorine	At 100 m of the cooling water discharge point	Once a month
5.	Meteorology	Temperature, Relative humidity, Wind speed & direction	At top of any building, at 10 m height from the ground level & free from any obstruction of wind	Hourly (Continuously at every hour)

7.2.2 Institutional & Infrastructural Arrangements for Monitoring

The post operational monitoring programme will be under the supervision of the FSEM at the power station site. For monitoring of environmental aspects in the Al-Hiswa power station an Environment Unit has to be formed with minimum one supervisor, one chemist, one monitoring technician and an environmental laboratory. The existing stacks have no stack monitoring facilities. Stack monitoring facilities have to be constructed for the existing 3 stacks including sampling port, working platform and stairs. For infrastructural strengthening of the Environment Unit at PEC Head Office, 2 sets of computers & printers are required along with office furniture.

7.2.3 Training

The Environmental Unit in PEC Head Office and Environmental Unit in Al-Hiswa power station, who would be responsible for the implementation of the EMP, need to be trained on the effective implementation of the environmental issues. To ensure the success of the implementation set up proposed, there is a high requirement of training and skill upgradation. The training has to be given by reputed Consultants having experience of environmental monitoring of power station.

7.3 Other Related Aspects

7.3.1 Greenbelt Development Plan

Power station

Substantial plantation in and around the Al-Hiswa power station have already been done and more plantation will be done in the unutilized open spaces in order to further enhance the aesthetic look of the area. This station will include:

- Plantation along the periphery for protection against fugitive dust and noise. Width of peripheral greenbelt will vary to suit the plant design requirement.
- Plantation along approach road and pathways for aesthetics.
- Block plantation in available open areas.
- Landscaping & grass plantation on open unpaved areas to prevent fugitive dust.

Substations

No tree plantation is recommended in the substation except landscaping with grass & flower beds. Development of green belt will include:

- Landscaping with flower beds along approach road and pathways.

- Grass plantation in patches in open unpaved areas to prevent fugitive dust.

7.3.2 Compensation

The project involves acquisition of land and loss of crop during placing of transmission towers through agricultural fields. The compensation will include:

- Compensation for land occupied by footings of the towers as per the **Resettlement Policy Framework (RPF)** prepared jointly by **the PEC and the World Bank**.
- 100% compensation for crop lost as per the RPF mentioned above.

7.3.3 Fire and Safety Management

The Fire Fighting & Safety Manager in the Al-Hiswa power station looks after the fire & safety aspects. Necessary fire fighting facilities already exist in the plant to tackle any fire contingency. Strict rules and regulation are being followed to take care of workers health and safety. Workers are provided with necessary safety devices & personal protective equipment to protect them from any occupational hazard.

7.4 Environmental Budget

A capital cost provision of about 135,720 US$ has been kept towards the environmental management measures in the EMP. The budgetary cost estimate for implementation of the environmental protection, mitigation & enhancement measures & environmental monitoring is elaborated in **Table-E7.2**.

Table-E7.2 Environmental Budget

SN	Item	Break up (US$)	Total Cost (US$)
	Capital Cost:		
1.	Pollution Monitoring:		96,875
	a) Monitoring facilities & equipment for Al-Hiswa power station (for details refer Table-7.4.3)	36,875	
	b) Construction of stack monitoring facilities in the existing stacks @ 20,000 US$ per stack (lump sum)	60,000	
2.	Plantation & landscaping including 3 years maintenance (lump sum)		5,000
3.	Institutional strengthening:		19000
	a) Infrastructure development of Environment Unit at PEC HO (lump sum)	4,000	
	b) Training of PEC staff for env. monitoring & management (lump sum)	15,000	
4.	Others (local development):		10,000
	a) Development of existing school near Al-Hiswa power station (lump sum)	5,000	
	b) Development of existing hospital near Al-Hiswa power station (lump sum)	5,000	
5.	Contingency @ 5% of total cost		6,545
	Total Capital Cost		**135,720**
	Recurring Cost per Annum:		
1.	Monitoring during operation (chemicals & spares)*		5,000
	Total Recurring Cost per Annum		**5,000**

* Cost of staff is not considered as the existing excess staff will be engaged for this job

1.0 INTRODUCTION, BACKGROUND, EIA OBJECTIVES & EIA METHODOLOGY

1.1 INTRODUCTION & BACKGROUND

The Public Electricity Corporation (PEC), a state corporation of the Republic of Yemen, requested the World Bank- IDA to finance the power sector project in Yemen. This proposed project consists of three sub-components, Generation sub-component, Transmission sub-component and Distribution sub-component. In compliance with the Bank's environmental safeguard policies, the World Bank has requested the PEC to conduct and submit an Environmental Impact Assessment (EIA) of the project to the Bank prior to project appraisal in order to provide a framework for identification, assessment and management of environmental and social concern of the project.

As per the Bank's Operation Policy 4.01on "Environmental Assessment (EA)", after the initial environmental screening it has been found that the proposed project falls into Category-B project for its limited environmental impacts. Therefore, a limited EIA is required for the project.

1.2 PROJECT COMPONENTS COVERED IN THE EIA STUDY

The project has three sub-components- Generation, Transmission and Distribution. However, the EIA study covers only two sub-components viz. Generation and Transmission. The project sub-components are shown in the index map in **Figure-1.1**.

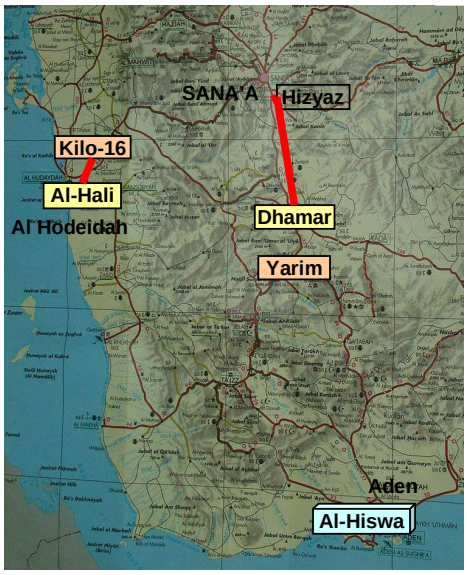


Figure-1.1 Index Map Showing Project Sub-components

Generation Sub-component

This sub-component consists of supply & installation of a 160 t/h boiler al Al-Hiswa steam power station (Aden region).

Transmission Sub-component

This sub-component consists of:

- Expansion of existing Al-Hali substation in Al-Hodeidah
- New substation at Kilo 16 in Al-Hodeidah
- Expansion of existing Dhamar substation
- New substation at Yarim by tapping the existing lines between Ibb and Dhamar
- New 12 km 132 KV transmission line from Al-Hali to Kilo-16

- New 90 km 132 KV transmission line from Dhamar to Hizyaz in Sana'a parallel to the existing line.

1.3 JUSTIFICATION OF THE PROJECT

1.3.1 Justification of Expansion of Al-Hiswa Power Station

PEC is short of generating capacity. Is also has deficiencies in transmission and distribution capabilities in some areas. In July 1997, PEC interconnected its southern transmission system comprising of Al-Hiswa Complex with northern transmission system comprising of Ras Katenib/ Al-Mukha complex, by energizing 132 KV transmission line between Aden and Taiz. This interconnection added flexibility in operations and provided some additional capacity on account of diversity of loads in the two systems. PEC added 30 MW capacity of diesel generation at Dhaban-2, including 5 MW of diesel generation at Al-Qa'a power station and rehabilitated 20 MW of diesel generation at Dhaban-1, increasing the plant capacity from de-rated 8 MW to 18 MW. A 30 MW diesel power plant has been commissioned in 2002 at Hizyaz and also another new 70 MW of diesel power plant in October 2004.

The interconnected system (oil fired steam as well as diesel plants including the new Hizyaz DPS) has now 771 MW of installed capacity of which the effective capacity is 530 MW. In addition to the interconnected grid system, PEC has isolated diesel generation (at Mukallah, Sayun, Ataq and Lawder) of total 161 MW installed capacity of which the effective capacity is 94 MW. From the data furnished by PEC, it is noted that there had been gap (deficit) between load demand and effective supply capacity (interconnected grid plus isolated generation). As example, for FY 2003, the load demand for the national grid was 710 MW which was more than effective supply capacity of the grid. As a result there had been load shedding which was about 20% of peak demand in average.

The gap between load demand and effective supply capacity is increasing every year, which is most prominent in Sana'a and Aden area. The upcoming Marib gas power station (800 MW) will take care of increased load of Sana'a and its interconnecting grids. But for Aden area which is located at furthest end (extreme south with respect to Marib power station), it is difficult to transmit the power from Marib station, due to long line loss and poor voltage regulation.

To increase the power generation in Aden area, PEC provides for rehabilitation of oil fired steam plants at Al-Hiswa (5x25 MW). There are five steam turbines of 25 MW each and six boilers of 160 t/h each for supply of steam to the turbines. PEC has already carried out overhaul of turbine nos. 3 and 4. Rehabilitation of boilers nos. 1 and 3 is complete. It now intends to overhaul the remaining three turbines nos. 1, 2 and 5 and boilers nos. 2, 4, 5 and 6. PEC also plans to replace some old parts and modernize the combustion control and firing systems. PEC also plans to modernize its control/ protection system. PEC is increasing the plant generation capacity by addition of one 60 MW turbine, which will be completed by March 2006. It is proposed to add 160 t/h new boiler under this present project for strengthening and augmenting the system.

Technical Justification:

It may be noted from above that the overhaul, rehabilitation & expansion is justified as it will:

a) Improve the efficiency of the plant;

b) Increase the rated MW capacity of the plant to meet the additional load demand;
c) Increase the available plant running hours.

1.3.2 Justification of New Substations & Transmissions Lines

The Project provides for augmentation of transmission facilities related to two BSP/ Grid substations (i) Hodeidah area and (ii) Dhamar area, as follows:

Expansion of Al-Hali (Hodeidah) Substation & New Kilo 16 SubStation

This 132 KV Bulk Supply Point (BSP) substation at Al-Hali in Hodeidah is at present interconnected to 132 KV substation of Ras Katenib power station through 132 KV double circuit line. The 33 KV load demand in Hodeidah area has gone up to 78 MW/ 70 MVAR (totaling 105 MVA), whereas 132/33 KV transformer capacity in this substation is 2x60 MVA, marginally higher than present 33 KV load demand. In view of further increase in 33 KV load demand due to substantial commercial development in this area, PEC proposes a 132 KV new substation at kilo 16 (with 1 no. 132/33 KV, 60 MVA & 1 no. 33/11 KV, 20 MVA transformers and a 50 MVAR compensation plant) which will be fed from existing Al-Hali substation through 12 km, 132 KV double circuit line. About 36 MW load at 33 KV presently fed from Al-Hali BSP station, Kornish, Maraweah & kilo 4 feeders will be transferred to new kilo 16 substation resulting in improved performance. For interconnection between kilo 16 substation & Al-Hali substation, PEC proposes expansion of Al-Hali substation by installing a new interlinking single bus-bar 132 KV substation in the vacant land within the boundary of the existing substation.

Expansion of Dhamar Substation

This is the second BPS substation proposed to be augmented under the Project. A 90 km of 132 KV double circuit line is proposed from existing Dhamar substation to future 132 KV Hizyaz substation. The 132 KV substation at Hizyaz is proposed to be constructed under the Marib Transmission Line Project. The 132 KV bus bar of Dhamar substation will be extended by two bays to draw the proposed line to Hizyaz. This line is required to reinforce/debottlenecking the existing line circuits between Dhamar and Asser (Sana'a) to transmit the excess power from Marib-Sana'a area, with the new generation at Marib. The existing 132 KV line from Dhamar to Asser is under rated to transmit the excess power from Marib-Sana'a area.

New Yarim Substation

PEC also proposes one 132 substation at Yarim (with 2 nos. 132/33 KV, 45 MVA transformers and 1 no. 33/11 KV, 20 MVA transformer) by tapping the existing 132 KV double circuit line between Dhamar and Ibb. The new Yarim substation will relieve overloading of Dhamar substation by sharing of 33 KV and 11 KV loads of surrounding areas.

Technical Justification:

To meet the increasing load demands, the new 132 KV works are justified instead of augmentation of existing 33 KV facilities, in order to reduce the system losses and improve the voltage regulation, and to transmit the excess power from Marib-Sana'a area.

1.4 OBJECTIVE AND SCOPE OF THE EIA STUDY

EIA is a method of forecasting the likely environmental impacts of a project before implementation begins, so that adjustments may be made, if necessary, to ensure that the environmental impacts will be avoided or minimized. The main purposes of the EIA are:

- To reveal positive and negative effects of the project that could have a significant impact on the environment, natural resources and society.
- To ensure that these effects are given consideration in the planning and that the effects are known to the decision-makers.
- To clarify conditions for implementation of the project including mitigating measures and a monitoring program

In summary, therefore, the EIA process will:

- Improve project design,
- Reduce environmental negative impacts & enhance positive impacts, and
- Ensure sustainable development.

1.4.1 Objective of the EIA Study

The broad objectives of the present study in line with the TOR are as follows:

- Establishing the physical, biological and social environmental baseline set-up in the project location and its surrounding influence area for the existing power plant, proposed transmission corridor and substation through available data/information supported by field studies, wherever necessary,
- Analysis of alternatives in terms of no action alternatives, fuel sources, plant design, power sources, route selection, site location etc.
- Identification of physical, biological and social significant environmental issues associated with project components.
- Assessment of environmental impacts associated with all identified significant issues during planning, construction and operational phases of the project.
- Recommending adequate enhancement/ mitigation measures for positive and negative impacts during different phases of implementation to minimize/reduce adverse impacts.
- Formulation of an Environment Management Plan (EMP) including Monitoring Plan, Training Plan and Institutional Mechanism to ensure its effective and timely implementation of the mitigation measures to make the project environmentally sound and sustainable.
- Preparation of an EIA report including EMP.

1.4.2 Scope of the EIA Study as per TOR

World Bank-financed projects are required to comply with its environmental and social policies and guidelines. This process involves an environmental and social assessment and the implementation of an Environmental Action Plan (EAP) which will set forth the necessary actions to bring the operation into compliance. The scope of Environmental Assessment (EA) for a Category B project may vary from project to project, but it is narrower than that of Category A, but the basic elements to prevent, minimize, mitigate or compensate adverse impacts to improve environmental performance remain.

In line of this requirement, the scope of services and key issues to be addressed as proposed in the Terms of Reference (TOR) are described below.

1. Generation: Conducting an audit of Environmental Conditions at Al-Hiswa Steam Power Plants Site proposed for expansion. The audit should include, but not be limited to:
   (i) Current and Potential Air Quality Impacts;
   (ii) Current and Potential Cooling Sea Water Impacts including discharge;
   (iii) Waste Management and Disposal Practice (both oily and solid);
   (iv) Worker Health and Safety;
   (v) Emergency Management;
   (vi) Environmental Impacts and Safety Risks associated with Residual Fuel;
   (vii) Any others site-specific environmental issues; and
   (viii) Proposed mitigation measures for any negative environmental impacts identified.

2. Transmission & Substations: conducting an environmental impact assessment (EIA) for the proposed transmission lines and substations sub-components. The EIA will include but not be limited to:
   (i) Identification and analysis of relevant environmental and social issues;
   (ii) Identification and analysis of the most likely physical constraints;
   (iii) Definition of international standards for height, distance from habitation (clearances), livestock, for transmission lines;
   (iv) Route selection and right-of-way;
   (v) Existing environment of the proposed project sites;
   (vi) Territorial description around the lines; including any endangered natural habitats to be crossed;
   (vii) Landscape of lines and substation sites;
   (viii) Land use;
   (ix) Economic and social benefits;
   (x) Identification of any historical and cultural in the vicinity project sites;
   (xi) Any others site-specific environmental issues;

3. Providing guide lines to PEC for disposal of PCB's contaminated oils;

4. Analyzing potential of alternatives to proposed sub-components if major, negative environmental impacts are identified.

5. Identifying necessary mitigation measures in all sub-components.

6. Preparing an environmental management and training plan that includes, but is not limited to:
   (i) A detailed Environmental Management plan (EMP)
   (ii) Costing of all mitigation measures and responsible party for financing those measures;
   (iii) Party (ies) responsible for supervising EMP; and
   (iv) Training plan for supervising engineers and contractors on the implementation of the EMPs.

7. Conducting public consultations with local stakeholders in conjunction with PEC on the contents of the EIA.

1.5 APPROACH & METHODOLOGY OF EIA

An EIA study basically includes establishment of the present environmental scenario, study of the specific activities related to the project and evaluation of the probable

environmental impacts, thus, leading to the recommendations of necessary environmental control measures. The entire EIA study has been carried out within existing policy, legal and administrative framework considering the applicable Environmental laws & standards of the EPA, Republic of Yemen, and applicable policies, directives & good practices guidelines of the World Bank.

An EIA study methodology basically includes:

- Establishment of the baseline/present environmental scenario
- Study of the project activities having environmental impacts
- Identification & assessment of the probable environmental impacts
- Recommendations of necessary environmental control measures.

The methodology adopted is presented in the form of flow chart (**Figure-1.2).** The methodology is presented in detail in the subsequent sections.

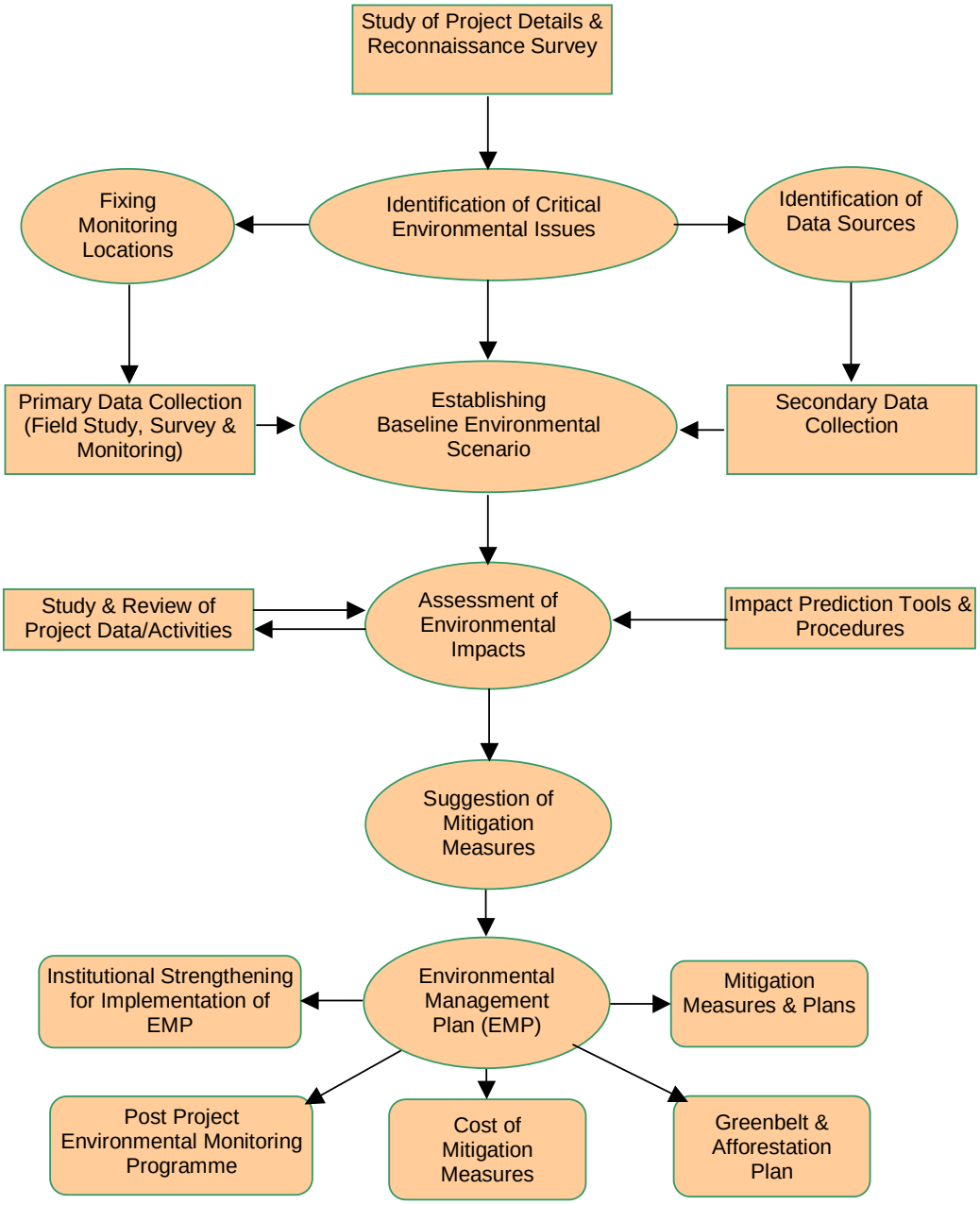


Figure-1.2 Schematic Diagram for Approach and Methodology of EIA

1.5.1 Establishment of Baseline Environmental Scenario

A comprehensive database on the baseline environmental status/conditions of the study area will be established through review, compilation & analysis of:

- Existing published secondary data/ literature/ information collected, and
- Primary data generated/ collected through field study, survey and monitoring.

1.5.1.1 Secondary Data Collection

Besides inputs from the client on the relevant information about the project, other secondary data sources (Governmental & other institutions) have been identified and secondary data/ information/ records & published literature with respect to physical, biological and social environment of the study area have been collected. The type of data, source and collection status are presented below in **Table-1.1**.

Table-1.1 Secondary Data Sources

SN	Data	Source
	Topographical Sheets	PEC, Sana'a
	Justification of New Transmission Lines	PEC, Sana'a
	Meteorological Data	Civil Aviation & Meteorology Authority, Republic of Yemen, Aden Airport Office
	Statistical Year Book 2003	Ministry of Planning & International Co-operation, Republic of Yemen
	Environment related Laws, Rules & Standards	Environment Protection Authority (EPA), Republic of Yemen
	Earthquake data for Al-Hiswa & Transmission corridors	Statistical Year Book 2003 and National Seismological Observatory Center
	Generation related data (Plant layout, Plant configuration, Water & Waste water data, Transformer oil data, Stack & emission data, Specifications of new boiler etc.)	Al Hiswa Power Plant
	Design of the transmission line	PEC, Sana'a

1.5.1.2 Primary Data- Survey & Monitoring

The collected secondary data has been appropriately supplemented by conducting the necessary primary data generation/ collection through field study/monitoring in the month of July 2005. Field study/monitoring has been conducted on:

- **Land use:** Land use patterns around the power station & substations and along the transmission line corridors have been established through the topographical maps & reconnaissance survey.

- **Soil Monitoring:** To study the soil characteristics in the study area, soil samples from representative locations in & around the power plant have been collected and analyzed for important relevant physical & chemical parameters.

- **Water Quality Monitoring:** For drawing up the baseline data on water quality, water quality monitoring has been conducted at representative locations in the study area. Effluent quality of all the plant effluents has been monitored before and after treatment, and its final discharge point into the sea. Drinking water quality in the power station has also been monitored. Water samples from all the locations have been collected and analyzed for important relevant physical, chemical and bacteriological parameters.

- **Ambient Air Quality Monitoring:** For drawing up the baseline status of ambient air quality in the study area, ambient air quality monitoring in respect of PM, PM_{10}, SO_2, NO_x, and CO has been conducted at 4 representative locations in predominant wind directions around the power plant adopting a 24-hours schedule (for CO 8-hourly) using High Volume Respirable Dust Samplers (RDS) along with gaseous sampling impingers.

- **Noise Monitoring:** To establish the ambient noise scenario in the study area, ambient noise level monitoring has been carried out at representative locations in and around the power plant using a portable sound level meter to obtain L_{eq} to compare with the standards.

- **Stack Monitoring:** There are 3 stacks in the Al-Hiswa power station, but none of them have stack monitoring facility (i.e. port hole, platform for monitoring man & equipment, and non-monkey ladder to reach there with equipment). Therefore, stack monitoring is not possible. SO_2 emissions from the stack have been computed from the Sulphur content in the fuel oil and the fuel oil combustion rate.

1.5.2 Study of Project Activities

The project data & activities consisting of the general layout and process description of the plant; its capacity and commissioning schedule; process flow paths; source, requirement and characteristics of fuels; source, requirement and characteristics of raw materials; sources of power; storage details of raw materials, products and other chemicals; material handling systems; quantity, nature and disposal of solid wastes; plant water use and water balance diagram; details of liquid wastes and its treatment facilities; particulars of atmospheric emissions; sources of noise and their levels; and other inherent details has been established from the available data & consultation with the officials of the Authority of power plant and the transmission line. The quality of effluents has been monitored under Environmental Audit program as part of the study.

1.5.3 Assessment of Environmental Impacts

The environmental assessment has been conducted in accordance with the norms and guidelines of the World Bank & Republic of Yemen. The project data/activities have been analyzed & linked with the existing baseline environmental conditions in order to list out the affected environmental parameters and assess the likely impacts on such parameters. Wherever practicable, a quantitative analysis has been performed. Suitable computer models, wherever applicable, have been used. Compliance of the project with Yemen standards has been duly checked

Power Station

Following aspects have been given due importance during assessment of impacts and recommending remedial measures:

- Nature and quantum of power plant emissions
- Water requirement during construction & operation and sources
- Wastewater treatment, disposal and reuse
- Noise levels during operation and noise control measures
- Felling trees and compensatory plantation
- Noise level, dust concentration and water logging near construction sites
- Nature, quantity and disposal of construction spoils
- Public health & sanitation, and occupational health & safety of construction workers

- Fire fighting arrangement

Air quality modelling has been conducted using USEPA approved ISCST3 model to predict the future air quality due to increased emission from the power station during operational phase of the project. Impact on noise during operational phase of the project has also been assessed. Significant impacts, if any, on soil and land use have also been identified. Impacts on water use have been evaluated based on the water requirement of the project and the availability of water in the area. Impacts on the surface water quality of the receiving water bodies due to receipt of the plant effluents have been studied. Impacts on demographic and socio-economic environment have been drawn from the data collected on project affected persons, employment potential, incidental benefits etc.

Transmission Lines & Substations

The approach adopted for carrying out environment assessment of electric power transmission system has been mainly as per guideline of World Bank. The transmission system will include the transmission line, its right-of-way (ROW), substations and access or maintenance roads. The principle structures of the transmission line will include the line itself, conductors, towers and supports .First of all, the EA includes an analysis of reasonable alternatives to meet the ultimate project objective of the distribution of electricity to load centers. One of the most important considerations will be an evaluation of alternative routes and substation sites. The following other significant environmental issues associated with transmission line are also being looked into:

- Land use of ROW
- Land acquisition, compensation and negotiation
- Topography of alignment
- Vegetation damage and habitat loss
- Visual and aesthetic impact
- Impacts on agricultural operation
- Safety measures during construction
- Induced effects from electromagnetic fields and clearances
- Wildlife Impact
- Heritage and Archeological Impact

Assessment of Socio-economic Impacts

The socio - economic study has been conducted to assess mainly the impacts of people due to land requirement for new substations and transmission as well as to assess the social benefits based on reconnaissance survey. The socio-economic impact assessment has been focused mainly on following issues:

- Assessment for loss of land particularly due to towers for the new transmission lines and land requirement for the new substations.
- The buildings & structures falling within the ROW of the new transmission lines.
- An overall assessment of the type of various landuse within the ROW of the new transmission lines.
- Public consultation with the stakeholders.

Public Consultation (socio-economic perception survey) jointly with PEC has been conducted to draw opinions about the project among the stakeholders around the power station, substations and the transmission lines. Emphasis has been laid on discussion with the plant personnel and people in the impact zone. The discussions and surveys are intended to elucidate the perception of the people and plant personnel about the

project, their suggestions for improvement, and any other positive or negative impacts as observed and anticipated by them. For conducting the survey, the people have been given a brief about the project and objective of the study.

1.5.4 Preparation of Environmental Management Plan

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. The desired results from the environmental mitigation measures proposed in the project may not be obtained without a management plan to assure its proper implementation and function. The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. EMP has been prepared addressing the issues like:

- Preventive, mitigation, compensatory & enhancement measures for minimization & abatement of the undesirable impacts caused during the construction and operation stage.
- Details of management plans including their implementation schedule and supervision programme:
  - Wastewater management plan
  - Solid waste management plan
  - PCB waste oil management plan
  - Occupational safety
- Institutional set up Identified/recommended for implementation of the EMP including institutional strengthening and training
- Environmental monitoring programme during construction and operation phase including parameters, locations and frequency of monitoring, suggested monitoring equipment and facilities, and their implementation programme to be undertaken.
- Expenditures for environmental protection measures and budget for implementation of the EMP.

1.6 STRUCTURE OF THE REPORT

This **Environmental Impact Assessment (EIA)** report has been prepared on the basis of the available secondary data/literature along with the on-site primary data (survey/monitoring). The EIA report contains legal framework, project features, baseline environmental setup, assessment of environmental impacts, formulation of mitigation measures & environmental management & monitoring plan, and analysis of alternatives.

The structure of the **EIA Report** complete with necessary tables, drawings and annexures is as follows:

Executive Summary
Chapter-1: Introduction, Background, EIA Objectives & EIA Methodology
Chapter-2: Policy, Legal & Administrative Framework
Chapter-3: Project Description
Chapter-4: Environmental Audit and Baseline Environmental Scenario
Chapter-5: Analysis of Alternatives
Chapter-6: Environmental Impacts of the Project and Mitigation Measures
Chapter-7: Environmental Monitoring & Environmental Management Plan
Annexes

2.0 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

2.1 RELEVANT WORLD BANK POLICIES & GUIDELINES

The applicable environmental and social policies, directives & good practices guidelines of the World Bank are mentioned below:

- Environmental Assessment Sourcebook & its Updates
- OP/BP 4.01 Environmental Assessment
- OP/BP 4.02 Environmental Action Plans
- OP/BP 4.04 Natural Habitats
- OP/BP 4.36 Forests
- OP/BP 4.12 Involuntary Resettlement
- OD 4.20 Indigenous Peoples
- OP 14.70 Management of Cultural Properties in Bank-Financed Projects
- Excerpt of Thermal Power Guidelines for New Plants

2.2 PROJECT CATEGORY AS PER WORLD BANK GUIDELINES

As per the provisions of operational directives, policies & guidelines of the **World Bank** "Electrical Transmission" has been classified as **Category B project**. Though "Thermal power development or expansion" has been classified as Category A project, it is also mentioned that "projects in Category B often differs from Category A projects of the same type only in scale", and "Projects entailing rehabilitation, maintenance or upgrading rather than new construction will usually be in Category B" and the "Rehabilitation or modification of existing industrial facilities (small scale)" are Category B project. Logically, therefore, the small scale Thermal power plant in Al-Hiswa can be treated as **Category B project**.

Category B projects are likely to have limited environmental impacts and a limited EA is needed covering limited public consultation. An Environmental Impact Assessment (EIA) report is required having contents specified in Annex B of OP 4.01 (January 1999).

In this case, the project, i.e. expansion of Al-Hiswa power station and laying new transmission lines is a **Category B project** and the following is required:

- A limited **Environmental Impact Assessment (EIA)** report
- Limited **Public Consultation** during the preparation of draft EIA report

2.3 LEGAL FRAMEWORK

The Environment Protection Law, No. 26 of 1995, is the most comprehensive law in the Republic of Yemen on the environment. The law grants power to the EPA in Central Government to take all measures necessary to protect and improve the quality of environment and to prevent pollution of the environment.

The standards relevant to the EIA studies of this power sector project are:

- Environmental Standards of Republic of Yemen
  - Air quality standards
  - Industrial emission standards
  - Wastewater quality standards

- Drinking water quality standards
- Irrigation water quality standards
- Noise standards

• World Bank Guidelines for Environmental Assessment

2.4 ADMINISTRATIVE FRAMEWORK

The organizations responsible for ensuring environmental compliance of the project include:

- **Public Electricity Corporation (PEC)**, Republic of Yemen: PEC being the project promoter is responsible for ensuring environmental compliance with the environmental laws & standards of the Republic of Yemen as well as to comply with the environmental & social safeguard policies & guidelines of the World Bank, the financer.
- **The World Bank**: The World Bank being the financer of the project has to ensure that all the environmental safeguards and mitigation measures are designed & implemented in the project as per the Bank's environmental & social safeguard policies & guidelines.
- **Environment Protection Authority (EPA)**, Republic of Yemen: EPA, Yemen (previously EPC) is the principal central authority in the Republic of Yemen empowered to formulate & enact the environmental policies & strategies, environmental laws, rules & standards, and responsible for implementation of the laws and safeguarding the environment.

2.5 RELEVANT ENVIRONMENTAL STANDARDS

The relevant environmental standards of Republic of Yemen, US-EPA, WHO and World Bank related to ambient air quality, industrial emission, noise, wastewater & treated effluents, irrigation water, and drinking water are given in the following paragraphs.

2.5.1 Ambient Air Quality Standards

Table-2.1 Ambient Air Quality Standards (in $\mu g/m^3$) of Yemen, WHO & USEPA

Air Pollutants	Time Weighted Average	Yemen-EPA[1]	WHO (1999)[2]	USEPA (July 1997)[3]	World Bank Guidelines
Nitrogen Dioxide (NO_2)	Annual	-	40	100 (P&S)	100
	24 hours	150	200	-	150
	1 hour	400	-	-	-
Sulphur Dioxide (SO_2)	Annual	-	50	80 (P)	80
	24 hours	-	125	365 (P)	150
	3 hours	-	-	1300 (S)	-
	10 minutes	-	500	-	-
Carbon Monoxide (CO)	8 hours	10,000	10,000	10,000 (P)	-
	1 hour	20,000	30,000	40,000 (P)	-
	30 minutes	-	60,000	-	-
	15 minutes	-	100,000	-	-

Air Pollutants	Time Weighted Average	Yemen-EPA[1]	WHO (1999)[2]	USEPA (July 1997)[3]	World Bank Guidelines
Lead (Pb)	Annual	1	0.5	-	-
	Quarterly	-	-	1.5 (P&S)	-
Particulate Matters	Annual	60	-	-	80
	24 hours	150	-	-	230
PM_{10}	Annual	-	-	50 (P&S)	-
	24 hours	70	-	150 (P&S)	-
$PM_{2.5}$	Annual	-	-	15 (P&S)	-
	24 hours	-	-	65 (P&S)	-
Ozone (O_3)	8 hours	120	120	157 (P&S)	-
	1 hour	200	-	235 (P&S)	-
Carbon Dioxide (CO_2)	Annual	60	-	-	-
	24 hours	150	-	-	-
	1 hour	250	-	-	-

Table legend: P- Primary standard, S-Secondary standard
References:
[1] Guidelines & Regulations of EPA, Republic of Yemen, Council of Ministers, Decree No. 148 of year 2000.
[2] WHO, Air Quality Guidelines
[3] USEPA, July 1997, EPA Office of Air Quality Planning & Standards, USEPA, Triangle Park, USA

2.5.2 Industrial Emission Standards

Table-2.2 Maximum Permitted Levels of Gases/Smokes Emitted from Manufacturers/Industries

SN	Pollutant	Max Level in mg/Nm^3 in Yemen
1.	Dihydride (Copper Aldehide)	20
2.	Antimony	20
3.	CO	Old 500, New 250
4.	Combustion of Petrol & Coal	Old 4000, New 250
5.	Non-ferrous Industries	3000
6.	Sulphuric Acid	1500
7.	Industrial Sulphur + Acids	150
8.	Nitric Acid Industry	3000
9.	Hydrochloric Acid (as HCl)	100
10.	Hydrofloric Acid (as HF)	15
11.	Lead (Pb)	20
12.	Mercury (Hg)	15
13.	Heavy metals (Total)	25
14.	Silicon Fluoride	10
15.	Fluors	20
16.	Gravit Industries	50
17.	Cardimum	10
18.	Captric Hydrogen	20
19.	Chlor	20

The world bank guidelines are:
NOx (as NO_2) : 125 mg/Nm^3
SO_2 : 2000 mg/Nm^3

Total Suspended Solids : 50 mg/Nm^3

2.5.3 Noise standards

Table-2.3 Permissible Noise Limits as per the Environment Protection Law, Yemen

Type of Area	Limit in dB(A) as per Article A of the Law			Limit in dB(A) as per Article B of the Law		
	Time			Time		
	A	B	C	A	B	C
Country side residential area & park area	45	40	35	60	55	55
Residential area (outside the city)	50	45	40	65	60	55
Residential area (inside the city)	55	50	45	65	60	55
Residential area (inside the city around workshops & commercial areas)	60	55	50	65	60	55
Industrial & commercial area	70	70	70	70	65	60

World Bank guideline values of noise are:
Industrial & commercial area: Daytime & Nighttime: 70 dB(A)
Residential, institutional & educational area: Daytime: 55 dB(A), Nighttime: 45 dB(A)

2.5.4 Wastewater Quality Standards

Table-2.4 Maximum Allowable Concentration in Industrial Wastewater for Discharge into General Sewerage Network

SN	Item	Code	Unit	Permissible Limit in Yemen
	Chemical Oxygen Demand	COD	mg/l	200
	Bio-chemical Oxygen Demand	BOD_3	mg/l	50
	Hydrogen Ion Concentration	pH		5.5-9.5
	Temperature		°C	45
	Total Suspended Solids	TSS	mg/l	500
	Total Dissolved Solids	TDS	mg/l	2000
	Oil & Grease		mg/l	100
	Phenols		mg/l	2
	Sulphate	SO_4	mg/l	1000
	Phosphorous	P	mg/l	50
	Cyanide	CN	mg/l	5
	Sulphide	S	mg/l	1
	Hydrogen Sulphide	H_2S	mg/l	1
	Iron	Fe	mg/l	50
	Chloride	Cl	mg/l	600
	Fluoride	F	mg/l	8

SN	Item	Code	Unit	Permissible Limit in Yemen
	Arsenic	As	mg/l	0.1
	Tin	Sn	mg/l	10
	Barium	Ba	mg/l	3
	Boron	B	mg/l	5
	Cadmium	Cd	mg/l	1
	Chromium	Cr	mg/l	5
	Copper	Cu	mg/l	5
	Lead	Pb	mg/l	0.6
	Mercury	Hg	mg/l	0.01
	Nickel	Ni	mg/l	5
	Selenium	Se	mg/l	1
	Silver	Ag	mg/l	1
	Manganese	Mn	mg/l	10
	Beryllium	Be	mg/l	5
	Zinc	Zn	mg/l	10
	Ammonium Hydroxide	NH_3OH	mg/l	0.5
	Phosphorous Pentoxide	P_2O_5	mg/l	5

World Bank guideline values for wastewater discharge are:
pH : 6-9
TSS : 50 mg/l
Oil & grease : 10 mg/l
TSS : 50 mg/l
Residual chlorine : 0.2 mg/l

Table-2.5 Maximum Allowable Concentration in Treated Effluent for Irrigational Use

SN	Item	Code	Unit	Permissible Limit	
				Yemen-EPA	FAO
1.	Biochemical Oxygen Demand	BOD	mg/l	150	-
2.	Chemical Oxygen Demand	COD	mg/l	500	-
3.	Dissolved Oxygen	O_2	mg/l	2	-
4.	Sodium	Na	mg/l	200	900
5.	Phosphate	PO_4	mg/l	30	-
6.	Aluminium	Al	mg/l	5	5
7.	Arsenic	As	mg/l	0.1	0.1
8.	Beryllium	Be	mg/l	0.1	0.1
9.	Cadmium	Cd	mg/l	0.01	0.01
10.	Cobalt	Co	mg/l	0.05	0.05
11.	Chromium	Cr	mg/l	0.1	0.1
12.	Copper	Cu	mg/l	0.2	0.2
13.	Fluoride	F	mg/l	1	1
14.	Iron	Fe	mg/l	5	5
15.	Lithium	Li	mg/l	2.5	2.5

SN	Item	Code	Unit	Permissible Limit	
				Yemen-EPA	FAO
16.	Manganese	Mn	mg/l	0.2	0.2
17.	Molybdenum	Mo	mg/l	0.01	0.01
18.	Nickel	Ni	mg/l	0.2	0.2
19.	Lead	Pb	mg/l	5	5
20.	Selenium	Se	mg/l	0.03	0.02
21.	Vanadium	V	mg/l	0.1	0.1
22.	Zinc	Zn	mg/l	2	2
23.	Mercury	Hg	mg/l	0.005	-
24.	Cyanide	CN	mg/l	0.1	-

Table-2.6 Microbiological Quality Guidelines of Yemen-EPA for Wastewater Use in Agriculture

SN	Re-use Conditions	Intestinal Nematodes (Arithmetic mean of no. of eggs per 1 liter)	Fecal Coliforms (Geometric mean of no. per 100 ml)
1	Irrigation of crops likely to be eaten uncooked	≤ 1	≤ 1000
2	Irrigation of sports fields, public parks & garden with which the public may come into direct contact	≤ 1	≤ 200
3	Irrigation of cereal crops, industrial crops, fodder crops, pasture & trees	≤ 1	-
4	Irrigation of fruit trees (irrigation should cease 2 weeks before fruit is picked up and no fruit should be picked off the ground)	≤ 1	-

Table-2.7 Microbiological Quality Guidelines of WHO (1989)[a] for Wastewater Use in Agriculture

Cate-gory	Re-use Conditions	Exposed Groups	Intestinal Nematodes (AM of no. of eggs per 100 ml)[b]	Fecal Coliforms (GM of no. per 100 ml)[c]	Wastewater treatment expected to achieve the required micro-biological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks [d]	Workers, consumers, public	< 1	< 1000	A series of stabilization ponds designed to achieve the micro-biological quality indicated or equivalent
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture & trees [e]	Workers	< 1	No standard	Retention in stabilization ponds for 8-10 days or equivalent helminth and fecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not Applicable	Not Applicable	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation

AM- Arithmetic Mean, GM- Geometric Mean

2.5.5 Irrigation Water Quality Standards

Table-2.8 Maximum Allowable Concentration in Irrigational Water

SN	Potential	Unit	Permissible Limit as per Yemen- EPA	FAO Standard (in Degree of Restriction on Use)		
				None	Slight to Moderate	Severe
1	Salinity affecting crop water availability:					
	EC_w	mmho/cm	0.7-2	< 0.7	0.7-3	> 3
	TDS	Mg/l	450-2500	< 450	450-2000	> 2000
2	Information (affects infiltration rate of water into the soil):					
	SAR = 0-3 EC_w =	mmho/cm	0.7-0.2	< 0.7	0.7-0.2	> 0.2
	SAR = 3-6 EC_w =	mmho/cm	1.2-0.3	< 1.2	1.2-0.3	> 0.3
	SAR = 6-12 EC_w =	mmho/cm	1.9-0.5	< 1.9	1.9-0.5	> 0.5
	SAR = 12-20 EC_w =	mmho/cm	2.9-1.3	< 2.9	2.9-1.3	> 1.3
	SAR = 20-40 EC_w =	mmho/cm	-	< 5	5-2.9	> 2.9
3	Specific ion toxicity (affects sensitive crops):					
	Sodium (Na):					
	Surface irrigation	SAR	≤ 9	< 3	3-9	> 3
	Sprinkler irrigation	me/l	≤ 2	< 3	> 3	
	Chloride (Cl):					
	Surface irrigation	SAR	≤ 10	< 4	4-10	> 10
	Sprinkler irrigation	me/l	≤ 2	< 3	> 3	
	Boron (B)	mg/l	≤ 2	< 0.7	0.7-3	> 3
4	Miscellaneous effects (affects susceptible crops):					
	Nitrogen (NO_3-N)	mg/l	≤ 20	< 5	5-30	> 30
	Bicarbonate (HCO_3)	me/l	≤ 5.8	< 1.5	1.5-8.5	> 8.5
	pH	-	6.5-8.4	Normal	6.5-8.4	6.5-8.4

2.5.6 Drinking Water Quality Standards

Table-2.9 Standards for Quality of Drinking Water

SN	Item	Code	Unit	Limit in Yemen		WHO Standards
				Desirable	Permissible	
	Physical Parameters:					
1.	Taste		-	Acceptable to people		Should be acceptable
2.	Odor		-	Acceptable to people		Should be acceptable
3.	Color		Pt-Co	15	15	15 TCU
4.	Turbidity		NTU	1	5	Median 5 ≤1 Single ≤5
5.	Temperature		C	8-25	25	-
6.	Hydrogen Ion Concentration	pH	-	6.5-8.5	5.5-9	-
7.	Electrical Conductivity	EC	µmhos/cm	450-1000	2500	-
	Chemical Parameters:					

SN	Item	Code	Unit	Limit in Yemen		WHO Standards
				Desirable	Permissible	
1.	Total Dissolved Solids	TDS	mg/l	650	1500	-
2.	Bicarbonate	HCO_3		150	500	-
3.	Chloride	Cl		200	600	250
4.	Sulphate	SO_4		200	600	-
5.	Fluoride	F		0.5	1.5	1.5
6.	Calcium	Ca		75	200	-
7.	Magnesium	Mg		30		-
8.	Barium	Ba		0.1	0.15	0.7
9.	Sodium	Na		200	400	-
10.	Potassium	K		12	12	-
11.	Nitrate	NO_3		45	50	50
12.	Iron	Fe		0.3	1	0.3
13.	Manganese	Mn		0.1	0.2	0.1
14.	Copper	Cu		1	1.5	1
15.	Zinc	Zn		5	15	-
16.	Silver	Ag		0.01	0.02	-
17.	Aluminium	Al		0.2	0.3	0.2
18.	Nickel	Ni		0.05	0.1	0.02
19.	Boron	B		0.5	1	0.3
	Organic Compounds:					-
1.	Endrin			0.0002		-
2.	Methoxine			0.1		-
3.	Toxaphene			0.002		-
	Toxic Elements:					
1.	Lead	Pb		0.05		0.01
2.	Selenium	Se		0.01		0.01
3.	Arsenic	As		0.05		0.01
4.	Chromium	Cr		0.05		0.05
5.	Cyanide	CN		0.1		0.07
6.	Cadmium	Cd		0.005		0.003
7.	Mercury	Hg		0.001		0.001
8.	Antimony	Sb		0.01		0.005
	Chemical Pollutants:					
1.	Ammonium Hydroxide	NH_3OH		0.5		1.5
2.	Phosphorous Pentoxide	P_2O_5		5		-
3.	Silicon Dioxide	SiO_2		40		-
4.	Biochemical Oxygen Demand	BOD_5		NA		-
5.	Chemical Oxygen Demand	COD		3		-

SN	Item	Code	Unit	Limit in Yemen		WHO Standards
				Desirable	Permissible	
	Radioactive Elements:					
1.	Alpha emitters		pCi/l	0.1		0.1 µg/l
2.	Beta emitters		pCi/l	1		1 µg/l
	Viruses:					
1.	Coliforms		No./100 ml	Nil		-
2.	Fecal Coliforms		No./100 ml	Nil		-

Table-2.10 Maximum Allowable Concentration in Bottled Water in Yemen

SN	Item	Code	Unit	Permissible Limit
1.	Hydrogen Ion Concentration	pH		7.5
2.	Bicarbonate	HCO_3	mg/l	207-240
3.	Sodium	Na	mg/l	42-90
4.	Potassium	K	mg/l	1.7-4.5
5.	Calcium	Ca	mg/l	24-64.6
6.	Magnesium	Mg	mg/l	1.02-17.93
7.	Iron	Fe	mg/l	0.1-0.9
8.			mg/l	33
9.	Nitrate	NO_3	mg/l	7.8
10.			mg/l	27.2-55

2.6 WORLD BANK GUIDELINES FOR THERMAL POWER PLANTS

The World Bank guidelines on thermal power plants i.e. "Excerpt of Thermal Power Plant Guidelines for New Plants" are attached in **Annex-1**. The salient features of the guidelines are summarized below.

Air Emissions:

Table-2.11 World Bank Guideline for Emissions from Thermal Power Plants

PM emissions	□ 50 mg/Nm^3 for all plants
SO_2 emissions	< 0.2 metric tons per day (tpd) per MW of capacity for the first 500 MW plus 0.1 tpd for each additional MW capacity over 500 MW. As well, the conc. of SO_2 in flue gases: □ 2,000 mg/Nm^3, with a maximum level of 500 tpd.
NOx emissions	750 mg/Nm^3 (or 260 ng/J or 365 ppm for a coal fired power plant, 460 mg/Nm^3 (or 130 ng/J or 225 ppm for an oil fired power plant, 320 mg/Nm^3 (or 86 ng/J or 155 ppm for a gas fired power plant.

Liquid Effluents:

The following effluent levels (for applicable parameters) should be achieved daily without dilution.

Table-2.12 World Bank Guideline for Liquid Effluents from Thermal Power Plants

Parameter	**Maximum value (mg/l)**
pH	6-9
Total suspended solids	50
Oil and grease	10
Chromium (total)	0.5
Copper	0.5
Iron	1.0
Zinc	1.0
Temperature increase at the edge of the mixing zone	□ 3°C

Ambient Noise:

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Table-2.13 World Bank Guideline for Ambient Noise for Thermal Power Plants

Receptor	**Maximum Allowable Leq (hourly), in dB(A)**	
	Daytime (07:00-22:00)	**Nighttime (22:00-07:00)**
Residential, institutional, educational	55	45

Industrial, commercial	70	70

3.0 PROJECT DESCRIPTION

3.1 PROJECT SUB-COMPONENTS

The project has three sub-components- Generation, Transmission and Distribution. However, the EIA study covers only two sub-components viz. Generation and Transmission which are detailed below.

3.1.1 Generation Sub-component

This sub-component is planned for expansion of existing Al-Hiswa oil-fired steam power station (5x25 MW) at Aden region. There are 5 steam turbines of 25 MW capacity each and 6 boilers of 160 tones/hour capacity each. Another 60 MW turbo-generator is under construction. The proposed expansion will consist of:

(1) Supply and installation of one new boiler of 160 tones/hour capacity (7^{th} boiler) in Al-Hiswa steam power station in Aden region for strengthening and augmenting the system and to increase the power station reliability.

3.1.2 Transmission Sub-component

This sub-component is planned for new transmission lines, new substations and expansion of existing substations related to two Bulk Supply Point (BSP) substations at Al-Hodeidah and Dhamar. The augmentation of the transmission facilities of Al-Hodeidah and Dhamar area will consist of:

Substations:

(1) 132 KV new substation at Kilo 16 in Al-Hodeidah (with 1 no. 132/33 KV, 60 MVA & 1 no. 33/11 KV, 20 MVA transformers, and a 50 MVAR compensation plant).
(2) Expansion of Al-Hali existing 132/33 KV BSP (Bulk Supply Point) substation in Al-Hodeidah by installing a new interlinking single bus-bar 132 KV substation in the vacant land within the boundary of the existing substation.
(3) Extension of existing Dhamar 132 KV substation (in the vacant land within the boundary of the Dhamar substation) to link the proposed 132 KV double circuit transmission line from Dhamar to Hizyaz (Sana'a).
(4) 132 KV new substation at Yarim (with 2 nos. 132/33 KV, 45 MVA and 1 no. 33/11 KV, 20 MVA transformers) by tapping the existing 132 KV double circuit transmission lines between Dhamar and Ibb on Dhamar to Taiz transmission route.

Transmission Lines:

(1) 12 km 132 KV double circuit new transmission line in Al-Hodeidah region from Al-Hali to Kilo 16 (i.e. from proposed interlinking single bus-bar 132 KV substation at Al-Hali to proposed 132 KV substation at Kilo 16).

(2) 90 km 132 KV double conductor double circuit new transmission line from Dhamar to Hizyaz in Sana'a (i.e from existing 132 KV BSP substation at Dhamar to proposed 132 KV Hizyaz substation. Hizyaz substation is proposed under the Marib transmission line project). Marib is located at a distance of 180km from Sana'a and a Gas Power Project is going to be implemented at Marib by PEC.

3.2 EXPANSION OF AL-HISWA POWER STATION

The Al-Hiswa power station is located 10 km north-west of centre of Aden City. The power station site is bounded by Aden to Little Aden road in the north, Gulf of Aden in the south and vacant lands on other sides. The area on the northern side is called Madinath Ashsha'b. Location of the power station is shown in the map in **Figure-3.2.1**.

Figure-3.2.1 Location of Al-Hiswa Power Station

3.2.1 Project Highlights

Location	Al-Hiswa in Aden region (about 10 km north-west of Aden city)
Capacity	5 x 25 MW (existing) + 60 MW generator under construction
Existing main	Boilers : 6 nos. 160 t/h each (oil fired)

units	Generators : 5 nos. 25 MW each existing + 1 no. 60 MW under construction Desalination plant for production of DM water
Proposed units	Boilers : 1 no. 160 t/h (dual firing- oil and gas) & 1 no. associated stack.
Fuel system	Heavy fuel oil for the existing oil fired boilers is taken from the Aden Refinery Company (ARC) through pipeline.
Cooling system	Once through cooling system. Cooling water is taken from the sea & the return cooling water is discharged into the sea through channel.
Pollution control	Sewage is treated in the Sewage Treatment Plant & the oily plant wastewater is treated in the Oil Water Separator, and the combined treated effluent is discharged into the sea through the cooling water discharge channel. Flue gas of boilers is emitted into the atmosphere through 3 nos. 80 m tall stacks.
Land requirement	Proposed boiler will be installed within the existing plant premises and no additional land is to be acquired.

3.2.2 Process Description

Existing Al-Hiswa oil-fired steam power station (5x25 MW) at Aden region was commissioned in 1985 with Russian technology. The generating units consist of 6 nos. of boilers of 160 t/h capacity each and 5 nos. of steam turbo-generators of 25 MW capacity each with accessories, transformer and other complementary parts. There are 3 stacks of 80 m height each one is connected to two boilers. The view of the power station is depicted in **Figure-3.2.2**.

Figure-3.2.2 Al-Hiswa Power Station

The plant structures include boiler house, turbine building, storage tanks, pump houses, desalination plant, administrative building, workshops, training center etc.

The desalination plant (**Figure-3.2.3**) which is a part of the power plant complex has 3

Figure-3.2.3 Desalination Plant

Figure-3.2.4 Fuel Oil Storage Tanks

Figure-3.2.5 Boiler, ID Fan & Connection to Stack

desalination units that produce de-mineralized (DM) water from sea water for boiler make-up.

The fuel oil is transported from the Aden Refinery Company (ARC) through the 9 km long pipelines. The fuel oil from the fuel oil storage tanks (3 nos. as shown in **Figure-3.2.4**) is fed to the boiler furnace through oil pumps with the help of heated air driven by forced draught (FD) fans which provide additional controllable air to the burners to assist desirable combustion. This combustion produces flue gas that passes through the chimneys/stacks with the help of induced draught (ID) fans (**Figure-3.2.5**).

The heat released by the burning fuel oil is absorbed by the de-mineralized boiler feed water passing through the boiler wall tubing to produce high-pressure steam. The steam then is discharged onto the turbine blades, which makes the turbine to rotate. The generators coupled to the turbines also rotate and produce electricity. The 10.5 KV electricity so generated is stepped up to 33 KV through step-up transformers, for evacuation of power.

Meanwhile, the steam that has exhausted its energy is converted back to water in the condenser and reused in the boiler. The condenser is cooled down through a once through sea water system. The sea water is pumped to the condenser through 5 nos. of intake pumps installed at the sea water intake pump house (**Figure-3.2.6**) located in the intake channel coming from the sea and the return cooling water is discharged to the sea through the cooling water discharge channel.

Figure-3.2.6 Cooling Water Intake Pump House

Adequate plantation and landscaping along the road and in open space of the plant is blending the functional requirements and aesthetics (**Figure-3.2.7 and Figure-3.2.8**).

Figure-3.2.7 Roadside Plantation inside the Power Plant

Figure-3.2.8 Landscaping near Training Center inside the Power

The simplified process flow diagram of the power station is depicted in **Figure-3.2.9**.

3.2.3 Salient Details

Main units:

- Boilers, 6 nos. x 160 t/h each (Design pressure 100 bars & temperature 535-540°C). Boiler 1 & 3 has been rehabilitated, 2, 4, 5 & 6 tendered for rehabilitation.
- 5 turbines (3000 rpm) & 5 generators of 25 MW each
- 3 stacks of 80 m height & 3.6 m internal diameter at top (stacks 1 is connected to boilers 1 &2, stack 2 to boilers 3 & 4, and stack 3 to boilers 5 & 6).
- ID fan (capacity 265000 m^3/h, 320 KW, 1480 rpm & outlet pressure 2434 Pa) for each boiler

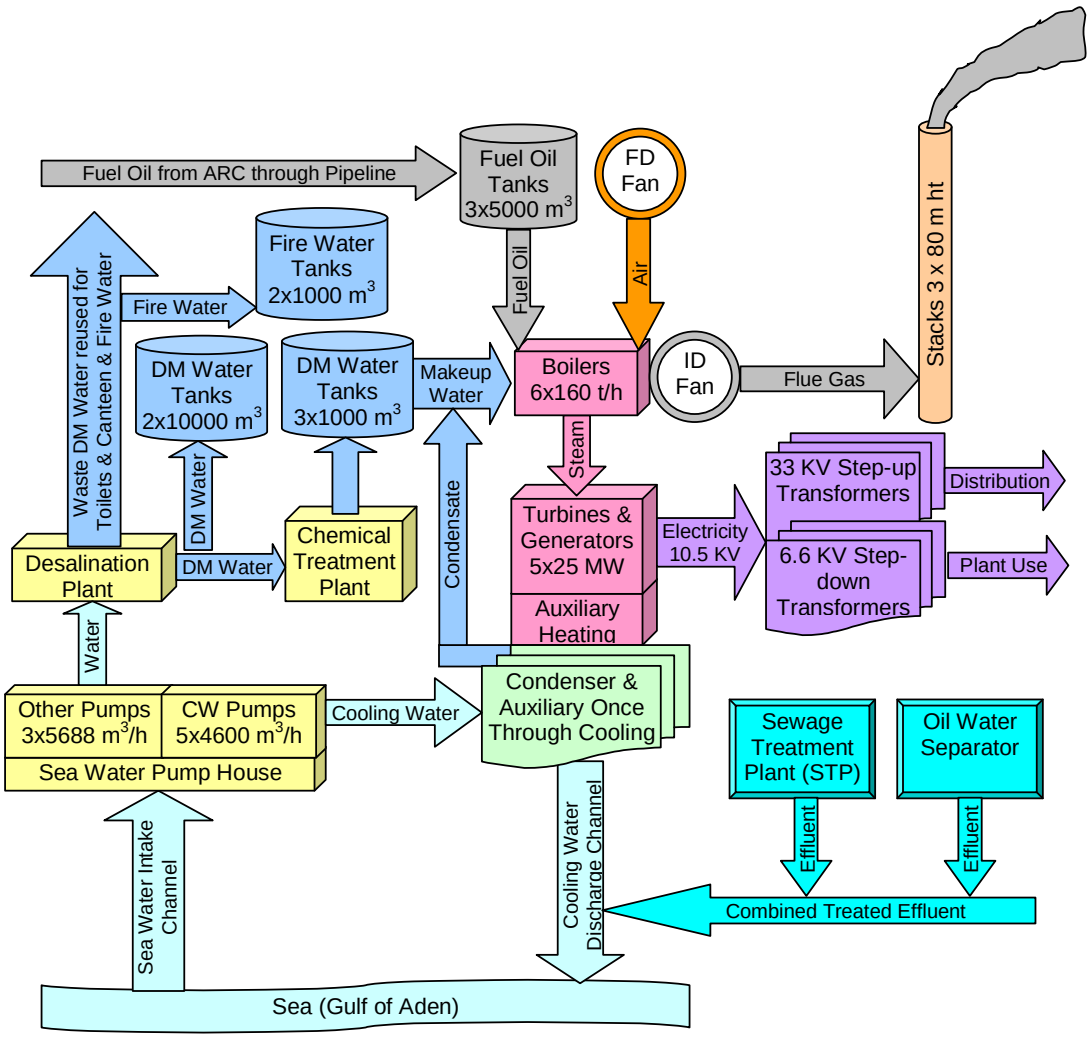


Figure-3.2.9 Simplified Process Flow Diagram of Al-Hiswa Power Station

Fuel system:

- Fuel oil from the Aden Refinery Company (ARC) through 2 pipelines (about 9 km long & 319 mm dia)
- Fuel oil storage tanks, 3 nos. x 5000 m^3 each (one running, one reserve & other for filling). A tank can store about 3 day's requirement. Fuel oil is feed to the tanks in a single batch of 3000 tons.
- Fuel consumption 10.5 t/h for a single boiler of 160 t/h capacity

- Fuel oil pump house (4 nos. x 45 m^3/h pumps in 1st stage, 4 nos. x 30 m^3/h pumps in 2nd stage)
- Fuel oil heaters, 3 nos.

Cooling system:

- Sea water channel
- Sea/cooling water pump house with 5 nos. x 4600 m^3/h pumps
- Chlorination plant (producing chlorine solution 40 kg/h from 50 m^3/h sea water)
- Cooling water discharge channel for discharge of return cooling water into the sea (**Figure-3.2.10**)

Figure-3.2.10 Cooling Water Discharge into Sea through

Water system:

- Chemical treatment plant for DM water
- Boiler makeup water storage tanks, 3 nos. x 1000 m^3 each
- Boiler makeup water requirement 12.5 t/h for each boiler (1800 t/day for power station)

Desalination plant complex:

- Sea water pumps 3 nos. x 5688 m^3/h within the cooling water pump house
- Desalination plant, 3 units x 14000 m^3/day (about 580 t/h) capacity
- Distilled water storage tanks in DC plant, 2 nos. x 10000 m^3 each
- Steam (13 bars, 250°C) from turbines for evaporation of sea water in desalination plant. Steam consumption 85 t/h and sea water consumption 6300 m^3/h.

Figure-3.2.11 Sewage Treatment Plant

Waste treatment & reuse system:

- Sewage treatment plant (with subsurface bubble type aeration) (**Figure-3.2.11**)
- Oil water separator
- Separated oil is pumped back to the storage tanks for reuse
- Reuse of waste DM water for toilets & canteen and for gardening

Fire fighting system:

- Fire water tanks, 2 nos. x 1000 m^3 each
- Fire water pumps, 2 nos. x 6.6 KV
- Fire water source: waste/unsuitable DM water form desalination plant
- Fire fighting tenders, 3 nos (**Figure-3.2.12**).
- Fire fighting supervisor & 5 to 6 fire fighting crews in each shift
- Foam system near fuel oil tanks & pump house

Figure-3.2.12 Fire Fighting Tenders inside the Power Station

- Flame detection system in oil storage & pumping area
- Smoke detection in underground cable channel
- Central control from the Control Room
- Fire hydrants (roadside hydrants 15 in plant area & 7 in DC plant in addition to hydrants within the plant buildings
- Fire extinguishers (CO_2, foam & powder type)

Working hours & number of workers:

- Operation in 3 shifts (1st shift 0060-1400 hrs, 2nd shift 1400-2200 hrs and 3rd shift 2200-0600 hrs, General shift 0700-1400 hrs with 1500-1800 overtime)
- About 572 workers (40 persons per shift x 4 shifts + 200 for maintenance of power plant + 100 for maintenance for DC plant + 112 others)

Power evacuation & transmission system:

- 5 nos. of step-up (33 kV) transformers for evacuation of power & 5 nos. step-down (6.6 kV) transformers (4 in the direct line + 1 standby in the network) for supply of power to plant auxiliaries inside the power station.

Expansion under progress:

- New generation unit under construction: 60 MW (commissioning target in March 2006) (**Figure-3.2.13**)

Figure-3.2.13 New 6th Generator under Construction

Expansion proposed:

- Proposed 7th boiler of 160 t/h (under this Power Sector Project)
- Proposal for 3 x 50 t/h evaporators for DM water requirement of about 1500 t/day

3.2.4 Features of the Proposed Project

Specifications of the Proposed New Boiler:

- Maximum continuous rating of steam : 160 t/h
- Maximum pressure at outlet : 100 bars
- Maximum temperature at outlet : 540°C
- Max. temp. of feed water at Economizer inlet : 215°C
- Outdoor unit
- Natural circulation
- Water tube pressurized furnace
- Fuel firing 100% residual or light fuel oil
- Two safety air heater
- Regenerative air heater
- Steam air pre heater
- Burners
  - Fuel oil type : heavy fuel oil
  - Fuel oil pressure : 40 kgf/m^2
  - fuel oil temperature : 140°C
- Fuel oil atomizer:
  - type : steam mechanic atomizer
  - capacity : 2.4-3.4 t/h

The power station was commissioned in 1985, i.e. about 20 years back and is of an old Russian design with obsolete control & instrumentation (C&I) system. From the World Bank report (August 2002) titled "Assessment of Gas to Power Development Options in Yemen" it is noted that overall efficiency of the power plant from 1986 to 2001 varied between 20.4% and 30.9% with average value of 25.4% which is comparatively less than modern steam power plants with oil fired boilers. The proposed 7th boiler of 160 t/h capacity will be of latest technology which will definitely improve the overall efficiency of the plant.

Based on the recent research project conducted by Dr. Herbert M. Eckerlin of North Carolina State University, on a total of 67 boiler installations, it can be found that at present the global trend of boiler efficiency is about 85% (based on stack loss) (**Figure-3.2.14**).

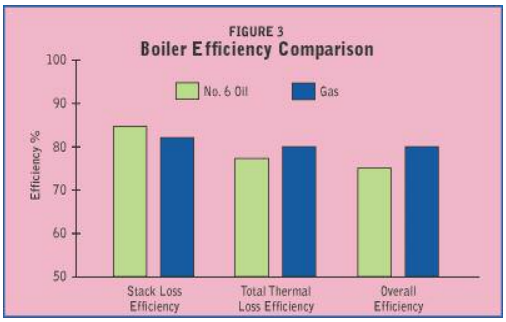


Figure-3.2.14 Boiler Efficiency Comparison between Recent Oil & Gas Fired Boilers

Therefore, for this project it has been assumed that the efficiency of the proposed 7th boiler will be about 85% and its fuel oil consumption rate will be about 7 t/h. And its SO_2 emission rate will be 0.16 tpd per MW which is within the World Bank guideline of 0.2 tpd per MW. Moreover, the new boiler should be of dual firing system (fuel oil as well as natural gas).

3.3 SUBSTATIONS & TRANSMISSION LINES

The existing and proposed substations, transmission lines & power plants in the Western Yemen are shown in **Figure-3.3.1**. There are three existing power stations: Al-Hiswa (5 x 25 MW) in Aden region, Al-Makha (4 x 40 MW) in Al-Makha region and Ras Katenib (5 x 30 MW) in Al-Hodeidah region. The fourth power station (Gas based 300 MW in Stage-I under construction) is proposed in Marib region that will be connected to Sana'a through the proposed 400 KV transmission line between proposed Marib substation & proposed Bani Hushish substation and then through proposed 132 KV transmission lines between proposed Bani Hushish, Dahban & Hizyaz substations near Sana'a, the lines & substations are proposed under the Marib project. The line diagram for substations & transmission lines is shown in **Drawing No. 3.1**.

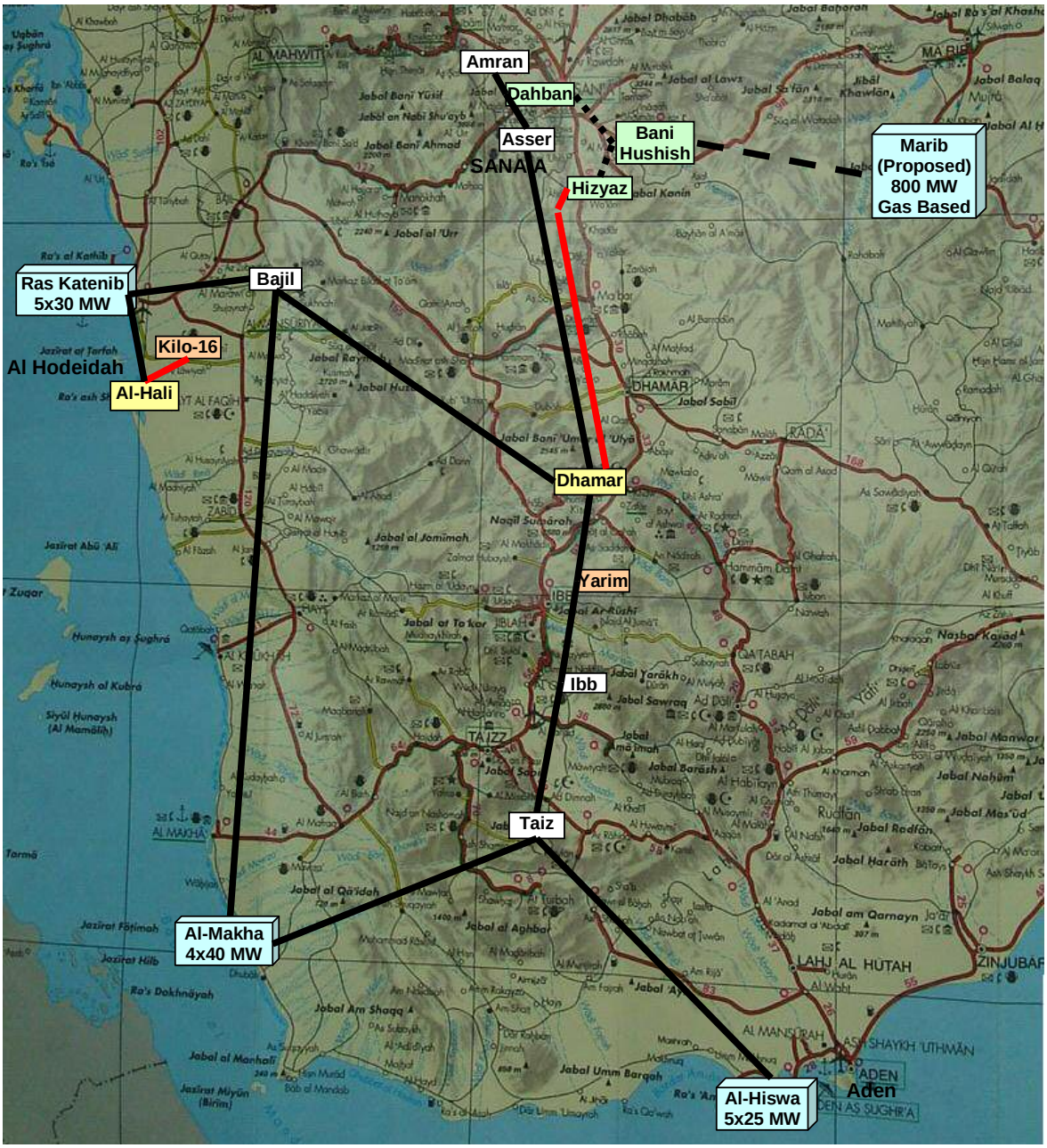
3.3.1 Substations

3.3.1.1 Expansion of Al-Hodeidah Substation

Al-Hali substation (**Figure-3.3.2**) is a 132/33 KV Bulk Supply Point (BSP) substation located in Al-Hodeidah and is at present inter connected to Ras Ketenib power station and 132 KV substation through a 28 km long 132 KV double circuit transmission line. The 33 KV load demand has gone up to 78 MW 70 MVAR (totaling 105 MVA), whereas existing 132/33 KV transformer capacity is only 2x60

Figure-3.3.2 Existing 132 KV Al-Hali Substation

MVA. Further, 33 KV load in the area is increasing due to commercial development.



Existing Substation
Expansion of Existing Substation (under Power Sector Project)
New Substation (under Power Sector Project)
Proposed Substation under Marib Project
Power Plant
132 KV Existing Transmission Line
132 KV Proposed Transmission Line (under Power Sector Project)
132 KV Proposed Transmission Line
400 KV Proposed Transmission Line

Figure-3.3.1 Power Plants, Transmission Lines & Substations in Western

Existing substation has enough land for an interlinking substation and no additional land acquisition is required. Therefore, PEC proposal calls for creation of a new 132 KV substation at Kilo 16, installation of a new interlinking single Bus-Bar 132 KV substation at Al-Hali in the vacant land **(Figure-3.3.3)** within the existing boundary of the substation and feeding the new Kilo 16 substation from Al-Hali through a 12 km long 132 KV transmission line.

Figure-3.3.3 Space for Expansion of 132 KV Al-Hali Substation

3.3.1.2 New Substation at Kilo-16

Kilo 16 is located in Al-Hodeidah about 8 km east of the existing Al-Hali substation. At Kilo 16 a new 132 KV substation is proposed under this project. The proposed substation will have 1 no. 132/33 KV, 60 MVA transformer, 1 no. 33/11 KV, 20 MVA transformer and a 50 MVAR compensation plant. The proposed site (**Figure-3.3.4**) for the new Kilo 16 substation is a piece of

Figure-1 Plant Water System & Water Balance Diagram

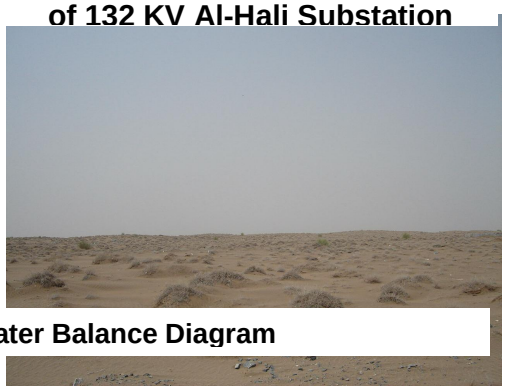


Figure-3.3.4 Site for New 132 KV Kilo 16 Substation

About 36 MW of 33 KV load fed from Hodeidh BSP station (Kornish, Maraweah & Kilo 4 feeders) will be transferred to the new Kilo 16 substation resulting in improved performance by avoiding poor voltage & high system loss.

3.3.1.3 Expansion of Dhamar Substation

Figure-3.3.5 Existing 132 KV Dhamar Substation

The Dhamar town is located about 100 km south of Sana'a. Existing Dhamar substation (**Figure-3.3.5**) is a 132/33 KV Bulk Supply Point (BSP) grid substation located south of Dmamar town and is at present connected to Al-Hiswa and Al-Makha power stations through Taiz 132 KV substation through 132 KV transmission lines from Al-Hiswa to Taiz, from Al-Makha to Taiz and then Taiz to Dhamar.

Figure-3.3.6 Space for Expansion of 132 KV Dhamar Substation

The Dhamar substation is proposed to be augmented by PEC under this project. Necessary extension will be done in the vacant land (**Figure-3.3.6**) within the existing boundary of the substation to link the proposed 132 KV double circuit transmission line from Dhamar to Hizyaz (Sana'a).

3.3.1.4 New Substation at Yarim

The Yarim town is located about 36 km south of Dhamar. At present the electricity demand of Yarim is met through the 33/11 KV transmission lines from Dhamar substation. A 132 KV new substation is proposed at Yarim under this project by tapping the existing 132 KV double circuit transmission lines between Dhamar and Ibb on Dhamar to Taiz transmission route. The proposed substation will have 2 nos. 132/33 KV, 45 MVA transformers and 1 no. 33/11 KV, 20 MVA transformer. The new Yarim substation will relieve the overloading of Dhamar substation. The proposed site (**Figure-3.3.7**) for the new Yarim substation is a piece of vacant & barren land and has no vegetation. The site is located east of the Yarim town.

Figure-3.3.7 Site for New 132 KV Yarim Substation

3.3.2 Transmission Lines

3.3.2.1 New Transmission Line from Hodeidah to Kilo-16

Under this project PEC proposed a 12 km long 132 KV single conductor double circuit new transmission line in Al-Hodeidah region from Al-Hali to Kilo 16 (i.e. from proposed interlinking single bus-bar 132 KV substation at Al-Hali to proposed 132 KV substation at Kilo 16).

3.3.2.2 New Transmission Line from Dhamar to Sana'a

A new 90 km long 132 KV single conductor double circuit new transmission line is proposed from Dhamar to Hizyaz in Sana'a (i.e from existing 132 KV BSP substation at Dhamar to proposed 132 KV Hizyaz

Figure-3.3.8 Existing 132 KV Dhamar-Sana'a Transmission

substation. Hizyaz substation is proposed under the Marib transmission line project).

The new line will run parallel and on the right side of the existing 132 KV transmission line (**Figure-3.3.8**) from Dhamar to Asser (in Sana'a).

3.3.3 Specifications for New Transmission Lines

Detail specifications of the transmission lines will be prepared by the Project Consultant after the job is awarded. Therefore for assessment of impacts relevant ***International Standards for Height, Distance from Habitation (Clearances) & Livestock for 132 KV Transmission Lines*** has been considered (**Figure-3.3.9**) along with some specifications available with PEC for the existing lines.

The definitions of various terms related to clearances for transmissions lines are:

O = Phase offset (or arm length)
H = Horizontal conductor swing
S1 = Clearance from building
R = O+H+S1 = ½ of ROW
2R = Minimum Right of Way (ROW)

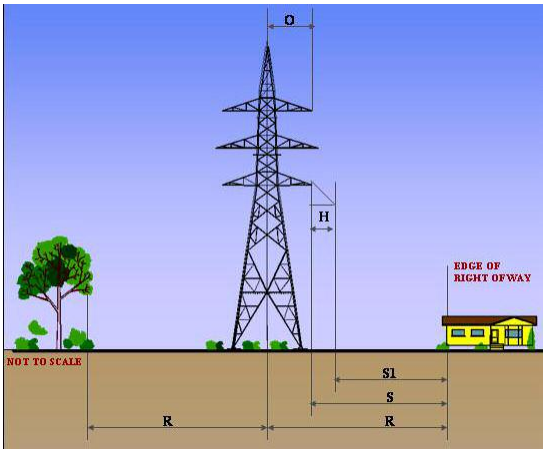


Figure-3.3.9 Clearances for a Typical Transmission Line

Following the International Standard like DIN VDE 0210 (Planning and Design of Overhead Power Lines), the minimum clearance of 132 KV overhead line conductor (at the point of support to the tower) to ground shall be 15.5 m and between conductor and the closest part of the residential and other buildings shall be:

- Building with roof having slope greater than 15°: 3.1 m
- Building with flat roof or roof having slope less than 15°: 5.1 m
- Road crossing: 5.1 m above the top of the highest vehicle

The high wind velocity and high seismicity of the region shall be dully considered for the design of transmission line towers. For 132 KV double circuit transmission line, the right-of-way (ROW) considering the above factors shall be 30 m.

Based on the above International Standard, typical specifications for the new transmission lines and towers as given in **Table-3.3.1** have been assumed as a guideline for this EIA Study.

Table-3.3.1 Typical Specifications for the New Transmission Lines

Type of Tower	132 KV, Double Circuit
Material of Construction	Galvanized Steel Sections
Height of Tower	32.5 m (max.)
Base Area	7.2 m x 7.2 m (max.)
Distance between Towers	150 m – 200 m
Type of Conductor	ACSR ZEBRA
Arm Length for Conductor	4.8 m

Lateral Swing of Conductor	5.25 m
Maximum Conductor Sag	7.5 m
Minimum Clearance of Conductor from Building	5.1 m
Right-of-Way (ROW)*	30 m

*Right-of-Way shall vary depending on line design specification

Other international standards like IEC (International Electricity Commission) can be used for design of the new transmission lines.

4.0 ENVIRONMENTAL AUDIT AND BASELINE ENVIRONMENTAL SCENARIO

4.1 ENVIRONMENTAL AUDIT OF AL-HISWA POWER STATION

4.1.1 Introduction and Background

As per the World Bank Policy, environmental audits are needed to examine the environmental conditions and determine the need for cleanup and other remediation measures at existing power facility. The environmental audits are an important part of baseline information used in the environmental assessments. Environmental audits help to reduce environmental and public health risks and assist in improving environmental management and output efficiency of the plant. It will also serve as a source of baseline information for an environmental assessment study whenever a rehabilitation or expansion is planned. In line with the requirements and objective of study, the present chapter deals with the environmental audit findings conducted at existing power plant of 5x 25 MW capacity located in Madinath Ashsha'b village near AL-Hiswa in sub-urban area of Aden Governorate. Tools adopted for the environmental audit are:

- Meeting & interview with plant personnel
- Review of existing documentation and data records
- Process understanding, site inspections and environmental monitoring.

Document reviews and physical examination of storage areas, treatment plants and other units are used both to gather information about environmental performance and to verify information received or findings noted. The following background information is important to note before discussing the findings of environmental audit:

- No environmental audit study has been conducted for the plant since its commissioning in 1985.
- Monitoring of environmental parameters has not been carried out during its operation and hence there is no data record and baseline information of the environmental parameters available in the plant.
- There is no facility in the existing stacks for monitoring the flue gas parameters.
- There is no facility for measuring wastewater flow from respective treatment units.
- Power Plant has limited information about actual levels of discharges and other aspects of its environmental performances.
- There is no audit criteria and guideline existing in Republic of Yemen except the standards for treated sewage water and disposal water for agriculture purpose. In absence of suitable national or local environmental standards, World Bank audit

guideline and specific guidance on industrial pollution prevention and abatement for thermal power plant have been mainly adopted as environment audit criteria.

With the above limitations, a detailed checklist of input information to get the required results was prepared and accordingly information was collected and verified with the experienced plant personnel. Where ever possible, primary data have been generated by monitoring the environmental parameters using standard practices. Where ever not possible, best professional judgment, experience of concerned plant personnel and secondary relevant plant data has been utilized to arrive at the required information judiciously. The following sections describe the findings of environment audit.

4.1.2 Project Location and Layout

The Al-Hiswa power station site is located at Bander Tawahi Bay shore of the Aden Bay, at about 300 m away from the shore line (**Figure-3.2.1**). The Tawahi Bay juts into the low lying shore of the southern extremity of the Arabian Peninsula and is a part of the Aden Bay. At the Aden Bay, it is covered south-eastward and south-westward by two mountainous formations with a wide (about 6 km) entrance to the Bay in between. The Bay bed is strongly flattened out towards the low-lying shore and is of a round shape resembling the shore outline. The sea depth at the entrance to the Bay 12 km off the shore is 10 m and 4 m at the distance of 1 km off the shore (at low tide).

The plant premises are confined by Tawahi Bay towards south and main bituminous road connecting Greater Aden and Little Aden towards north. The plant site can be approached from Greater Aden through this bituminous road covering about 15 km distance. Before commissioning of this plant in 1985, the area was remote and under developed. During construction period, a camp site was constructed just opposite to plant site on the other side of road for constructional personnel. Since then, the area has attracted a lot of residential buildings on the other side of the road where most of the plant personnel reside presently. The plant opposite side of the road has a lot of potential for further development and many residential plots have already been allotted. The inhabited area of opposite side of plant is about 1 km by 1 km presently. The land towards East and West of plant premises on the sea side (on the plant side of the road) is barren sandy land interspersed with babool bushes and branched palm trees.

The general layout of the plant is shown in **Drawing No. 4.4**. The main existing units are turbine and boiler house, Desalination plant complex, Fuel storage area, Fuel Pumping House, Intake Pump House, Chlorination house, Central and electrical workshops, Administrative Building, Fire Water Storage tank, Emergency control room etc.

4.1.3 Capacity and Commissioning

The existing plant comprises of 6 nos. of boilers of 160 t/h capacity each and 5 nos. of turbo-generators of 25 MW capacity each, totaling to the installed capacity of 125 MW commissioned in 1985.

One turbo generator of 60 MW capacity will be added by March 2006 for which construction is under progress. All the 6 boilers are interconnected to common header from where steam can be sent to any turbine. After commissioning of new turbine, the

ultimate capacity will be 185 MW. It is proposed to add 160 t/h new boiler under this present project for strengthening and augmenting the system.

The plant load varies depending on the demand and maintenance of various units. The variation in plant load during the audit period is presented in **Table-4.1.1**.

Table-4.1.1 Plant Load during the Audit Period

Date	Load (MW)		Date	Load (MW)	
	Maxm	Minm		Maxm	Minm
17/07/2005	115	83	22/07/2005	85	79
18/07/2005	114	90	23/07/2005	85	83
19/07/2005	106	104	24/07/2005	86	77
20/07/2005	112	89	25/07/2005	80	56
21/07/2005	109	72	27/07/2005	115	101

Source : Al-Hiswa Power Plant

4.1.4 Steam & Water Balance

Some part of used steam at different stages of turbine is utilized for desalination plant and different auxiliary purpose. The exhausted steam is converted back to water in the condenser and reused in the boiler. The steam (heat) flow is shown in enclosed **Drawing No. 4.1**.The condensers are cooled using once through cooling water system utilizing water from sea. Sheet balance of steam for power capacity of 185 MW (125 MW existing + 60 MW proposed) is given in **Table-4.1.2**. Sheet balance of circulating cooling water for power capacity of 185 MW is given in **Table-4.1.3**.

Table-4.1.2 Sheet Balance for Steam for Power Capacity of 185 MW

Sr No	Consumer	Consumption (t/h)	Supplier	Production (t/h)
1	0.12 Mpa Steam: Deaerator 0.12 Mpa	 9.1	Turbine heat extraction	9.1
	Total	**9.1**	**Total**	**9.1**
2	0.6 Mpa Steam: Boiler air heater Steam mech Atomizer	 25.7 1.8	0.8-1.3/0.6 Pressure reducing & De-superheating plant	 27.5
	Total	**27.5**	**Total**	**27.5**
3	0.8-1.3 Mpa steam: Fuel oil heaters Deaerators 0.6 New Desalination unit 0.6 Pressure reducing & De-super heating plant	 4.5 10 30 27.5	Turbines: (1), (2), (3), (4), (5) & Extractions	 72
	Total	**72**	**Total**	**72**
4	10 Mpa steam: Turbines: (1) (2), (3), (4), (5) (6)	 150 4x110 240	 Boilers: (1), (2), (3), (4), (5) (6)	 5x140 130
	Total	**830**	**Total**	**830**
	-----	-----	Boiler Capacity Reserve	130

Sr No	Consumer	Consumption (t/h)	Supplier	Production (t/h)
5	TPS Power Capacity MW	185	Turbines: (1), (2), (3), (4), (5) (6)	 5x25 60
	Total	**185**	**Total**	**185**

Table-4.1.3 Sheet Balance for Circulating Cooling Water for Power Capacity of 185 MW

Sr No	Consumer	Consumption (m^3/hr)	Supplier	Production (m^3/h)
1	Condenser & oil coolers for turbines: (1), (2), (3), (4), (5) (6)	 5x3700 10000	TPS & Desalination circulating water pumps: (1), (2), (3), (4), (5) (6), (7), (8)	 5x4600 3x5688
2	Diesel Plant	150	Total	40064
3	Chlorination plant	50		
4	Main condensate coolers of turbine nos. 1 to 5	1350		
5	Coolers of closed circuit system	585		
6	Coolers of generator gas coolers	1400		
7	Desalination units	1320		
	Total	**33355**	**Total**	**40064**
			Reserve	**6709**

4.1.5 Fuel Requirement and Characteristics

4.1.5.1 Fuel Oil Requirement and System

Heavy oil is used as main fuel. Diesel oil is used during initial start up. Fuel oil is supplied through an existing pipeline by Aden Refinery Company located at about 9 km from the plant. Three tanks of 5000 m^3 each are provided for storage of fuel oil. One tank is kept reserve for its utilization during emergency period.

Remaining two tanks are filled with 3000 tons fuel oil alternatively at 3 days interval of time. On an average, one boiler of 160 t/h consumes 10.5 t/h of fuel oil. Fuel oil is pumped to boiler through two stage pumps. First stage pumps consist of 4 nos. pumps of capacity 45 m^3/h each. Oil is filtered by 6 nos. filters before pumping to common header by first stage pumps. Fuel oil is again filtered by 3 nos. filters before pumped finally to boiler by 2nd stage 4 nos. pumps of 30 m^3 capacity each.

4.1.5.2 Fuel Oil Spillage & Leakage

Oil storage areas are dyked properly to contain oil spillage and leakage, if any, within its boundary. Chance of spillage and leakage is very less because tanks are filled through pipes. Run-off water is contained within dyked area avoiding contamination of any area with oily wastewater. About 0.42 m^3/h oily wastewater is produced mainly from fuel pumping house due to spillage and leakage which is separately treated in oil trap tank. Other intermittent stream of oily wastewater is produced when pumps and filters are

cleaned with steam and hot water. This intermittent stream of wastewater is collected in local pit for cooling and finally sent to oil trap unit for its treatment.

4.1.5.3 Fuel Oil Characteristics

The fuel oil characteristics collected from plant data record is given in **Table-4.1.4**. The design fuel oil specifications are given in **Table-4.1.5**.

Table-4.1.4 Fuel Oil Characteristics

SN	Parameters	Unit	Method	Result
1	Specific Gravity @ 60/60°F		ASTM D 1298	0.9546
2	Relative Density @ 60/60°F		ASTM D 1298	-
3	Flash Point	°C	ASTM D 93	110
4	Sulphur, total	% wt	ASTM D 1552 or IP336	2.90
5	Calorific Value (gross)	Btu/lb	Bs 2869(calculated)	18413
6	Calorific Value(gross)	kcal/kg	Bs 2869(calculated)	10229
7	K Viscosity @ 140°F	cSt	ASTM D 445	-
8	Viscosity @ 50°C	cSt	ASTM D 445	152.1
9	Pour Point	°C	ASTM D 97	18
10	Ash Content	% wt	ASTM 482	0.03
11	Water by Distillation	% vol	ASTM D 95	0.20
12	Sediment by Extraction	% wt	ASTM D 473	Less than 0.01
13	Carbon Residue	% wt	ASTM D 189	9.5
14	Asphaltenes	% wt	IP 143	-
15	Nickel	ppm	IP 285	-
16	Vanadium	ppm	IP 285	-

Source: Al-Hiswa Power Plant (Analysis done by Aden Refinery Company)

Table-4.1.5 Design Fuel Oil Specifications

SN	Specifications	Design Value
1	Carbon Content (%)	85.1
2	Hydrogen Content (%)	12
3	Oxygen & Nitrogen (%)	0.03
4	Ash Content (%)	0.02
5	Sulphur Content (%)	2.8
6	Water Content (%)	0.05
7	Specific Gravity (@ 15.6°C) (t/m^3)	0.943
8	Pour Point, °C (°F)	15.6 (60)
9	Flash Point, °C (°F)	101.2 (214)
10	Calorific Value (kcal/kg)	9638

Source : Al-Hiswa Power Plant

The fuel oil analysis results collected from the plant management for last two months (May & June 2005) is given in **Table-4.1.6**, from which it is evident that average sulphur content is fuel oil feed into the boilers is 2.9% by wt.

Table-4.1.6 Sulphur Content in Fuel Oil

Date	Sulphur Content (% wt)	Date	Sulphur Content (% wt)
3/5/2005	2.9	3/6/2005	3.45
7/5/2005	2.8	6/6/2005	3.45
11/5/2005	2.85	8/6/2005	3.1
15/5/2005	2.85	12/6/2005	3.1
17/5/2005	2.85	15/6/2005	3.2
20/5/2005	2.2	17/6/2005	3.2
24/5/2005	2.98	21/6/2005	2.3
26/5/2005	3.45	2306/2005	2.3
30/5/2005	3.45	29/6/2005	2.3
		30/6/2005	2.2
Average sulphur content 2.89%			

From environment point of view, main characteristics of fuel oil are its high sulphur content. Sulphur content of fuel oil received at plant varies from 2.2% to 3.26%. Sometimes, Refinery provides fuel oil with low sulphur content upto 0.55 % as per availability. It is mixed with high sulphur content fuel oil in the ratio 2:1 to reduce overall sulphur content. But this happens on very few occasions. There is no guideline and policy to keep sulphur content low for the refinery in Republic of Yemen.

4.1.5.4 Start-Up Fuel Oil

Diesel is used as start up fuel. There are two no of storage tanks of 75 m^3 capacity each. Diesel oil is supplied by ARC and tank is filled through tanker once in a year. Start up fuel is required rarely and its sulphur content is less than fuel oil.

4.1.6 Transformer and Turbine oil

There are 5 nos. step up transformers (10.5/33 KV) and 5 nos. step down transformers (4 nos. 10.5/6.6 KV and 1 no. 33/6.6 KV). Power for 4 nos. step down transformers are tapped from the generator output before step up transformers to meet the auxiliary requirement of electricity inside the plant and one no step down transformer is connected with 33 KV city grid to get the power supply for auxiliary consumption from other power stations in city when internal auxiliary power supply from generator output is not available. There is proposal to install one new step up transformer (10.5/132 KV) along with new turbine which will be connected to 132 KV grid line through 1 km transmission line from power station.

Oil is needed to cool transformers and turbines. There are 5 and 3 nos. storage tanks of 70 m^3 capacity each for turbine and transformer oil respectively. Storage area is dyked properly to avoid contamination of other water streams. Consumption of turbine oil is about 20 barrels per month and that of transformer oil is once in 5 to 6 years. Current practice for disposal of waste transformer and turbine waste oil is to mix it with main fuel oil and is burnt in the boiler. Typical characteristics of turbine and transformer oil collected from plant data records are given in **Table-4.1.7**.

Table-4.1.7 Typical Characteristics of Turbine and Transformer Oil

SN	Test Parameters	Unit	Turbine Oil	Transformer Oil

SN	Test Parameters	Unit	Turbine Oil	Transformer Oil
1	Specific Gravity at 20°C	g/m^3	0.867-0.869	0.885
2	Water Content	%	Nil	Nil
3	Mechanical Impurities (by seen)	%	Nil	Nil
4	Flash Point (Open Crucible)	°C	>200	142
5	Total Acid Number	mg KOH/g	0.018-0.022	-
6	Viscosity, Kinematics at 40°C	cSt	26.0-30.5	7.8
7	Viscosity, Kinematics at 100°C	cSt	3.8-5.5	1.4

Source: Al-Hiswa Power Plant

4.1.7 Water & Wastewater Management

4.1.7.1 Water System & Source of Water

The plant water system consists of sea water for once through cooling & desalination plant (for production of DM water for boiler make-up), drinking water from city supply and use of unsuitable DM water for toilets, canteen & gardening. Plant water system and water balance diagram is shown in **Figure-4.1.1**.

The water requirement for the existing plant is drawn from the sea except drinking water which is met from city water supply of Water Authority. Sea water is brought to Intake Pump House through earthen channel from where water is pumped and sent to meet the requirement of desalination plant and cooling purpose of different plant units. Once through cooling system is adopted for cooling system. Desalination water produces make-up water requirement of boilers.

4.1.7.2 Water Requirement

The net raw water requirement is about 23355 m^3/h of sea water and 0.52 m^3/h of drinking water, the break up of which is given in **Table-4.1.8** (refer water balance diagram presented in **Figure-4.1.1**).

Table-4.1.8 Break-up of Water Requirement

SN	Section	Quantity (m^3/h)	
		Sea Water	Drinking Water
1	Cooling water for condenser and auxiliary cooling	21985	-
2	Desalination Plant for boiler make-up water	1320	-
3	Chlorination Plant	50	-
4	Drinking Water	-	0.52
	Total	**23355**	**0.52**

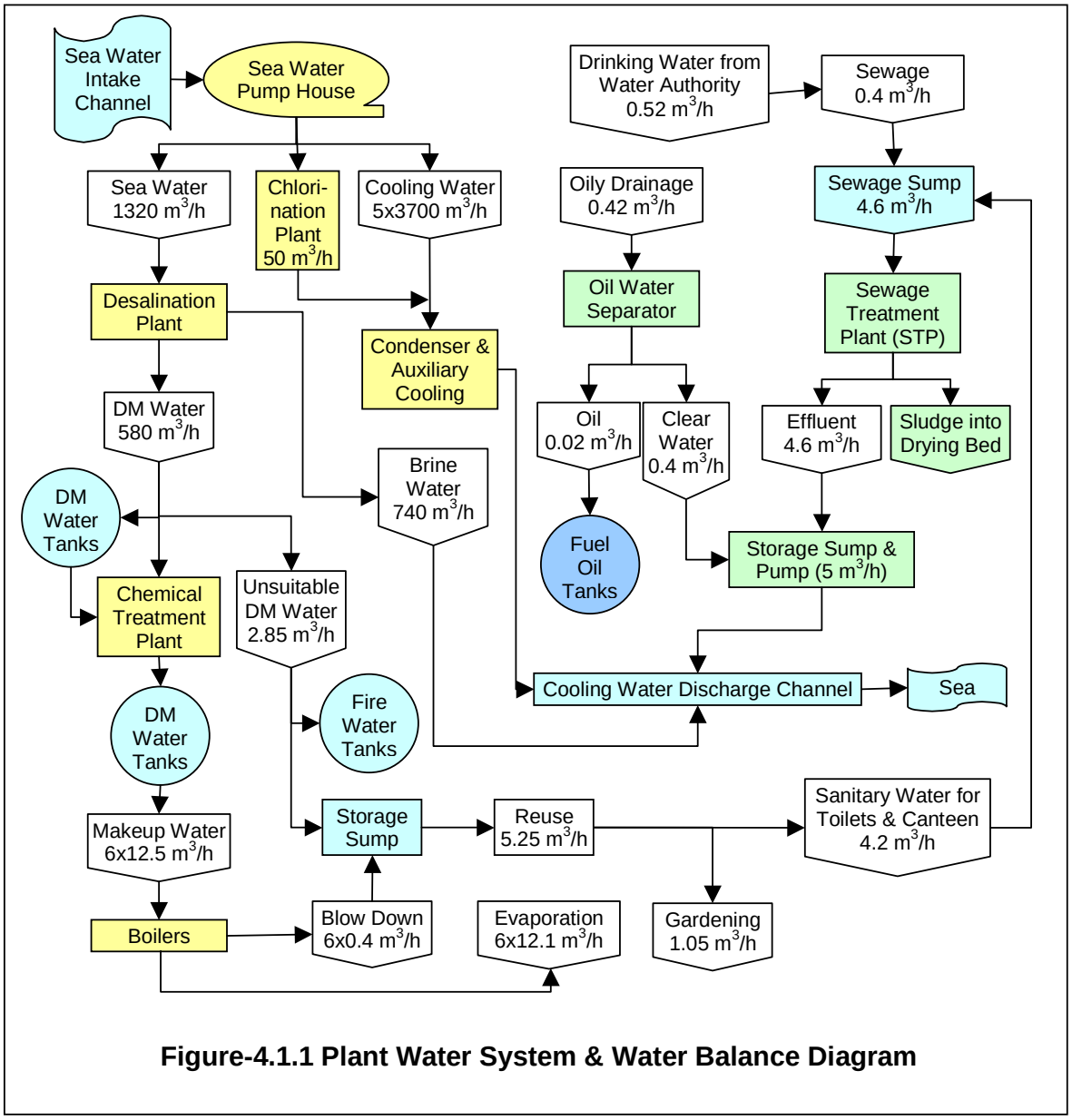


Figure-4.1.1 Plant Water System & Water Balance Diagram

4.1.7.3 Wastewater Generation

The break-up of wastewater generation from different sections is given in **Table-4.1.9**.

Table-4.1.9 Break-up of Wastewater Generation

SN	Section	Quantity(m^3/h)	Discharge/Reuse
1	Brine water from desalination plant	740	Discharged into the sea through the cooling water discharge channel
2	Cooling water discharge	21985	
3	Clear water from oil trap	0.4	

SN	Section	Quantity(m^3/h)	Discharge/Reuse
4	Effluent from sewage treatment plant	4.6	
	Total	**22730**	
5	Unsuitable DM Water	2.85	Collected in storage sump and reused for gardening and sanitary water for toilets & canteen
6	Boiler Blow down	2.4	
	Total	**5.25**	

The net quantity of finally disposable wastewater from combined discharge channel is about 22730 m^3/h. In addition to this, 5.25 m^3/h combined unsuitable DM water and boiler blow down is utilized within the premises of plant. The leakages of condensate from recirculating boiler water is collected in a tank of 1000 m^3 called as Dirty Tank near the boiler and sent back to DM plant to make it suitable for boiler make-up water for its re-utilization. There is one boiler dump tank of 50 m^3 capacity for collecting floor washing and waste leakages from boiler house which is finally discharged to storage sump occasionally. Wastewater is also generated occasionally due to washing of pumps, floors of other sections, washing of air heaters etc. which is finally led to oil trap unit.

4.1.7.4 Treatment of Industrial Effluents

The wastewater from the operating units is subjected to necessary treatment to make it suitable for discharge. Cooling and brine water streams are not given any treatment before its discharge to sea. Unsuitable DM water and boiler blow down are collected in a storage sump for its cooling and reutilized within plant premises without any treatment. Oily wastewater generated from leakage and washing activities from different plant units is collected in sump from where it is sent to gravity oil separator (**Figure-4.1.2**) for trapping oil. The trapped oil is collected in a sump for its reutilization in boiler. Clear water from oil trap is collected in storage sump where treated sewage water is mixed and finally discharged to sea through combined discharge channel.

Figure-4.1.2 Oil Water Separator

4.1.7.5 Treatment of Sanitary Influent

Raw sewage and canteen wastewater is collected in a sump. From there It is pumped intermittently (twice in a week) into the twin chambers called aeration cum sedimentation tanks of capacity 59 m^3 each in the STP (**Figure-4.1.3**). Wastewater is aerated with sub surface aerators properly and allowed to settle there. The supernatant is led to outlet chamber from where it is collected in storage sump and finally discharged to sea through combined discharge channel. The settled sludge is collected in 2 nos. sludge drying beds (silt tanks) of 180 m^3 capacity each (**Figure-4.1.4**). Sewage treatment plant is performing well and there is no foul smell found surrounding the plant.

Figure-4.1.4 Sludge Drying Bed

4.1.7.6 Water and Wastewater Quality

Eight nos. of water and wastewater samples have been collected from the following locations and analysis has been done as per internationally standard practices.

- Cooling water (at condenser outlet)
- Cooling water at discharge point in sea (before mixing)
- Sea water at cooling water discharge point (after mixing)
- Boiler blow down
- Untreated sewage (at the entrance to STP)
- Combined treated effluent (before discharge to the cooling water discharge channel)
- Drinking water from the tap of the administrative office
- Oily effluent before entry to the oil water separator

Parameters are selected on the basis of likely pollution from oil powered thermal power plants, raw material use and World Bank guideline of effluents from thermal power plant. Analysis results are shown in **Table-4.2.5 in Section 4.2.4**.

The analysis results have been compared with national and international standards as well as World Bank guidelines as discussed in Chapter-2. All the parameters are found conforming to stipulated standards and guideline of respective water use and disposal.

4.1.8 Air Emissions

There are three existing stacks of 80 m height connected to two boilers each for the flue gas dispersion generated from burning of fuel oil in the boiler. No facility is available with the existing stacks to monitor the flue gas parameters. Sulphur Dioxide (SO_2) gas is the critical air pollutant from oil fired thermal power plant. Based on the fuel characteristics and average oil consumption (10.5 t/h per boiler), it is estimated that the plant

discharges SO_2 at the rate of 609 kg/h per boiler i.e. 87.696 t/day at its full operating load assuming all sulphur is converted to SO_2. Emission of particulate matter is negligible. There are no other sources of air pollution in the plant. In Republic of Yemen, there is no SO_2 emission standard. As per the World Bank guideline, the total SO_2 emissions from the power plant or unit should be less 0.20 metric tons per day per MW of capacity for the first 500 MW plus 0.10 t/day for each additional MW of capacity over 500 MW. As such, total emission limit of SO_2 for existing Al-Hiswa power plant (125 MW) should be 25 t/day as per World Bank guideline. Actual emission rate (87.696 t/day) is far above the World Bank permitted level of 25 t/day.

4.1.9 Noise Pollution Level

Noise pollution levels have been monitored at different strategic locations within plant premises using Integrated Noise Level Monitoring Instrument. Noise levels observed at different locations are given in **Table-4.2.15 in Section 4.2.7**.

In-plant noise level (8-hourly L_{eq}) varies from 66.1 dB(A) (near the Training Center) to 83.4 (inside the Control Room) dB(A), which is within the permissible work zone area limit of 90 dB(A) for 8-hourly exposure of workers.

4.1.10 Solid Waste Management and Disposal Practices

The main sources of solid waste generation in the plant are sewage treatment plant and canteen. Sludge from sludge drying beds is disposed to city landfill sites once in five years. Municipal garbage collection vehicle visits plant twice in a week and collects garbage from the bins kept at different locations within the plant premises. No hazardous or oily solid waste is generated from plant as reported by plant personnel. As discussed, waste oil is trapped and reutilized in boilers. Waste transformer and turbine oil is mixed with fuel oil and burnt in the boiler. There is no oil sludge generation from oil storage tanks as reported by plant personnel. The overall house keeping within plant premises is observed to be good.

4.1.11 Emergency Management

Adequate fire detection and protection system exists to meet any crisis during emergency period. The salient features of emergency management are given below:

- 2 nos. 1000 m^3 capacity fire water storage tanks are kept always full with unsuitable DM water from desalination plant for fire fighting.
- 2 nos. fire water pumps are installed for fire fighting.
- 3 nos. fire tenders of water type are provided in the fire station.
- Hydrant system exists for complete power plant covering administrative building, boiler and turbine house and its auxiliaries, all pump houses and miscellaneous buildings of plant.
- Foam injection system for fuel oil storage tanks & pump house consisting of foam concentrate tanks, foam pumps, in-line inductors, valves, piping, instrumentation etc.
- Portable CO_2, foam & powder type fire extinguishers are located at strategic locations throughout the plant.
- Flame detectors are provided in oil storage areas.
- Smoke detectors are placed in underground cable channel at strategic locations.
- A computerized automatic control room is provided for fire detection and alarm system to cover the complete power plant.
- Oil storage area is located at adequate distance from main buildings of the plant.

- For fire fighting and other safety purposes, adequate trained personnel are deployed under Fire Fighting & Safety Manager.
- One transformer oil emergency dump tank in transformer area is provided to transfer transformer oil to this tank during any emergency
- Similarly, one turbine oil emergency dump tank is provided to transfer turbine oil during emergency.

4.1.12 Workers Health and Safety

Strict rules and regulation are being followed to take care of workers health and safety. Penalties are imposed by concerned authority (Fire Fighting & Safety Manager) in case of non-compliance of safety rules. Workers are provided with safety jackets, helmets, boots, gloves, gas masks, ear plugs and ear mufflers etc. to protect them from any occupational hazard.

Regular visit of doctor has been arranged for routine check-up of employees. Proper hygiene standards are maintained in Canteen. Toilets and Urinals are provided in all buildings close to working areas of plant personnel. Toilets and urinals are cleaned on regular basis with treated wastewater. There is Government Hospital near by plant for getting treatment in case of emergency. No occupational disease appears to be prevalent as revealed during consultation with plant personnel.

4.2 BASELINE ENVIRONMENTAL SCENARIO AROUND AL-HISWA POWER STATION

4.2.1 Topography & Earthquakes

The Al-Hiswa power station is located 10 km north-west of centre of Aden City. The power station site is bounded by Aden to Little Aden road in the north, Gulf of Aden in the south and vacant lands on other sides. The area on the northern side is called Madinath Ashsha'b. Location of the power station and its surrounding area is shown in **Figure-3.2.1**.Topography of the area around Al-Hiswa power station is characterized by sandy barren flat terrain with gentle slope towards South with sparse vegetation, mainly palm and thorny bushes. The Gulf of Aden is located about 300 m south of the power station.

The number of registered earthquakes is given in **Table-4.2.1**. It can be seen that the number of earthquakes in Aden in 2003 was only 1 compared to the total 1816 no. of domestic & regional events. Though earthquake is very common in Yemen, mostly is very weak in nature, (**Table-4.2.2**) only 3.9% of them touch 6 points mark in the Richter scale.

Table-4.2.1 No. of Registered Domestic & Regional Earthquake Events during 2003

Event Area	No. of Events	Event Area	No. of Events
Aden	1	Al-boida + Lodar	646
Aden Bay	715	De-sofal + Oddain	58
Red Sea	32	Yefee + Cataba	78
Ibb	84	Haja + Al-Tawalla	25

Dhamar	13	Goban-Daimt	5
Al-Hodeidah	47	Amran	1
Sana'a	5	Regional	12
Taiz	14	Outside regional boundaries	73
Al-Mokala	7	**Total**	**1816**

Source: Statistical Yearbook 2003

Table-4.2.2 Scale of Registered Domestic & Regional Earthquake Events during 2003

Richter Scale	No. of Events	% of Total Events
< 1	23	1.3 %
1-2	230	12.7 %
2-3	1123	61.8 %
3-4	251	13.8 %
4-5	57	3.1 %
5-6	60	3.3 %
6-7	30	1.7 %
7-8	3	0.2 %
> 8	39	2.1 %
Total	**1816**	**100 %**

Source: Statistical Yearbook 2003

4.2.2 Soil & Agriculture

The physico-chemical characteristics of soils within the study area have been studied by collection & analysis of soil samples from 1 representative location in the study area. The location of the sampling point is the garden within the power station.

The physico-chemical characteristics of the soil in the study area, as obtained from the analysis of the soil sample, are presented in **Table-4.2.3**.

Table-4.2.3 Physico-Chemical Characteristics of Soil in the Study Area
(Based on On-site Soil monitoring during July'05)

SN	Parameter & Unit	Sampling Location
		Power Station Garden
	Physical Parameters:	
1.	Texture	Sandy loam
2.	Grain size distribution	
	a) Gravel (% w/w)	4.5
	b) Sand (% w/w)	76.5
	c) Silt (% w/w)	12.4
	d) Clay (% w/w)	6.6
	Chemical Parameters:	
1.	pH (30% w/v slurry)	7.8
2.	Conductivity (μmhos/cm at 30°C)	166
3.	Organic matter (%)	0.56

SN	Parameter & Unit	Sampling Location
		Power Station Garden
4.	Nitrogen (%)	0.0013
5.	Phosphorous (%)	0.0014
6.	Calcium (%)	0.0051
7.	Magnesium (%)	0.0023
8.	Sodium (%)	0.0032
9.	Potassium (%)	0.0010
10.	Alkalinity (%)	0.0421
11.	Sodium Absorption Ratio	0.92

Texture of the soil is sandy loam. The percentage of sand, silt and clay fractions are 76.5%, 12.4% and 6.6% respectively. Such soils are highly permeable and well drained but are less water retentive and hence need more frequent irrigation for successful crop growth than fine textured clay soils. Clay fraction being very less the soil has very less nutrient and water retentive capacity and therefore less fertile.

The soil is alkaline with pH of 7.8. Electrical conductivity (EC) is very low, only 166 µmhos/cm. EC less than 2 mmhos/cm represent the good quality soil. Sodium level in the soil sample (0.0032%) is also low. Though low EC and sodium level is good from agricultural view point, the soil is deficient in necessary nutrients like nitrogen, potassium and phosphorous.

The quantity of nitrogen in surface soils generally ranges between 0.02-0.25%. In the soil sample nitrogen level is 0.0013%, which is very low than the requirement. The phosphorous content of most mineral soils falls between 0.02-0.5%. Observed phosphorous level in the soil sample is found low 0.0014%. Organic matter content of the soil sample is also low (0.56%). This indicates that the vegetative potential of the soil is poor and therefore the soil is not suitable for normal growth of agricultural crops.

Calcium and magnesium are very important elements in the life of soils and plant growth. Calcium content in the soil is 0.0051%. Since in most of soils, calcium content is found to be less than 1%, it can be said that the soil has sufficient Ca level to make it available to plant as nutrient. Magnesium content in the soil (0.0023%) is also found similar trend to that of calcium, which shows no deficiency of Mg in the soil.

Agriculture: Due to low fertile soil, scanty rainfall and absence of irrigation system, no agricultural activities are observed around the power station. Only some thorny bushes are visible around. Inside the power station, soil has been imported from outside for plantation & gardening.

4.2.3 Land Use

Land use pattern highlights the environmental quality of a particular area. It is an important indicator of environmental health, intensity of human activity and degree of interaction between the two. Land use pattern is significantly influenced by the nature of soil, water availability and also climatic conditions of the area.

Figure-4.2.1 Landuse on North Side of Al-Hiswa Power Station

Aden to Little Aden road runs parallelly to the northern boundary of the power station and beyond the road there exists the residential area Madinath Ashsha'b (**Figure-4.2.1**). Gulf of Aden exists in the south at about 300 m of the power station (**Figure-4.2.4**). Other sides i.e. eastern & western sides (**Figure-4.2.2 & Figure-4.2.3**) are vacant lands where some sparsely distributed palm trees mingled with thorny bushes are found.

4.2.4 Water Quality

Figure-4.2.2 Landuse on West Side of Al-Hiswa Power Station

Figure-4.2.3 Landuse on East Side of Al-Hiswa Power Station

4.2.4.1 Water Quality Monitoring

For generating data on water & effluent quality parameters and drawing up the baseline scenario in the study area, 8 representative water & effluent quality monitoring locations were selected. The location and brief description of the water & effluent quality monitoring stations are listed in **Table-4.2.4**.

Figure-4.2.4 Landuse on South Side of Al-Hiswa Power Station

Table-4.2.4 List of Water Quality Monitoring Stations

Location No.	Location Description
1	Cooling water (at condenser outlet)
2	Cooling water at discharge point in sea (before mixing)
3	Sea water at cooling water discharge point (after mixing)
4	Boiler blow down
5	Untreated sewage (at the entrance to STP)
6	Combined treated effluent (before discharge to the cooling water discharge channel)
7	Drinking water from the tap of the administrative office
8	Oily effluent before entry to the oil water separator

Water samples were collected (**Figure-4.2.5 & 4.2.6**) once in the month of July 2005 from all these locations. The samples were analyzed for relevant physical & chemical

parameters including certain heavy metals, trace elements and toxic constituents for drawing up the baseline data.

Figure-4.2.5 Water Sample Collection from OWS Inlet

Figure-4.2.6 Water Sample Collection from Boiler Blow Down

All the basic precautions and care were taken during the sampling to avoid contamination. Analysis of the samples was carried out as per established standard methods and procedures prescribed in the "Standard Methods for Examination of Water and Wastewater" published by APHA, USA. Details of water & effluent quality monitoring results are presented in **Table-4.2.5**.

Table-4.2.5 Water Quality Monitoring Results
(Based on On-site Water Quality Monitoring during Jul'05)

SN	Parameter and Unit	Sampling Locations						
		1	2	3	4	5	6	7
		CW at Conden-ser Outlet	CW before dis. to Sea	Sea after mixing with CW dis.	Boiler Blow Down	Untreated Sewage	Combined Treated Effluent	Drinking Water
1.	Temperature (°C)	41	39	35	91	35	35	30
2.	Odor	Unobjjec-tionable	Unobjjec-tionable	Unobjjec-tionable	Unobjjec-tionable	Objec-tionable	Objec-tionable	Unobjjec-tionable
3.	Color	Colorless	Colorless	Colorless	Colorless	Grayish	Greenish	Colorless
4.	pH	7.9	8.0	7.9	10.1	6.8	6.5	7.8
5.	Conductivity (µmhos/cm)	54080	53040	53040	354	680	736	1768
6.	Dissolved Oxygen (mg/L)	5.8	6.1	6.5	2.1	2.8	3.3	4.5
7.	BOD (mg/L)	2.5	2.8	2.6	ND	180	25	ND
8.	COD (mg/L)	8.1	10.5	9.2	ND	410	72	ND
9.	Total Suspended Solid (mg/L)	18	42	26	ND	160	72	ND
10.	Total Dissolved Solid (mg/L)	44416	46500	45524	212	416	428	992
11.	Oil and Grease (mg/L)	ND	1	ND	ND	22	12.4	ND
12.	Hardness (mg/L as $CaCO_3$)	6600	6800	6210	10	190	200	440
13.	Alkalinity (mg/L $CaCO_3$)	310	315	310	40	55	60	190
14.	Chloride (mg/L as Cl)	22759	23113	22617	87	90	99	383
15.	Sulphate (mg/L as SO_4)	1580	1680	1610	22	40	48	175
16.	Nitrate (mg/L as NO_3)	2.4	2.5	2.7	ND	0.8	0.5	3.5
17.	Phosphate (mg/L as PO_4)	0.24	0.2	0.25	ND	0.1	0.15	ND
18.	Fluoride (mg/L as F)	1.1	1	1.2	ND	0.5	0.45	0.62
19.	Sodium (mg/L as Na)	5600	5800	6000	25	25	20	59
20.	Potassium (mg/L as K)	368	368	368	ND	3	3	3
21.	Calcium (mg/L as Ca)	484	463	505	ND	15	17	84
22.	Magnesium (mg/L as Mg)	1310	1371	1202	2.4	37	38.3	56
23.	Copper (mg/L as Cu)	ND	ND	ND	ND	ND	ND	ND
24.	Iron (mg/L as Fe)	0.23	0.25	0.27	ND	0.2	0.2	0.25
25.	Zinc (mg/L as Zn)	0.32	0.3	0.35	ND	ND	ND	ND
26.	$Chromium^{6+}$ (mg/L as Cr)	ND	ND	ND	ND	ND	ND	ND

SN	Parameter and Unit	Sampling Locations						
27.	Percent Sodium (%)	63.3	63.4	66.1	84.6	22	17.6	22.4
28.	Sodium Absorption Ratio	30	30.6	33.1	3.5	0.79	0.62	1.22
29.	Salinity (mg/l)	41080	41719	40824	157	163	179	

BOD: Biochemical Oxygen Demand, COD: Chemical Oxygen Demand

Location No. 8: Oily Wastewater:
pH: 7.1
Oil and Grease (mg/L): 28470

4.2.4.2 Cooling water

The monitoring results of the cooling water discharge at various points for salient water quality parameters are listed in **Table-4.2.6**.

Table-4.2.6 Salient Features of the Cooling Water Discharge & Treated Effluent

SN	Parameter & Unit	CW at Conden-ser Outlet	CW before dis. to Sea	Sea water after mixing with CW dis.	Combined Treated Effluent	Yemen Standards for Discharge into General Sewage Network	World Bank guidelines for effluents from Thermal Power Plants
17.	Temperature (°C)	41	39	35	35	45	□ 3°C#
18.	pH	7.9	8.0	7.9	6.5	5.5-9.5	6-9
19.	Conductivity (μmhos/cm)	54080	53040	53040	736	700-2000$	-
20.	Dissolved Oxygen (mg/L)	5.8	6.1	6.5	3.3	2$	-
21.	BOD (mg/L)	2.5	2.8	2.6	25	50	-
22.	Total Suspended Solid (mg/L)	18	42	26	72	500	50
23.	Total Dissolved Solid (mg/L)	44416	46500	45524	428	2000	-
24.	Oil and Grease (mg/L)	ND	1	ND	12.4	100	10
25.	Chloride (mg/L as Cl)	22759	23113	22617	99	600	-
26.	Sulphate (mg/L as SO_4)	1580	1680	1610	48	1000	-
27.	Nitrate (mg/L as NO_3)	2.4	2.5	2.7	0.5	20$	-
28.	Sodium (mg/L as Na)	5600	5800	6000	20	200$	-
29.	Copper (mg/L as Cu)	ND	ND	ND	ND	5	0.5
30.	Iron (mg/L as Fe)	0.23	0.25	0.27	0.2	50	1
31.	Zinc (mg/L as Zn)	0.32	0.3	0.35	ND	10	1
32.	Chromium^{6+} (mg/L as Cr)	ND	ND	ND	ND	5	0.5

@ standards for irrigational use
# at the edge of 100 m mixing zone

The combined treated effluent (treated sewage & treated oily wastewater) is discharged intermittently (average 4 hours per day @ 30 m^3/h) into the continuously flowing cooling water discharge (@ 5x4600 m^3/h) for its final disposal into the sea. Therefore the treated effluent achieves about 767 times dilution in the cooling water discharge channel before its final disposal into the sea.

Temperature of cooling water varied between 34°C at cooling water intake and 38°C at discharge point. This means only 4°C increments between the intake & outfall temperature. The sea water temperature after mixing with hot cooling water discharge measured at edge of 100m mixing zone was found to be 35°C which is only 1°C more than the sea water temperature of 34°C and therefore this increment is within the World Bank guideline limit of 3°C (Handbook on Industrial Pollution Prevention and Abatement, World Bank 1995).

No oil & grease was detected in the cooling water at condenser outlet. However, cooling water at final discharge point contained 1 mg/l oil & grease. This is due to the mixing of the treated effluent that contains 12.4 mg/l oil & grease. However, no oil & grease was detected in sea water after mixing with cooling water discharge measured at edge of 100m mixing zone.

BOD in the cooling water at condenser outlet was 2.5 mg/l. However, cooling water at final discharge point contained 2.8 mg/l BOD. This increment is due to the mixing of the treated effluent that contains 25 mg/l BOD. The BOD value in sea water after mixing with cooling water discharge measured at edge of 100m mixing zone was 2.6 mg/l.

As no remarkable change in the sea water after mixing with cooling water discharge & treated effluent is noticed, it may be concluded that there is no significant pollution in sea due to plant discharge.

4.2.4.3 Combined Treated Effluent

The combined effluent was bit acidic (pH value 6.5) but was within the tolerance limit of 5.5-9.5. Conductivity was 736 μmhos/cm with TDS 428 mg/l & TSS 72 mg/l, all these parameters were within the permissible limits.

Though oil & grease content of the oily wastewater was 28,470 mg/l, the same in treated combined effluent was only 12.4 mg/l indicating proper functioning of the oil water separator. The oil & grease level in the treated effluent is below the permissible limit of 100 mg/l.

The BOD content of the raw sewage was 180 mg/l, but BOD in treated combined effluent was only 25 mg/l indicating proper treatment of sewage in the sewage treatment plant (STP). The treated effluent BOD level (25 mg/l) is within the permissible limit of 50 mg/l. All other parameters including heavy metals & toxic constituent in the treated effluent were found to be within their respective permissible limits.

As all the parameters were within the permissible limits, it may be concluded that there is no significant pollution potential of the treated effluent discharge into the sea.

4.2.4.4 Drinking Water

The salient water quality features of the drinking water are presented in **Table-4.2.7**. It can be found from this table that most of parameters meet the desirable drinking water quality standards. The water being hard & containing excess salts, levels of some parameters e.g. conductivity, total dissolved solids, alkalinity, chloride and calcium are higher than the desirable limits, but their levels are within the permissible limits. Therefore, the water is safe for drinking.

Table-4.2.7 Salient Features of the Drinking Water in Power Station

SN	Parameter and Unit	Drinking Water (Monitored)	Yemen Standards	
			Desirable	Permissible
1.	pH	7.8	6.5-8.5	5.5-9
2.	Conductivity (μmhos/cm)	1768	450-1000	2500
3.	Total Dissolved Solid (mg/L)	992	650	1500
4.	Alkalinity (mg/L $CaCO_3$)	190	150	500
5.	Chloride (mg/L as Cl)	383	200	600
6.	Sulphate (mg/L as SO_4)	175	200	600
7.	Nitrate (mg/L as NO_3)	3.5	45	50

SN	Parameter and Unit	Drinking Water (Monitored)	Yemen Standards	
			Desirable	Permissible
8.	Fluoride (mg/L as F)	0.62	0.5	1.5
9.	Sodium (mg/L as Na)	59	200	400
10.	Potassium (mg/L as K)	3	12	12
11.	Calcium (mg/L as Ca)	84	75	200
12.	Copper (mg/L as Cu)	ND	1	1.5
13.	Iron (mg/L as Fe)	0.25	0.3	1
14.	Zinc (mg/L as Zn)	ND	5	15
15.	Chromium^{6+} (mg/L as Cr)	ND	0.05	0.05

4.2.4.5 Ground Water Quality in the Study Area

Though groundwater is the important source of drinking and domestic water needs for people in the country, ground water of the Aden city being highly saline it is not used & extracted. The total supply of water for Aden for all domestic & drinking purposes is supplied by the Water Authority. The drinking water needs of the Al-Hiswa power plant is met from the piped supply by the Water Authority. As ground has no use in the study area it's monitoring & impact analysis is redundant.

4.2.5 Climate & Meteorology

Past meteorological data described in this section is based on the data of the nearest observatory of the Civil Aviation & Meteorology Authority, Republic of Yemen located at Aden Airport which deemed representative of the study area. The month wise climatic features of the study area based on the available past climatological data of Aden are presented in **Table-4.2.8.**

Table-4.2.8 Monthly Summary of Climatological Records of Aden City (during 2002)

Month	Mean Daily Temperature (°C)			Average Relative Humidity (%)	Monthly Rainfall (mm)	Wind Speed (Knots)	Wind Direction
	Maxm	Minm	Mean				
Jan	29.5	20.0	25.9	67	1.1	10.1	E
Feb	29.8	20.5	25.8	65	2.0	12.9	E
Mar	32.0	20.5	26.7	71	9.5	11.8	E
Apr	33.7	21.5	28.4	72	42.4	9.8	E
May	39.0	24.5	31.7	66	0.0	8.0	SE
Jun	39.0	28.2	31.7	62	0.0	10.8	SW
Jul	38.0	28.0	32.6	57	0.0	9.4	SW
Aug	38.2	27.2	32.3	58	0.0	11.5	SW
Sep	38.2	26.2	31.6	65	0.0	7.7	E
Oct	35.0	21.7	28.4	69	0.0	8.9	E
Nov	31.8	20.6	27.1	67	0.0	9.0	E
Dec	30.2	22.5	26.6	70	2.1	11.2	E
Mean/Total	**34.5**	**23.5**	**29.1**	**66**	**57.1**	**10.1**	**E**

Source: Statistical Year Book 2003, Ministry of Planning & International Co-operation, Republic of Yemen

Available past meteorological data for Aden (Airport) has been summarized in **Table-4.2.9**. The maximum mean daily temperature of 39.0°C is observed in the hottest month June and the minimum of 20.0°C in the coldest month January. The average monthly

relative humidity varies between 57% & 72% with annual mean of about 66%. Total annual rainfall is very low, about 57.1 mm, out of which about 91% rainfall takes place during the months of March & April, month of April being the rainiest (about 42.4 mm) and months of May to November being rainless.

Table-4.2.9 Summery of Climatological Data of Aden City

Parameter	**Monthly Range**	**Annual Mean/Total**
Mean daily maximum temperature (°C)	29.5°C (Jan) – 39.0°C (Jun)	
Mean daily mimimum temperature (°C)	20.0°C (Jan) – 28.2°C (Jun)	
Average relative humidity (%)	57 (Jul) – 72 (Apr)	
Total rainfall (mm)	0.0 (May to Nov) – 42.4 (Apr)	57.1
Wind speed (Knots)	7.7 (Sep) – 12.9 (Feb)	

The annual mean wind speed, observed at Aden is around 10.1 Knots (18.2 km/h) which is high. Wind speed is high (>10 Knots) during December to March and in June & August, and in rest of the year it is moderate (4 to 10 Knots). Predominant wind direction is from east for most of year (for September to April) followed by south-west (for June to August).

4.2.6 Air Quality

4.2.6.1 Ambient Air Quality Monitoring

Four monitoring stations were set up for monitoring of ambient air quality around the power plant. The locations of the monitoring stations were selected so as to accord an overall idea of the ambient air quality scenario around the power plant. The locations of the monitoring stations were based predominant wind directions. Logistic considerations such as accessibility, security, and availability of reliable electric power supply etc. were examined while finalizing the locations of such stations.

The locations of the ambient air quality monitoring stations with respect to the position of the stacks of the power station are summarized in **Table-4.2.10** and depicted in **Figure-4.2.7**.

Table-4.2.10 Details of Ambient Air Quality Monitoring Stations (AAQMS)

Location No.	**Location of Monitoring Station (and Position of Monitoring Equipment)**	**Direction w.r.t Stack**	**Distance from Stack (km)**
1	Power Station Camp (Monitoring equipment was placed on roof top of a single storied residential building).	North	0.9
2	Free Zone Police Guest House (Monitoring equipment was placed on roof top of a single storied building of the guest house).	North-East	0.8
3	Radio Station (Monitoring equipment	West	0.6

Location No.	Location of Monitoring Station (and Position of Monitoring Equipment)	Direction w.r.t Stack	Distance from Stack (km)
	was placed on roof top of a single storied office building.)		
4	University Campus (Monitoring equipment was placed on roof top of a single storied building.)	North	1.3

Monitoring was conducted in respect of the following parameters:

- Total Particulate Matters (PM)
- Particulate Matters below 10 micrometers (PM_{10})
- Sulphur Dioxide (SO_2)
- Oxides of Nitrogen (NO_x)
- Carbon Monoxide (CO)

Figure-4.2.7 Ambient Air Quality Monitoring Locations

The equipment were placed at a height of 3 to 3.5 meters above ground level at each monitoring station, thus negating the effects of wind blown ground dust. The equipment was placed at open space free from trees and vegetation which otherwise act as a sink of pollutants resulting in lower levels in monitoring results. At locations close to roads, the equipment was placed at least 100 m away from such roads to avoid influence of traffic exhaust emissions. Ambient air quality monitoring was conducted at each station adopting a 24-hours schedule.

With a view to collecting the samples for SPM, RPM, SO_2 and NO_x, High Volume Respirable Dust Samplers (RDS) (make: Envirotech) along with gaseous sampling impingers were used (**Figure-4.2.8 & 4.2.9**).

Figure-4.2.8 Ambient Air Quality Monitoring in FZP Guesthouse

Figure-4.2.9 Ambient Air Quality Monitoring in Radio Station

Glass micro-fibre filter papers (GFA Sheets, Whatman) were used for the collection of SPM. SO_2 was collected by drawing air through absorbing solution of sodium tetrachloromercurate (West and Gaek Method) and NO_x was collected by drawing air through the mixture of absorbing solutions of sodium hydroxide and sodium arsenite (Jacobs and Hochheiser Method). The measurement for both SO_2 and NO_x was done colorimetrically. All the analyses were carried out as per Standard Methods.

The detailed on-site 24-hourly monitoring results presented in **Table-4.2.11.**

Table-4.2.11 Detail Ambient Air Quality Monitoring Results

SN	Location	Date	24-hourly Concentration ($\mu g/m^3$)				
			SPM	RPM	SO2	NOx	CO
1	Power Station Camp	20/07/2005	310	120	49.6	16	309
2	Power Station Camp	21/07/2005	447	143	44	16.4	316
3	Power Station Camp	24/07/2005	275	100	55.5	13.7	280
4	FZP Guesthouse	21/07/2005	710	138	40.5	30.6	719
5	FZP Guesthouse	22/07/2005	786	145	22	43.6	940
6	FZP Guesthouse	24/07/2005	615	118	35.2	26.6	620
7	Radio Station Office	23/07/2005	693	127	40.5	21	425
8	Radio Station Office	24/07/2005	443	88	46	7.1	286
9	Radio Station Office	26/07/2005	580	135	41.3	15.6	352
10	University Campus	22/07/2005	181	36	40.3	15.4	250
11	University Campus	23/07/2005	196	39	38	13.1	222
12	University Campus	25/07/2005	172	32	36	14.3	235

4.2.6.2 Ambient Air Quality in the Study Area

Monitoring station-wise as well as overall statistical analysis (minimum, maximum, arithmetic mean and 98-percentile values) of the ambient air quality in study area for the entire monitoring period is shown in **Table-4.2.12**.

Table-4.2.12 Statistical Analysis of Ambient Air Quality in the Study Area
(Based on On-site 24-hourly Monitoring Results during July'2005)

Pollutant		Location	Min	Max	Mean	p98	PTV
Particulate Matters (PM) ($\mu g/m^3$)	1	Power Station Camp	275	447	344	439	100
	2	FZP Guesthouse	615	786	704	781	100
	3	Radio Station Office	443	693	572	686	100
	4	University Campus	172	196	183	195	100
		Overall 4 Locations	**172**	**786**	**451**	**768**	**100**
Particulate Matters below 10µm (PM_{10}) ($\mu g/m^3$)	1	Power Station Camp	100	143	121	142	100
	2	FZP Guesthouse	118	145	134	145	100
	3	Radio Station Office	88	135	117	135	100
	4	University Campus	32	39	36	39	0
		Overall 4 Locations	**32**	**145**	**102**	**145**	**75**
Sulphur Dioxide (SO2) ($\mu g/m^3$)	1	Power Station Camp	44	55.5	49.7	55.1	0
	2	FZP Guesthouse	22	40.5	32.6	40.2	0
	3	Radio Station Office	40.5	46	42.6	45.7	0
	4	University Campus	36	40.3	38.1	40.2	0
		Overall 4 Locations	**22**	**55.5**	**40.7**	**54.1**	**0**
Oxides of Nitrogen (NOx) ($\mu g/m^3$)	1	Power Station Camp	13.7	16.4	15.4	16.4	0
	2	FZP Guesthouse	26.6	43.6	33.6	42.8	0
	3	Radio Station Office	7.1	21	14.6	20.7	0
	4	University Campus	13.1	15.4	14.3	15.3	0
		Overall 4 Locations	**7.1**	**43.6**	**19.5**	**40.5**	**0**
Carbon Monoxide (CO) ($\mu g/m^3$)	1	Power Station Camp	280	316	302	316	0
	2	FZP Guesthouse	620	940	760	927	0
	3	Radio Station Office	286	425	354	421	0
	4	University Campus	275	300	286	299	0
		Overall 4 Locations	**275**	**940**	**425**	**887**	**0**

Mean: Arithmetic Mean, p98: 98 Percentile Value, PTV: Percent time violation with respect to the standard

Ambient Air Quality Monitoring Results in the study area has been summarized in **Table-4.2.13**.

Table-4.2.13 Location Wise Summary of Ambient Air Quality Monitoring Results

Ln. No.	Station Location	PM ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)		SO_2 ($\mu g/m^3$)		NOx ($\mu g/m^3$)		CO ($\mu g/m^3$)	
		Standard: 150		Standard: 70		Standard: 125*		Standard: 150		Standard: 10000	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Power Station Camp	275-447	344	100-143	121	44-55.5	49.7	13.7-16.4	15.4	280-316	302
2	FZP Guesthouse	615-786	704	118-145	134	22-40.5	32.6	26.6-43.6	33.6	620-940	760
3	Radio Station Office	443-693	572	88-135	117	40.5-46	42.6	7.1-21	14.6	286-425	354
4	University Campus	172-196	183	32-39	36	36-40.3	38.1	13.1-15.4	14.3	275-300	286
	Overall 4 locations	**172-786**	**451**	**32-145**	**102**	**22-55.5**	**40.7**	**7.1-43.6**	**19.5**	**275-940**	**425**

* WHO standard for SO_2, others are as per National Ambient Air Quality Standards of Yemen.

From the above table it is clear that in all the cases the 24-hourly average values of PM were observed to be above the permissible limit of 150 $\mu g/m^3$ and in 75% cases (i.e. except the University Campus in all other locations) the PM_{10} levels were above the limit of 70 $\mu g/m^3$ as stipulated in the National Ambient Air Quality Standards of Yemen. Boilers being oil fired, the particulate emission from the power plant is negligible. The area is barren & bare and the soils being loose sandy silt coupled with high speed coastal wind, huge wind blown dust is observed round the clock. And that is the reason for such high levels of PM & PM_{10}.

Though, the 24-hourly average SO_2 levels in all the locations were observed to be within the permissible limit of 125 µg/m^3 as per WHO standards (Yemen has no ambient air quality standard with respect to SO_2), the monitored levels (maximum 55.5 µg/m^3 and average 40.7 µg/m^3) were high. As there is no other industry or other source of SO_2 emission in the vicinity, it can be concluded that the high levels of SO_2 is due to the emissions from the Al-Hiswa power station.

The 24-hourly average NOx levels in all the locations were observed to be within the permissible limit of 150 µg/m^3 as stipulated in the National Ambient Air Quality Standards of Yemen.

Similarly, the 8-hourly average CO levels in all the locations were observed to be within the permissible limit of 10,000 µg/m^3 as stipulated in the National Ambient Air Quality Standards of Yemen.

4.2.7 Noise

4.2.7.1 Noise Monitoring

To assess the noise scenario in the study area ambient noise level monitoring was conducted at 17 representative locations within or very close to the power plant covering industrial & residential areas (as indicated in **Table-4.2.14 and Table-4.2.15**).

The stations were selected judiciously based on following considerations:
- Obstruction free exposure of equipment
- Away from temporary noise generating sources to monitor true background levels
- Accessibility of the location
- Security and safety of the instrument

Figure-4.2.10 Noise Monitoring near Training Center

Figure-4.2.11 Noise Monitoring near Plant Boundary Wall

Sound pressure levels (SPL) have been measured (**Figure-4.2.10 & 4.2.11**) by a portable sound level meter having built in facilities to read noise level directly in dB(A). A-weighted equivalent continuous sound pressure level (L_{eq}) values have been computed from the values of A-weighted SPL measured with the help of noise meter. At each location, noise monitoring has been conducted continuously over a period of 8 hours to obtain L_{eq} values.

4.2.7.2 Ambient Noise Levels in the Study Area

The summarized ambient noise level data, monitored on-site around the plant, are presented in **Table-4.2.14**. Ambient air quality standards in respect of noise are given in Chapter-2.

Table-4.2.14 Ambient Noise Levels in the Study Area
(Based on On-site Noise Monitoring during July'2005)

Locn No.	Location	Noise Level L_{eq} (dBA)
1	Outside the plant (about 40 m north of the plant main gate)	68.5
2	About 100 m north-east of the Desalination plant	65.6
3	Near a Mosque at about 140 m north of the plant	65.0
4	Madinath Ashaab area near a Shop (about 240 m north of the plant)	63.8
5	Madinath Ashaab area near a Residence (about 360 m north of the plant)	58.8
6	Madinath Ashaab area near a Residence (about 400 m north of the plant)	50.0
7	Radio station (about 500 m west of the plant)	57.0

Permissible ambient noise standards in dB(A):
a) Industrial & commercial area : 70
b) Residential area (inside the city around workshops & commercial area): 65

Equivalent noise level (L_{eq}) outside the plant varied between 65-68.5 dB(A) which are within the permissible limit of 70 dB(A) for industrial area. In the residential area of Madinath Ashsha'b the noise levels varied between 50-63.8 dB(A) which is within the limit of 65 dB(A) stipulated for residential area inside the city around industrial area. Therefore, it may be concluded that the noise level outside generally conform to the standard.

4.2.7.3 In-Plant Noise Levels inside the Plant

The summarized in-plant noise level data, monitored on-site inside the plant, are presented in **Table-4.2.15**.

Table-4.2.15 Noise Levels inside the Plant
(Based on On-site Noise Monitoring during July'2005)

Locn No.	Location	Noise Level (dBA)		
		L_{eq}	L_{min}	L_{max}
1	Inside the Panel Control Room No. 1	83.4	80.9	97.6
2	Near Main Gate	75.8	74.4	86.4
3	In front of the Administrative Office Building	67.6	64.1	76.1
4	In Central workshop Hall	82.6	76.5	93.2
5	Road Inside Plant at 25 meter from turbine house	76.0	73.8	82.3
6	Road Inside Plant in front of transformer	81.8	78.4	86.6
7	Near construction site of new turbine house	82.7	76.1	88.7

Locn No.	Location	Noise Level (dBA)		
		L_{eq}	L_{min}	L_{max}
8	Near training center	66.1	62.9	70.5
9	Near the boundary wall (Plant Backside near sea)	71.6	68.3	74.8
10	Near worship hall within plant premises	66.3	63.4	70.2

Permissible limit for 8-hourly exposure in work zone area inside the industry: 90 dB(A)

In-plant noise level (8-hourly L_{eq}) varies from 66.1 dB(A) (near the Training Center) to 83.4 (inside the Control Room) dB(A), which is within the permissible work zone area limit of 90 dB(A) for 8-hourly exposure of workers.

4.2.8 Flora & Fauna

4.2.8.1 Flora in the Study Area

The area around the power station are either built up or vacant barren land. While the northern side is built up area of Al-Hiswa. The southern side between the power plant & the sea, and the western side is vacant barren land where any vegetation is barely visible. The eastern side thorny bushes are commonly found along with few palm trees (date palm & branched palm). However a lot of planted trees exist along the roads & pathways inside the power station, common of them are Neem, Date Palm etc. **No endangered or rare species** of plants or medicinal herbs are found around the power station.

4.2.8.2 Fauna in the Study Area

Very few wild animals exist around the power station because of barren and with lack of vegetation, human activities including roads in the northern side and light of the power station in the night. It is reported by local people that rodents, squirrel, birds, lizards & snakes are common in the area. Rabbits, mongoose & cranes have been found during field studies. Other animals reported to be found rarely are fox. **No endangered or rare species** of animals have been found in the study area.

4.3 BASELINE ENVIRONMENTAL SCENARIO AROUND TRANSMISSION LINES & SUBSTATIONS

4.3.1 Topography & Land Use

4.3.1.1 Topography & Land Use in & around the Substations

Al-Hali: Generally flat terrain. The area around the boundary wall of the existing substation (**Figure-4.3.1**) is urban with residential & commercial area except on the northern side where the present transmission line exists. Necessary extension will be done in the vacant land within the existing boundary of the substation.

Figure-4.3.1 Existing 132 KV Al-Hali Substation

Figure-4.3.2 Site for New 132 KV Kilo 16 Substation

Kilo-16: Generally flat terrain. The site (**Figure-4.3.2**) earmarked for Kilo 16 substation is a barren land and located away from inhabited area. The proposed site is located just north of the Al-Hodeidah to Sana'a main road. The eastern & western side of the site is vacant plots allotted for development in near future. The northern side of the site is vacant & barren sandy land with no vegetation through which the new transmission line is proposed.

Figure-4.3.3 Existing 132 KV Dhamar Substation

Figure-4.3.4 Site for New 132 KV Yarim Substation

Dhamar: Undulating terrain. The substation (**Figure-4.3.3**) is located on high land. The area around the existing substation is vacant undulating land with no agriculture or vegetation. Necessary extension will be done in the vacant land within the existing boundary of the substation.

Yarim: Undulating terrain. The substation (**Figure-4.3.4**) is located in the valley. The site has already been acquired and the boundary wall has already been constructed. The area around the boundary wall of the proposed substation site is agricultural.

4.3.1.2 Topography & Land Use along the Transmission Line Routes

New Transmission Line from Al-Hali (Hodeidah) to Kilo-16

The route of the proposed 12 km long Al-Hali to Kilo 16 132 KV transmission line in Al-Hodeidah region (**Figure-4.3.5**) starts from the proposed interlinking single bus-bar 132 KV substation at Al-Hali and terminates at the proposed 132 KV substation at Kilo 16. The route of the proposed transmission line marked on topographical map is shown in **Drawing No.-4.2**.

Figure-4.3.5 Route Map of Al-Hali to Kilo 16 New Transmission Line

Figure-4.3.6 Landuse along Al-Hali – Kilo 16 T Line (initial 2.6

The line will start from the existing Al-Hali substation and travel north word upto a distance of 2.6 km (from the existing tower no. 61 to tower no. 54) along the right side of the existing Ras Katenib to Al Hali 132 KV transmission line (**Figure-4.3.6**). Then it will turn eastward and from there after travel for about 8 km along sandy tracts (**Figure-4.3.7**) it will turn south and traveling about 1.4 km to terminate at the proposed Kilo 16 substation.

Figure-4.3.7 Landuse along Al-Hali – Kilo 16 T Line (final 9.4 km)

The line has been proposed to avoid planned uses of land and inhabited area of Hodeidah city, following longer alignment almost in barren area. As such, much of the environmental problems have been minimized in corridor routing.

Figure-4.3.8 Some Squatters Found within ROW of Existing

The landuse along the entire route is barren

& sandy desert land with little or no vegetation. Rarely some thorny vegetation found in the route. No human settlement is found close to the route except the first few hundred meters.

In the first 200 m (between the existing tower nos. 61 and 60) some squatters are found who are rag pickers (**Figure-4.3.8**). As they live within the ROW of the existing transmission line, PEC has the Govt. order to clear its ROW.

New Transmission Line from Dhamar to Hizyaz (Sana'a)

The route of the proposed Dhamar to Hizyaz (Sana'a) 90 km long 132 KV transmission line (**Figure-4.3.9**) starts at the existing 132 KV BSP substation at Dhamar and terminates at the proposed 132 KV Hizyaz substation. The route of the proposed transmission line marked on topographical map is shown in **Drawing No.-4.3**.

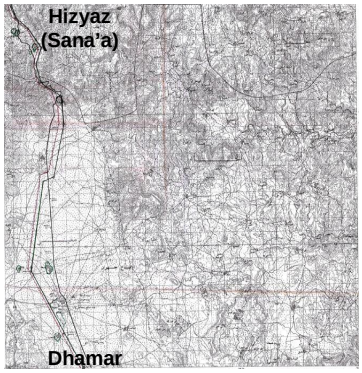


Figure-4.3.9 Route Map of Dhamar to Hizyaz (Sana'a) New

Route corridor marked on topographical map has been carefully examined. The corridor options considered is not a precise route but has been established to allow for routing variations made at the time of survey to accommodate site specific environmental and land owner concerns. The line alignment has been proposed almost parallel and on the right side of the existing Dhamar to Asser (in Sana'a) 132 KV transmission line upto Hizyaz.

Figure-4.3.10 Line will Pass through Highly Undulating Terrain

Figure-4.3.11 Line will Pass through Valleys & Some Small

The environment issues noted from topographical map have been substantiated by reconnaissance survey for ground truth verification. The proposed transmission corridor from Dhamar to Hizyaz, like the existing line, is passing through highly undulating hilly terrain (**Figure-4.3.10**). In most part of its 90 km travel it will pass through valleys and encounter some small patches of agricultural land (**Figure-4.3.11**) like the existing line. The settlements near the alignment are Khidar, Biat Al Jaidi, Wasita, Qatail, Mawar, Bait Almidi and Al-Hijara.

4.3.2 Earthquakes

From **Table-4.2.2** it can be seen that though earthquake is very common in Yemen, mostly is very weak in nature, only 3.9% of them touch 6 points mark in the Richter

scale (2003 data). The number of earthquakes in Dhamar was only 13 compared to the total 1816 no. of domestic & regional events (**Table-4.2.1**). Compared to Dhamar, Ibb is more prone to earthquakes (84 nos.). Al-Hodeidah area encountered 47 earthquakes.

4.3.3 Climate & Meteorology

The meteorological parameters that have influence on the transmission line are temperature & wind speed. Past meteorological data of various observatories near the substations & transmission lines are summarized in **Table-4.3.1.**

Table-4.3.1 Summary of Climatological Records of the Study Area (during 2002)

Month	Mean Daily Temperature (°C)			Monthly Relative Humidity (%)		Rainfall (mm)		Monthly Wind Speed (Knots)		Predominant Wind Direction
	Maxm	Minm	Annual Mean	Range	Annual Mean	Max. Monthly	Total Annual	Range	Annual Mean	
Sana'a	33.6 (Aug)	0.8 (Feb)	19.1	30 (Jun)-52 (Dec)	43	34.0 (Aug)	83.4	7.5 (Apr)-10.1 (Jun)	9.0	NE
Dhamar	31.0 (Jul)	0.0 (Jan)	16.6	26 (Jun)-50 (Dec)	38	93.3 (Aug)	201.8	4.3 (Feb)-7.9 (Sep)	6.2	E
Ibb	34.6 (Jul)	3.4 (Feb)	15.5	41 (Feb)-67 (Aug)	54	144.6 (Aug)	556.8	3.2 (Jan)-7.4 (Aug)	4.4	S
Al-Hodeidah	40.4 (Jul)	17.0 (Feb)	29.6	68 (Aug)-81 (Dec)	73	10.0 (Jan)	18.9	8.9 (Dec)-11.0 (Mar)	9.6	S

Source: Statistical Year Book 2003, Ministry of Planning & International Co-operation, Republic of Yemen
1 knot = 1 nautical mile/h = 1.853 km/h

Sana'a-Dhamar-Ibb Area:
The maximum mean daily temperature of 31-34.6°C is observed in the hottest months July & August and the minimum of 0-3.4°C in the coldest months January & February. The annual mean relative humidity is about 38-54%. The total annual mean rainfall received is about 83.4-556.8 mm. The rainfall peaks during the month of August (mean monthly being about 34-144.6 mm). The annual mean wind speed is around 4.4-9 knots. The predominant wind directions are east, south & north east.

Al-Hodeidah Area:
The maximum mean daily temperature of 40.4°C is observed in the hottest month July and the minimum of 17°C in the coldest month February. The annual mean relative humidity is about 73%. The total annual mean rainfall received is about 18.9 mm. The rainfall peaks during the month of January (mean monthly being about 10 mm). The annual mean wind speed is around 9.6 knots. The predominant wind direction is south.

4.3.4 Endangered Natural Habitats along the Transmission Lines

No endangered natural habitats like national parks, sanctuaries, biosphere reserve, game reserve etc. are observed or reported along the route of the transmission lines.

5.0 *ANALYSIS OF ALTERNATIVES*

This chapter deals with analysis of alternatives with different case scenario as per the World Bank guideline. Analysis of reasonable alternatives has been done for power plant, transmission line and sub-station components of the project from an environmental, socio-cultural and economic point of view in separate section of this chapter. The main alternatives are considered as below:

- Taking no action to meet the required capacity
- Alternative sources of electricity including construction of smaller power facilities closer to the loads as an alternative to bulk power transmission
- Energy and load management plans to reduce need for additional power
- Upgrading of existing facilities
- Alternative routes for transmission lines and sites for substations

The proposed sites & routes are physically visited to examine its suitability and to identify other better alternative sites, if any, from environmental and social point of view. The observation and findings are discussed in the following sections of this chapter

5.1 EXPANSION OF AL-HISWA POWER STATION

5.1.1 Alternative-1: No Action Alternative

The electricity demand in Republic of Yemen has been increasing and the gap between supply and demand is increasing day by day. The demand for electricity is expected to continue to increase well into the coming years. Yemen generating capacity of power is inadequate for the country needs, and a rolling load shedding schedule is maintained in many cities. Under the no action alternative, the resulting power shortages will cause serious economic and environmental problems. Industries, commercial establishments and rich families will purchase secondhand and inefficient generators as temporary measures resulting air and noise pollution. The poor will resort to kerosene and candle. Economical activities will be hampered resulting unemployment of people which will further cause too many social problems. Realizing this critical situation, PEC has already started on some modest projects to expand and improve its power sector. Hence, augmentation of power generation has become indispensable alternative to avoid environmental, social and economical problems. In order to minimize transmission losses and to avoid regional disparity, it is planned to increase generating capacity near the high load demand of Aden Region.

5.1.2 Alternative-2: Expansion of Al-Hiswa Power Station

Under different site options in Aden Region, PEC reviewed the different options from environmental, technical and logistical reasons point of view. The development of existing power plant at Al-Hiswa in Aden Region was given priority for the following reasons:

- The existing power plant has the slot with operational flexibility for accommodating extra turbine and boiler with no interruption of power supply
- The power plant has adequate land within its existing premises and no extra land is further required for its development. No person will be displaced or replaced.

- The capacity of auxiliary units is adequate and will not require further augmentation and modification. Hence, the existing power plant can be augmented with least impact and public inconvenience during construction and operational stages.
- There is no dearth of water due to proximity of plant to sea and will not have any impact on fresh water resources of the region due to this development plan.
- A supply line for fuel oil is already available
- The plant is close to the demand area.
- The power evacuating system is being strengthened under current development plan.
- In July 1997, PEC with the energization of 132-kv Aden-Taiz line interconnected its southern transmission system comprising Al-Hiswa complex with northern transmission system. This interconnection has the flexibility in benefiting other regions with the increased capacity of power plant.
- The existing additional boiler steam capacity will be utilized in increasing the power generation.
- The plant site is located with least environmental and social problems as there are no major sources of pollution and is sparsely populated within 5 km radius of the existing power plant.

Technically also, the overhaul and rehabilitation of turbines and boilers is required because it will improve efficiency, increase the available rated MW capacity and will finally increase the available running hours. All the units are about 20 years old and can continue to provide useful service with existing manpower if maintained properly.

Under the no-action alternative, use of existing old units with existing capacity to provide peak power will continue to degrade air quality because of the low efficiency & old design associated with boiler and turbine operation. The disparity between the minimum and maximum daily power demand in the region will continue to increase. The continued increase in the base load for the grid and relative reduction in available peak-load generating capacity will further increase the frequency and duration of power outages and load shedding hampering economical development and causing public agitation.

5.1.3 Alternative-3: Small Power Facilities

New distributed generating capacity (e.g., based on small-scale cogeneration plants, micro diesel turbines, and/or fuel cell technologies) would also be subject to fuel supply, cost effectiveness and peak-demand delivery limitations apart from limitations like:

- Due to the hilly topography of major load centers such as Sana'a, Taiz, Ibb etc, it is difficult to get suitable land for power facility development.
- Locating a power plant in valley, topography like Sana'a surrounded by hills, will be critical from air pollution point of view due to poor dispersion of air pollutants, cold climate and less oxygen in air being located at high altitude from sea level.
- There is acute dearth of water resources in most part of Yemen, which is essential requirement of power facility developments.

5.1.4 Alternative-4: Natural Gas Fired Boilers

Based on the other viable alternative study, the alternative environmental friendly power source is considered to be natural gas. With natural gas reserves of 16.9 trillion cubic feet (Tcf), Yemen has considerable potential as a natural gas producer and exporter. The bulk of Yemen gas reserves are concentrated in the Marib-Jawf fields, operated by the Yemen Exploration and Production Company (YEPC). There is proposal under consideration to lay the gas pipeline from Marib to Aden (Marib- Mabar- Hodeidah-

Mokah- Aden pipeline) as reported by plant personnel. The boilers at the power station were designed for use of either gas or heavy fuel oil. There would appear to be no technical problems associated with conversion. This flexibility facility should also be incorporated in specification of new boiler. It is understood that the sulfur levels in the natural gas in Yemen are very low. This would have a substantial impact in reducing SO_2 emission from stack and addressing the existing corrosion difficulties in the boilers. However, this option is not readily viable as natural gas is not readily available on a preferential basis in the project area.

5.1.5 Alternative-5: Oil Fired Boilers

The only viable alternative power source is the construction of Heavy Fuel Oil-fired thermal generating stations or gas turbine units. The impacts associated with oil-fired plants include incremental increases in sulfur dioxide (SO_2) emissions, green house gas CO_2 addition and depletion of finite fossil fuel resources reserve. AL-Hiswa power station has experienced major environmental and boiler technical problems principally due to the use of high sulfur content fuels. Power Plant staff is trying to address this problem through the blending of lower sulfur content fuel. But this option has also its limitation due to non-availability of low sulfur content from ARC.

5.1.6 Conclusion

The only alternative remained under present condition is to increase efficiency of boilers and turbines by its overhauling, provision of one new stack with adequate height for new boiler to disperse SO_2 properly and blending of fuel oil with low sulfur content oil as far as practicable. When gas availability will be in Aden, the Plant would be switched over to natural gas power source.

5.2 SUBSTATIONS

The proposed sites of substations are physically visited to examine its suitability and to identify other better alternative sites, if any, from environmental and social point of view. The observations are discussed as below:

5.2.1 Expansion of Al-Hali Substation

The proposed development work will be executed within existing boundary of sub-station and no extra land will be required for this. No alternative is required to be identified.

5.2.2 New Kilo 16 Substation

The identified land selected among other alternatives is located at the outskirt of city area and there is no habitation surrounding the land. The present land use of the land is barren land with sandy soil.

5.2.3 Expansion of Dhamar Substation

Dhamar substation is an existing substation and its development work will be done within the existing premises. The surrounding area is not inhabited and adequate land within the existing boundary is available for the extension of this substation. This is the only alternative in Dhamar with least environmental and social concerns.

5.2.4 New Yarim Substation

This is the new substation to be constructed for relieving over loading of Dhamar substation. The identified land is located away from city area and located just side of the existing Dhamar-Taiz 132 KV transmission line from which the tapping will be made. The site has already been acquired and the boundary wall has already been constructed. The site selected for this substation among all alternatives is with minimum environmental and social concern.

5.3 TRANSMISSION LINES

PEC is strengthening its transmission line network due to the following main reasons:

- Ensuring power distribution from excess generated power to other load centers in shortage of power.
- Interconnection among load centers to have flexibility for ensuring reliable and quality power supply.
- Improving system performance and reducing transmission losses

5.3.1 No action alternative

As discussed under power generation alternatives, electricity is the key to socio-economic development of a country and it is required to bridge the gap between demand & supply of power in Yemen immediately with no alternative. Energy and load management plans to reduce need for additional power are long term efforts and are having limitations to meet the pressing demand. Hence, taking no action to meet the needed capacity as an alternative is not possible. The existing transmission grid would not provide a secure and reliable electricity supply with projected load growth. Hence, network capacity has to be strengthened to get the benefits of increased generation as one alternative.

5.3.2 Alternative-1: Small power facilities

The other alternative is construction of smaller power facilities closer to the loads as an alternative to bulk power transmission. Wherever possible, it has been adopted as major policy of load development. But in Republic of Yemen, this option has some limitations as discussed below:

- Due to the hilly topography of major load centers such as Sana'a, Taiz, Ibb etc, it is difficult to get suitable land for power facility development.
- Locating a power plant in valley, topography like Sana'a surrounded by hills, will be critical from air pollution point of view due to poor dispersion of air pollutants, cold climate and less oxygen in air being located at high altitude from sea level.
- There is acute dearth of water resources in most part of Yemen, which is essential requirement of power facility developments.
- Heavy fuel oil is main fuel available for power facility development, which is having high sulfur content. As discussed earlier, utilization of this fuel results high emission of SO_2 and also causes corrosion of boiler. As such, natural gas as cleanest fuel available in Marib, is planned to be utilized in 300 MW (Stage-I) gas based Power Plant under construction at Marib itself.

5.3.3 Alternative-2: New transmission lines

As such, main bulk of power will be generated at Marib in near future and therefore, the surplus power after meeting the peak demand of Sana'a and Marib region has to be

transmitted to different remaining parts of Yemen (refer **Figure-3.3.1** showing transmission network). This requires strengthening of existing transmission network and laying new transmission lines as shown in **Figure-3.3.1**. And it is most justified alternative.

As a result of this alternative, PEC proposes to develop a national grid to ensure reliable and quality power to all parts of Yemen. As a part of this, it is technically justified to reinforce/debottlenecking existing Dhamar- Hizyaz 132 KV transmission line having a double circuit capacity of 100 MW to transmit an excess of 445 MW at peak as a lifeline of southern part of Yemen with the new generation at Marib. Another 132 KV transmission line selected under this project is the 12 km long Al-Hodeidah-Kilo16 line connecting Al-Hali substation in Al-Hodeidah city and proposed Kilo16 substation. Technical justification of this line has already been discussed in Chapter-1 of this report. This line is required to transmit power from existing AL-Hali substation to Kilo 16 substation near industrial and commercial zone with minimum loss and development option in future. This is the only alternative to supply reliable and quality power to this area ensuring its commercial and industrial development of the area.

As it is now concluded that among other alternatives, the best is the for strengthening of existing Dhamar-Hizyaz transmission line and new Al-Hodeidah-Kilo 16 line, the following section describes about route selection of these lines.

5.4 ALTERNATIVE ALIGNMENTS FOR NEW TRANSMISSION LINES

The most critical environmental decision associated with electrical power transmission line construction and operation is route selection. Many of the environmental impacts resulting from electric power transmission lines can be avoided or minimized by careful route selection. Environmental Consultant has discussed with PEC transmission line engineers about possible alternative routes for the proposed power lines and combined visit was conducted for physical verification of alignment.

5.4.1 Hodiedah - Kilo16 New Transmission Line

Three alternatives routes are possible for transmission line from existing Al-Hali sub-station in Hodeidah city to new proposed Kilo 16 sub- station as discussed below:

Alternative-1: Shortest route

The alternative-1 alignment route is shortest route connecting straight Al-Hali and Kilo 16 sub-stations. This alignment is passing through densely populated area and land is not available for either for placing towers or for Right-of-Way. Moreover, the line has to cross so many residential and commercial buildings which not permissible. Therefore, this alternative is not feasible.

Alternative-2: Roadside alignment

The alternative-2 alignment route is slightly longer route following existing road passing through the city area. 33 KV transmission lines are already passing on both sides of the road and it is not safe to take 132 KV transmission line through busy traffic route. And is minimum building clearance is not available throughout the route. Therefore, this alternative is not feasible.

Alternative-3: Long route outside city area

The alternative-3 alignment route is the longest route (about 12 km) following ROW of existing 132 KV feeder line coming from Ras Katenib power station upto 54th tower (about 2.6 km) and then it is diverted to Kilo 16 sub-station. This alignment is passing out of city area through uninhabited and sandy barren land. About 15 nos. slum dwellers of rag pickers are residing in unauthorized way along 200 m length of ROW of existing 132 KV line. These rag pickers will be resettled suitably as reported by concerned officials. Minimum 50 m ROW is required for two transmission lines (one new and one existing).

Among the three alternatives, alternative-3 is the preferred option with least environmental and social concern. The ROW selected for this alignment is out of the future city development plan area and land use is sandy barren land.

5.4.2 Dhamar - Hizyaz New Transmission Line

Alternative-1: Upgrading Existing Line

One of the alternatives is upgrading the existing transmission line between Dhamar and Hizyaz. This line needs to remain operational as it is the only line supplying electricity between Dhamar and Sana'a. As future lifeline for this region of Yemen, another parallel line is required for reliable and secure supply of electricity.

Alternative-2: Proposed Alignment Parallel to Existing Line

The alignment of existing transmission line is passing through most of the hilly barren terrain and it is always preferred option to utilize existing transmission line route. The experience of PEC transmission line engineers and physical verification of site conclude that it is the alignment of least environmental and social concerns among all alternatives. Above all, the proposed alignment parallel to the existing line has the main advantage of closeness to the Sana'a to Dhamar highway from where it is easily accessible for construction, inspection & maintenance

Alternative-3: Shortest Alignment through Hills

Though totally new shortest alignment only through hills may avoid agricultural land, but it has to cross more hills increasing difficulty in access of construction & maintenance man & machineries and increasing cost of construction & maintenance, and above all, totally new access roads has to be build for construction, inspection & maintenance that will increase the project cost tremendously..

Among the three alternatives, alternative-2 is the preferred option because of the advantages of proximity of highway and the existing line for ease of construction, inspection & maintenance and least project cost.

5.5 CONCLUSION

The proposed locations of all development works associated with three components of project are observed to be sound among other available alternatives from environmental, socio-culture and economic point of view.

5.6 SUMMARY OF ANALYSIS OF ALTERNATIVES

A summary of the analysis of alternatives in terms of alternative expansion options of the power station, alternative sites for the new substations and alternative routes for the new transmission lines is presented in **Table-5.1**.

Table-5.1 Summary of Analysis of Alternatives

Alternatives	Merits	Demerits
	Expansion of Al-Hiswa Power Station:	
Alternative-1: No Action Alternative	No additional constructional & operational impacts.	Existing old units of low efficiency & old design will continue high fuel oil consumption & more air pollution and high O&M cost. Power shortage will continue hampering economical development. During load shedding people will use generators, kerosene lamps & candles resulting air & noise pollution.
Alternative-2: Expansion of Al-Hiswa Power Station	Infrastructures like land, water, fuel, offices, auxiliary units, power evacuation system etc. and staff already exists and no expansion of infrastructures or staff is required. It is close to the demand area.	None
Alternative-3: Small Power Facilities	Distributed generating capacity in demand areas	Cost effectiveness & peak-demand delivery limitations, more air pollution, acute dearth of water resources in most part of Yemen
Alternative-4: Gas Fired Boilers	Less pollution (no SO_2 & particulates emission), Cost effective	No gas is readily available in Aden at present.
Alternative-5: Oil Fired Boilers	Supply & storage facility readily exists.	More air pollution than gas fired boilers (SO_2 & particulates pollution).
	Route of Hodiedah - Kilo16 New Transmission Line	
Alternative-1: Shortest route	Shortest length, minimum transmission loss.	Passing through densely populated area. Land not available for towers & ROW. The line has to cross many buildings.
Alternative-2: Roadside alignment	Slightly loner route.	33 KV lines already exsit on both sides and it is not safe to take 132 KV line through city area. Minimum building clearance is not available.
Alternative-3: Long route outside city area	Passing out of city area through uninhabited and sandy barren land.	Longest route.
	Route of Dhamar - Hizyaz New Transmission Line	
Alternative-1: Upgrading Existing Line	No new route is required.	Existing line needs to remain operational as it is the only line supplying electricity between Dhamar and Sana'a.
Alternative-2: Proposed Alignment Parallel to Existing Line	Advantage of ROW of existing transmission line and closeness to the Sana'a to Dhamar highway from where it is easily accessible for construction, inspection & maintenance.	Crossing through some small agricultural lands.
Alternative-3: Shortest Alignment through Hills	Shortest alignment and avoid agricultural land.	Crossing more hills. Difficulty in access of construction & maintenance man & machinery and increases construction & maintenance cost. New access roads to be build that will increase the project cost tremendously.

6.0 ENVIRONMENTAL IMPACTS OF THE PROJECT & MITIGATION MEASURES

The proposed project will have impacts on the environment in two distinct phases. During the construction phase which may be regarded as temporary or short-term; the other during the operation stage, which will have long term effects. The environmental impacts in this study have, as such, been discussed separately for the construction phase and the operation stage.

Identification of impacts is followed by recommendations of appropriate cost effective mitigation measures. These impacts along with the mitigation measures are given in the following sections.

Spatially the impacts have been assessed in the study area or area of influence around the project sites (power station and substations) and within the ROW of the transmission lines. Overall impacts in the regional context are negligible unless stated otherwise.

6.1 PROJECT ACTIVITIES

The project will involve:
- Construction and operation one new boiler in the Al-Hiswa power station
- Construction and operation of two new substations, and expansion & their operation of two substations
- Construction and operation two new transmission lines

6.1.1 Activities during Construction Phase

During the construction phase, the following activities among many are considered to be important towards creating environmental impacts:

During construction of new components in existing power station:
- Excavation, backfilling and leveling
- Hauling and dumping of earth materials & construction spoils
- Foundation works
- Erection of concrete & steel structures
- Painting and finishing
- Clean up operations
- Clean up operations, landscaping and plantations

During construction of new components in existing substations:
- Excavation, backfilling and leveling
- Hauling and dumping of earth materials & construction spoils
- Foundation works
- Erection of steel structures
- Painting and finishing
- Clean up operations

During construction of new substations:
- Site preparation (fencing, boundary & clearing of site)
- Excavation, backfilling and leveling

- Hauling and dumping of earth materials & construction spoils
- Foundation works
- Erection of steel structures
- Construction of internal offices, roads, drains & water supply
- Painting and finishing
- Clean up operations, landscaping and plantations

During laying of new transmission lines:
- Clearing & grading of area of the towers
- Foundation & erection works for towers
- Tieing of the cables
- Clearing trees in the ROW

The main sources of pollution & impacts during construction phase are cutting of few trees & bushes, dust generation, noise generation by construction equipment & traffic, inflow of construction labour, sediment load in construction wastewater, and generation of solid waste in the form of construction spoils.

6.1.2 Activities during Operational Phase

During the operation phase, the following activities among many are considered to be important towards creating environmental impacts:

During operation of new components in existing power station:
- There will have certain sources of pollution & impacts in the power station. The said expansion of the power station involves the setting up of certain additional units and facilities within the existing plant premises for producing power. The operation of the project which, in other words, involves burning of fuel oil in boilers, water uptake and waste handling operations at the site, would necessarily involve additional discharge to the environment of wastewaters, solid wastes, air emissions from stacks and generation of noise.

During operation of substations & transmission lines:
- Project activities during operation phase include transmission of electricity through the overhead transmission lines and substations. There will have as such no sources of pollution & negative impacts, except waste transformer oils.

Impacts on various environmental components during construction phase and operation phase are discussed below along with suitable mitigation measures.

6.2 IMPACTS OF AL-HISWA POWER STATION DURING CONSTRUCTION

Construction phase activities would have moderate impacts on on-site noise & air quality. It could also develop minor impacts on on-site soils, landuse, water use, water quality, & ecology. It will have also minor local socio-economic impacts.

6.2.1 Impacts on Topography & Impacts of Earthquake

<u>Impacts on Topography & Impacts of Earthquake</u>
- The construction site is a piece of plain vacant land within the plant premises and no major cutting or filling is involved during construction. Therefore no disfiguration of topography is envisaged.

- Aden being prone to earthquake of small intensities there will have a low risk of potential damage due to earthquake.

Mitigation Measures
- Suitable seismic design of the new units will be adopted to mitigate the earthquake impacts in future.

6.2.2 Impacts on Soil

Impacts on Soil
- The construction activities would be confined to a very small area within the existing plant premises and therefore the impacts on soil will be negligible.
- During storms, some of the excavated soil and construction materials such as sand, cement etc. would be blown up in the air and dispersed in the power plant.

Mitigation Measures
- Plantation & turfing at open spaces in the power plant has been undertaken to restrict soil erosion.
- Construction materials would be stored in covered godowns or enclosed spaces.

6.2.3 Impacts on Land Use

Impacts on Land Use
- No additional land acquisition is involved for the additional units. The construction activities for additional units would be confined to a very small area within the existing boundary of the plant premises and therefore the impacts on landuse will be negligible. There will be no impact on the landuse outside the plant premises.
- All infrastructures like access roads, offices, godowns, drainage, water supply etc. already exists. No new such construction is required that may alter the land use pattern of the site.
- As construction labourers and suppliers will be accommodated within the plant premises it will not hamper the land use aspect outside.
- Generation of construction spoils from construction sites.

Mitigation Measures
- Construction camp will be located within the plant premises to avoid indiscriminate settlement of construction laborers.
- The small amount of construction spoils will be disposed of in suitable pre-identified areas within the plant premises.

6.2.4 Impacts on Drainage & Water Use

Impacts on Drainage & Water Use
- As adequate drainage exists in the plant, no problem of water stagnation is anticipated in the construction site.
- Impact on the local water sources due to use of construction water.
- As no ground water will be abstracted, there will be no impact on the ground water.

Mitigation Measures
- Existing drains near the construction site will be regularly cleaned to avoid problems like formation of stagnant water pools, soil erosion & breeding of mosquitoes

- The water demand for the proposed units during construction will be met from the existing sources (piped supply) within the plant area and, therefore, not likely to have impacts on other users.

6.2.5 Impacts on Water Quality

Impacts on Water Quality

- Sediments in the run off from construction sites will increase the turbidity of receiving streams/water bodies.
- Water pollution due to sewage and sullage from construction camps.

Mitigation Measures:

- Construction wastewater emanating from the construction site will be disposed through suitable drainage system & desilting basin for arresting the silt/sediment load before its disposal into the main natural drainage system near the site.
- Proper sanitation facilities already exist inside the plant that will be provided to the construction personnel to prevent water & sanitation related health problems.

6.2.6 Impacts on Air Quality

Impacts on Air Quality:

- Deterioration of air quality due to fugitive dusts emission from construction activities like excavation, backfilling & concreting, and hauling & dumping of earth materials & construction spoils, and vehicular movement along unpaved roads.
- Deterioration of air quality due to gaseous emissions from construction equipment & vehicular traffic.

Mitigation Measures:

- Construction materials would be stored in covered godowns or enclosed spaces.
- Truck carrying soil, sand and stone will be duly covered to avoid spilling.
- Adequate dust suppression measures such as regular water sprinkling in unpaved areas of the construction sites will be undertaken to control fugitive dust during material handling & hauling activities.
- Stringent construction material handling/overhauling procedures will be followed.
- Low emission construction equipment, vehicles and generator sets will be used.
- Construction machinery would be in good working condition and engines turned off when not in use.

6.2.7 Impacts on Noise Level

Impacts on Noise Level

- Increase in noise level due to construction activities like operation of construction equipment & vehicular traffic.

Residential areas being mostly far away, no significant impact is apprehended. This projection is already evident from the base line noise scenario. When construction of new Turbine was under progress, ambient noise level of 75.8 dB(A) was observed near the plant Main Gate, which are within the permissible limit for industrial area.

Mitigation Measures

- Construction camp will be located away from the immediate vicinity of the construction sites.
- Protective gears such as ear plugs etc. will be provided to construction personnel exposed to high noise levels as preventive measure.
- Low noise construction equipment will be used.
- Construction machinery would be in good working condition and engines turned off when not in use.

6.2.8 Impacts on Flora & Fauna

Impacts:

- The proposed construction site is a piece of vacant land and no tree is found there. Therefore, there will no loss of flora.

Enhancement Measures

- Plantation in the available open spaces of the plant will be undertaken to enhance the floral resources.

Impacts on Fauna

- As the proposed construction site is a vacant space lying within existing plant area, **no impact** on fauna during construction is expected.

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6.2.9 Impacts on Socio-economics

Impacts on Socio-economics

- As the land required for the proposed expansion is a piece of barren & vacant land existing within the plant premises, no additional land acquisition is necessary for the expansion. Therefore, the expansion will not involve any loss of agriculture, displacement of people or demolition of public properties.
- It is estimated that a substantial construction personnel including skilled, semi-skilled and unskilled labourers employed by various contractors will work at site during the peak period of construction phase. Since most of sizeable labor force will be drawn from neighborhood, no change in demographic profile is anticipated. Only for a few skilled personnel, brought to site from outside the locality, proper housing/ accommodation would be provided in the construction camps.
- Due to employment opportunities, some competition among workers during construction phase is anticipated.
- Procurement of construction materials will generate trading opportunities.

Mitigation Measures:

- Most of the unskilled construction labourers will be recruited from the local areas to create some employment opportunities and sense of well being among local people. This will also reduce social tension of migration.
- Some of the construction materials like stone chips & sand will be procured locally to for generation of local trading opportunities, though temporary.

Impacts of construction labourers:

- Influx of construction work-force & supplier who are likely to construct temporary tents in the vicinity.
- Likely sanitation & health hazards & other impacts on the surrounding environment due to inflow of construction labourers.

Mitigation Measures:

- Temporary construction camps at designated sites within the plant premises.
- As most of the job will be done by contractors, it will be ensured that the contractor's workers are provided with adequate amenities, health & sanitation facilities in the camp by the contractor.
- It will be ensured that wastes from construction camp is cleared regularly

6.3 IMPACTS OF AL-HISWA POWER STATION DURING OPERATION

Operation phase activities would have moderate impacts on air quality & water quality due to addition emission & wastewater. It could also develop minor impacts on on-site noise & water use. It will have also minor positive socio-economic impacts.

The process description including quantum of pollution loads from liquid and gaseous effluents and solid wastes considering their proposed environmental control measures has been discussed earlier in detail in the “Project Description” Chapter.

6.3.1 Impacts on Soil

Impacts on Soil

- The impact of fall out of pollutants present in the industrial emissions on soil quality is rather a slow process. There is no evidence of any adverse impact on soil quality due to power plant emissions & wastes. Moreover, it would be noted from the findings of air pollution dispersion modelling that the pollutant levels will increase only marginally due to the plant operations. At these levels, however, no appreciable adverse changes in the soils are anticipated. Moreover, the soil around the plant being sandy of no agricultural value, it shall be of no importance to ensure that no degradation of soils shall result from the emissions.
- Degradation of top soil of the non-built up portion of the construction site.

Mitigation Measures

- The top soil in non-built up areas of plant would be restored and such portions of the site would be subjected to plantations which would help in bonding together of the soil, thus increasing its strength.

6.3.2 Impacts on Land Use

Impacts on Landuse

- Following the construction phase, the temporarily modified land use pattern, such as construction of temporary camps/tents to accommodate some construction personnel would gradually stabilize itself during the operation stage.
- The operation of the plant has already impacts on the land use pattern of the surrounding area over a period of time, mainly in the form of some induced peripheral developments like residential areas. However, this small expansion is not expected to induce any radical changes of the existing land use pattern of the surroundings.
- Solid waste from the plant is mainly domestic scraps & papers which are transported and disposed as per the prevailing practice in the area. No significant additional solid waste will be generated by this small expansion of the plant, therefore no impact.

Mitigation Measures

- Land released from the construction activities would be put to economic and aesthetic use to hasten recovery from adverse impacts.
- Plantation of trees in the open spaces will be undertaken which would add a different dimension and would provide a visual comfort.

6.3.3 Impacts on Water Use

The plant water requirement consists of:

- Once through cooling sea water for condenser & auxiliary cooling system from the Gulf of Aden.
- Demineralized water for boiler make up from the Desalination Plant.
- Drinking water for canteen, office, control rooms etc. from the piped water supply from the Water Authority.
- Sanitation water for toilets from the waste DM water from the desalination plant.

Apart from the above continuous requirements other intermittent requirements are:

- For emergency use adequate water is stored in fire water storage tanks for fire fighting in the fuel oil tank farms and other section of the plant.
- The water requirement for gardening is met from the waste DM water from the desalination plant.

Impacts on Water Use

- The additional water requirement for the new boiler is only Demineralized water. As this additional water requirement for operation & maintenance will be met from the existing sources there will no impact on water use aspects outside the plant.

Mitigation Measures

- Additional water requirement would be met from the existing sources within the plant area.

6.3.4 Impacts on Water Quality

The plant wastewater streams consist of:

- Once through return cooling water.
- Boiler blow down.
- Waste/unsuitable DM water from the desalination plant (that fails to meet the required standards for use in the boilers).
- Oily drainage from the fuel oil tank farms, fuel oil pump area, boiler area & other plant drains.
- Sewage from the toilets & canteen.

All the wastewater in the plant is treated properly in respective treatment plants. The wastewater treatment in the plant consists of:

- The return hot cooling water is directly discharged into the sea (Gulf of Aden) through a rectangular covered concrete discharge channel. The discharge point is about 800 m away from the cooling water intake point. The temperature of the return cooling water is about 4°C more than the intake cooling water temperature.

- The boiler blow down and the waste/unsuitable DM water coming from the desalination plant is collected in an underground tank where it gets mixed and the pH of the boiler blow down neutralizes. The water from this tank is then reused for gardening, toilet flushing, canteen & floor washing.

- The drainage from the fuel oil tank farms, fuel oil pump area, boiler area & other plant drains (due to routine cleaning and maintenance) contains some traces of oil escaped during handling. In order to arrest any oil, the same is led to **oil water separator**. The oil free effluent is then led to an underground siltation tank to arrest any suspended solids. The oil & sediment free clear supernatant effluent after satisfying the stipulated regulatory standards is stored in a treated effluent sump and then intermittently pumped & disposed into the sea through the cooling water discharge channel where it gets huge dilution before its final disposal into the sea.

- The sanitary wastewater including any canteen wastewater is collected in a sewage sump & then intermittently pumped to the sewage treatment plant (STP) to assure necessary treatment and to meet the regulatory standards. The STP consists of underwater bubble type aerators. The treated sewage is stored in the treated effluent sump (where treated oily wastewater is stored). The combined treated effluent is led out of the plant premises by intermittently pumping into the cooling water discharge channel where it gets huge dilution before its final disposal into the sea.

Impacts on Water Quality

- As all the effluents are completely treated and their quality conforms to the prescribed discharge standards, no tangible impact is observed on the surface water quality in the study area due to the project.
- The temperature of the return cooling water is only about 4°C more than the intake cooling water temperature. And when it discharged into the sea it gets huge dilution and no tangible negative impact on sea ecosystem has been observed near the discharge point.

6.3.5 Impacts on Air quality

Impacts:

- Air pollution due to stack emission from the plant.

Detailed air quality modelling has been carried out for predicting the concentration of sulphur dioxide (SO_2).

6.3.5.1 Air Quality Modelling

Upon discharge to atmosphere, the emissions from sources are subjected to transport and diffusion processes which together are termed as dispersion. The main processes which govern the atmospheric dispersion of pollutants are plume rise, transport by wind, diffusion by turbulence.

Pollutants emitted from stacks have the potential to deteriorate the air quality of the area. In order to evaluate the impact on ambient air quality due to such releases, the ground level concentrations (GLCs) as a result of the plant emissions have been evaluated through mathematical modelling using computer aided techniques.

The Model

Ambient air quality prediction at different receptor locations has been carried out by using most widely used air quality model **ISCST-3** developed by the US-EPA. The model is based on Gaussian diffusion equation & Pasquill stability classes and given the site characteristics, average time, source strength and meteorology, the model predicts concentration of pollutants.

Model Input

The modelling is based on some assumption such as flat terrain with rural characteristic, steady state conditions, continuous homogeneous flow, inert passive pollutants, no ground absorption and a Gaussian distribution of the plume in both horizontal and vertical planes.

Sources of Emissions

Existing sources of emission in the plant are 3 number of 80 m tall stacks, each connected to 2 boilers of 160 t/h capacity each. There will be one new source, the stack to be connected with the new proposed boiler of 160 t/h capacity which will contribute additional emission from the plant.

Stack & Emission Characteristics

In the process of power generation fuel oil is burnt in the boilers at high temperatures and as a result stack emissions consists of mainly, sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). Other emissions like particulates, Carbon Monoxide (CO) and Hydrocarbons (HC) are negligible and therefore are not considered for modelling.

The stack and emission characteristics pertaining to the existing and proposed stacks are presented in **Table-6.3.1**. The location of the stacks has been shown in the plot plan.

Table-6.3.1 Stack and Emission Characteristics of Al-Hiswa Power Station

Particular and Unit	Stack-1 (existing)	Stack-2 (existing)	Stack-3 (existing)	Stack-4 (proposed)
Connected boiler nos.	Boiler 1&2 (existing)	Boiler 3&4 (existing)	Boiler 5&6 (existing)	Boiler 7 (proposed)
Stack co-ordinates (x,y) in m	33.8,12.3	0,0	-38.5,-14.0	-84.6,-30.8
Physical stack height (m)	80	80	80	110
Internal diameter of flue at top (m)	3.6	3.6	3.6	2.5
Flue gas exit velocity (m/s)	14.5	14.5	14.5	20
Flue gas temperature (°C)	165	165	165	165
Flue gas flow rate (m^3/s)	147.2	147.2	147.2	73.6
SO_2 Emission rate (kg/h)	1218	1218	1218	406
SO_2 Emission rate (mg/Nm^3)	3686	3686	3686	1842

Notes:
1) Basis of emission figures:

Fuel oil consumption rate for 160 t/h capacity existing boiler = 10.5 t/h
Fuel oil consumption rate for 160 t/h capacity proposed boiler = 7 t/h
Average sulphur content in fuel oil = 2.9% by wt
Capacity of existing ID fans = 265000 m^3/h

2) Stack height of the new stack:
   a) Minimum stack height requirement of 160 t/h new boiler = $14Q^{0.3}$ = 14 $(406)^{0.3}$ = 84.86 m (say 90 m), where Q is the SO_2 emission rate in kg/h.
   b) Minimum stack height requirement of 160 t/h proposed new boiler keeping the provision of connection to another 160t/h new boiler in future = $14Q^{0.3}$ = 14 $(406 \times 2)^{0.3}$ = 104.47 m (say 110 m).

From the fuel oil analysis results collected from the plant management for last two months (May & June 2005), it is evident that average sulphur content in fuel oil fed into the boilers is 2.9% by wt. Based on this sulphur content and average fuel oil consumption of 10.5 t/h per boiler, it is estimated that the plant discharges SO_2 at the rate of 609 kg/h per boiler i.e. 87.696 t/day at its full operating load of 125 MW which is far above the World Bank permitted level of 25 t/day (World Bank guideline stipulates that SO_2 emission should be less than 0.20 metric tons of per day per MW). In Republic of Yemen, there is no SO_2 emission standard.

Design details of the new boiler & its stack will be prepared by the Project Consultant who is yet to be appointed. Therefore, for this project it has been assumed that the proposed 7th boiler of 160 t/h capacity will be of latest technology & high efficiency and its fuel oil consumption rate will be about 7 t/h. Then its SO_2 emission rate will be 0.16 tpd per MW which is within the World Bank guideline of 0.2 tpd per MW.

The stack height & other parameters for the proposed stack for the proposed new boiler are computed using standard calculations. For the new stack, it is recommended to keep the minimum stack height of 110m which has been computed based on the 2.9% sulphur content in fuel oil, 7 t/h of fuel oil consumption in the new boiler and keeping the provision of connection to another 160 t/h new boiler in future. The other recommendations are: stack exit diameter of 2.5 m & stack gas exit velocity 20 m/s.

Meteorological data

Hourly meteorological data (e.g. ambient temperature, wind speed and wind direction) of Aden (given in **Annex-2**) collected for the period 17th to 23rd July 2005 and has been used as input to the model. The distribution of wind in 16 cardinal directions (prepared for the period based on the hourly wind data) is presented in **Table-6.3.2**. From the table it can be observed that most of the time the wind blows from south and south-southwest.

Table-6.3.2 Distribution of Wind in Aden Region (during 17/7/2005-23/7/2005)

Wind from	% Frequency of Occurrence of Wind Speed (km/h) within Class						
Direction	1.8-6	6-11	11-19	19-29	29-39	>39	Total
N	1.19	0	0.6	0	0	0	1.79
NNE	1.19	2.38	0	0.6	0	0	4.17
NE	1.19	2.98	2.38	2.38	0	0	8.93
ENE	0.6	2.38	0.6	0	0	0	3.57

E	1.79	4.76	2.38	0	0	0	8.93
ESE	2.38	2.98	2.38	0.6	0	0	8.33
SE	1.19	2.38	1.79	0.6	0	0	5.95
SSE	0	2.38	3.57	1.19	0	0	7.14
S	0	1.79	3.57	10.71	2.38	0	18.45
SSW	1.19	1.19	1.19	4.17	4.76	1.19	13.69
SW	0	0.6	0.6	0.6	0	0	1.79
WSW	0.6	0	0	0.6	0	0	1.19
W	1.19	1.79	0	1.19	0	0	4.17
WNW	0.6	1.79	0	1.19	0	0	3.57
NW	0	1.79	0	0	0	0	1.79
NNW	0	0	0.6	0	0	0	0.6
Calm							5.95
Total	**13.10**	**29.17**	**19.64**	**23.81**	**7.14**	**1.19**	**100**

Average wind speed: 14.51 km/h

Modelling Procedure

Pollutants : SO_2
Averaging time : 24-hourly

Stack & emission data for the future stack (i.e. stack-4) as given in **Table-6.3.1** has been used for the model input. The actual locations of the stacks have been defined in a Cartesian co-ordinate (x,y) system with middle stack (stack-2) as origin or Absolute Reference Point (ARP), x-axis along the East direction and y-axis along the North direction.

It may be noted that, when ambient air monitoring was conducted all the units of the plant was in operation, and therefore, the concentration of pollutants monitored at field includes the effect (i.e. pollutant concentration) imparted or contributed by the existing stacks. ***Therefore, the modelling for projection/prediction of incremental concentration of pollutants has been made only for the proposed future stack (i.e. stack-4).***

6.3.5.2 Modelling Results & Discussion

As observed from modelling results presented in **Table-6.3.3**, the predicted 24-hourly maximum GLCs for the future stack will be about 3.8 $\mu g/m^3$. When the maximum predicted increment of SO_2 (in the Power station camp) is superimposed on /added to the maximum present background/baseline level (55.5 $\mu g/m^3$), the resultant maximum ambient level of SO_2 is expected to attain a value of about 59.3 $\mu g/m^3$, which is within the permissible limit of 125 $\mu g/m^3$.

Table-6.3.3 Air Pollution Modelling Results

SN	Location	Direction	Distance (km)	24-hourly GLC of SO_2		
				Max Baseline Level (Monitored)	Predicted Max Increment for Stack-4	Total Projected Concentration
1	Power Station	North	0.9	55.5	3.8	59.3

SN	Location	Direction	Distance	24-hourly GLC of SO_2		
	Camp					
2	FZP Guesthouse	Northeast	0.8	40.5	2.8	43.3
3	Radio Station Office	West	0.6	46	2.2	48.2
4	University Campus	North	1.3	40.3	3.3	43.6

From analysis of the air quality modelling results stated above the following pictures can be drawn:

- The 110 m tall future stack would assist in a wide spatial dispersion of pollutants, thus lowering the GLCs (predicted maximum increment is only 3.8 $\mu g/m^3$).

- The coastal high speed wind assists in a wide & quick dispersion of pollutants, thus lowering the GLCs, which is reflected in the relatively low monitored GLCs of SO_2 (maximum only 55.5 $\mu g/m^3$) though its present emission rate is quite high (about 3654 kg/h compared to the World bank guideline of 1042 kg/h for 125 MW power production).

It may, therefore, be concluded that the setting up and operation of the proposed new boiler will not cause any intolerable impact on the ambient air quality.

Mitigation Measures
- As the SO_2 emission levels of the existing boilers is very high, it is desirable to use low sulphur fuel oil in the boilers to the maximum extent possible and switch over to natural gas when it is available.
- New boiler should be of dual firing system (fuel oil as well as natural gas).

6.3.6 Impacts on Noise Level

Impacts on Noise Level
- The operation of certain machinery like boilers, pumps and compressors generate high and continuous noise inside the plant. However, due to geometric attenuation and atmospheric absorption, noise level beyond the plant boundary does not exceed permissible limit as already evident from the noise monitoring results. Though operational activities do not cause any continuous undue disturbances to the local residents outside the plant boundary, there are impacts on plant workers working very close to the sources.
- And pressure release through the safety valves of the existing boilers generates loud noise that creates nuisance to residents of the surround area particularly during night time sleep.

Mitigation Measures
- Administrative office is located away from the boiler/ pump/ compressor house.
- Impacts of noise on workers are minimized through adoption of adequate protective measures in the form of (a) use of personal protective equipment (ear plugs, ear

muffs, noise helmets etc.), (b) education and public awareness, and (c) exposure control through the rotation of work assignments in the intense noise areas.
- For expansion project low noise equipment should be installed.
- Safety valves of the existing boilers should be augmented to reduce the noise level.

6.3.7 Fire & Safety

Impacts:
- Fire hazard due to fuel oil storage tanks, fuel oil pumps and oil fired boilers.

Mitigation Measures:
- Adequate safety measures (for details refer Section 3.2.3 & Section 4.1.11) already exist in the plant for use during the fire emergency that consists of:
  - Fire water storage tanks & pumps
  - Fire hydrants throughout the plant
  - Fire fighting tenders & crews round the clock
  - Portable fire extinguishers ate strategic locations
  - Automatic foam injection system for fuel oil storage tanks & pumps
  - Flame & smoke detectors at strategic locations

6.4 IMPACTS OF TRANSMISSION LINES & SUBSTATIONS DURING CONSTRUCTION

The main impacts of construction phase are construction dust & noise, loss of small amount of agricultural land and few trees and such impacts are long term. It has negligible impacts on water use & water quality. The other impacts of construction phase will be small in magnitude as well as temporary in nature and are expected to wear out gradually once the construction activity is completed.

6.4.1 Impacts on Landuse, Agriculture & Human Settlements

6.4.1.1 Substations

For expansion of existing Al-Hali and Dhamar substations necessary extension will be done in the vacant land within the existing boundary of the substation (as shown in **Figure-3.3.3** and **Figure-3.3.6**). The site earmarked for Kilo 16 substation (**Figure-3.3.4**) is a barren land and located away from inhabited area. In case of Yarim substation (**Figure-3.3.7**) the site has already been acquired and the boundary wall has already been constructed. Therefore **no impact** on landuse is anticipated during construction of the substations. The land requirement and land acquisition status is presented in **Table-6.4.1**.

Table-6.4.1 Land Requirement for the Project

Purpose	Additional Land Requirement (ha)	Acquisition Status
Extension of Al-Hali substation within the existing boundary	Nil	-
Kilo 16 new substation	236 m x 236 m (i.e. 9.5696 ha)	Land has already been earmarked for substation purpose

Extension of Dhamar substation within the existing boundary	Nil	-
Yarim new substation	80 m x 140 m (i.e. 1.12 ha)	Land has already been acquired and the boundary wall has already been constructed around the site

6.4.1.2 Transmissions lines

The route of the new transmission lines have been proposed to avoid planned uses of land and inhabited area of Hodeidah city, following longer alignment almost in barren area. As such, much of the environmental problems have been minimized in corridor routing.

New Transmission Line from Hodeidah to Kilo-16

Impacts

The landuse along the entire route is barren & sandy desert land with little or no vegetation. Rarely some thorny vegetation found in the route. Therefore, there is no impact on the agricultural land.

The route of the Al-Hali to Kilo 16 line avoids inhabited area of Hodeidah city, following longer alignment almost in barren area (**Figure-4.3.6 & 4.3.7**). No human settlement is found close to the route except the first 200 m (between the existing tower nos. 61 and 60) where some squatters are found who are rag pickers (**Figure-4.3.8**). There are about 15 such squatter families within the ROW living in houses of temporary hutment type with earthen wall and thatched roof. As they live within the ROW of the existing transmission line, PEC has the Govt. order to clear its ROW.

Mitigation Measures

- Adequate compensation shall be given to the squatters before their displacement as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.

New Transmission Line from Dhamar to Sana'a

Impacts

The line alignment of the proposed Dhamar to Hizyaz new transmission line has been proposed almost parallel and on the right side of the existing Dhamar to Asser (in Sana'a) 132 KV transmission line upto Hizyaz. The proposed transmission corridor from Dhamar to Hizyaz, like the existing line, is passing through highly undulating hilly terrain (**Figure-4.3.10**). In most part of its 90 km travel it will pass through valleys and encounter some small patches of agricultural land (**Figure-4.3.11**) like the existing line.

The land required for footings of the transmission towers has to be acquired. The right of use of the ROW for maintenance of lines & towers will be vested to PEC. However, the ownership of the land within the ROW remains with the owners, and they are permitted to do cultivation. But building of structures or growing of trees within the ROW is not permitted. Therefore, the value of the land decreases. As cultivation is permitted under

the lines & within the base area of the towers, there will be only minor loss of agricultural land due to footings of the towers.

The settlements near to the alignment are Khidar, Biat Al Jaidi, Wasita, Qatail, Mawar, Bait Almidi and Al-Hijara. As the ROW of the line will not pass through any human settlements, there is no impact.

Mitigation Measures

- Adequate compensation shall be given to the owners of the agricultural land falling within the ROW as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.

6.4.2 Impacts on Water Use & Water Quality

Impacts on Water Use & Water Quality

- Impact on the local water sources due to use of construction water.
- As no ground water will be abstracted, there will be no impact on the ground water.
- Sediments in the run off from construction sites will increase the turbidity of receiving streams/water bodies.
- Water pollution due to sewage and sullage from construction camps.

Mitigation Measures

- The water demand for the proposed units during construction will be met from the existing local supply and, therefore, likely to have minor impacts on other users. For construction of transmission line tower water will be supplied through tankers.
- Construction wastewater emanating from the construction site will be disposed through suitable drainage system & desilting basin for arresting the silt/sediment load before its disposal into the main natural drainage system near the site.
- Proper sanitation facilities will be provided to the construction personnel to prevent water & sanitation related health problems.

6.4.3 Impacts on Air Quality & Noise Level

The impacts and mitigation measures on air quality & noise level during construction of substations & transmission lines will be similar to the construction for exepansion for power station as discussed in sections 6.2.6 & 6.2.7.

6.5 IMPACTS OF TRANSMISSION LINES & SUBSTATIONS DURING OPERATION

The main impacts of operation phase are electrical hazards and socio-economic benefits and such operational impacts are long term. It could also develop minor local impacts due to waste transformer oil disposal containing PCB. Substation operation has negligible impacts on water use & water quality, it has no impact on soil, landuse, air quality, noise level and flora & fauna. Transmission of electricity during operation has no impact on soil, landuse, water use, water quality, air quality, noise level and flora & fauna

6.5.1 Impacts of Electrical Hazards

The following ***Control & Protection System for Transmission Lines*** will be adopted:

- Each circuit of transmission lines shall be controlled through circuit breakers located at both ends (at interconnecting sub-stations) of the lines. These circuit breakers

shall de-energize the circuits automatically on occurrence of fault in the transmission lines.

- The fault in the transmission line may be between conductor to conductor and conductor to ground (in case of snapping of conductor between the towers). PLC based Distance Protection Relays shall be provided to sense and locate these faults and which shall switch off the circuits through circuit breakers.

- PLC based carrier communication through transmission lines shall also be provided for communication between sub-stations which will help in the matter of maintenance of lines, finding location of line fault, etc.

- The entire line route will be routinely patrolled by line walkers engaged by PEC to check the healthiness of the towers, conductors & insulators so that any damage can be repaired timely. They will also monitor the unauthorized construction, if any, within the ROW of the line.

Impacts
- Accidental snapping of conductors may cause electrocution.
- Electro-magnetic induction may cause hazards if minimum clearances are not maintained.
- Unauthorized construction of building or growing of trees may cause accidents.

Mitigation Measures
- All the standard protection measures like circuit breakers, PLC based protection relay, routine maintenance and routine line patrolling by line walkers will be taken. Therefore, the chances of such accidents are very remote.
- As minimum building clearance 5.1 m and ROW of 30 m (including conductor swing) will be maintained throughout the line length, there will be no hazards from electro-magnetic induction.
- No construction of building or growing of trees will be permitted within the ROW to avoid accidents.

6.5.2 Impacts of PCB Oil Disposal

Impacts
- As polychlorinated biphenyls (PCBs) are hazardous to human health its indiscriminate disposal or incineration of waste transformer oil containing PCBs, particularly near inhabited area, may cause health hazards to public.

Mitigation Measures

Disposal of PCB's Contaminated Oils

There is no concrete guideline and policy related to disposal of PCBs contaminated oils, stipulated by Yemeni EPA. Currently, such oil as waste from transformer, capacitor, etc is mixed with other fuel oil and burnt in the boiler of thermal power plant or sold to local industry as burning fuel.

Transformer oil is replaced once in 5 to 6 years and its quantity is not huge. Whatsoever, the waste transformer oil containing PCB will be handled & disposed as per International standard practice as per Code ANSI IEEE Standard 799 (1987), "Handling & Disposal of Transformer Grade Insulating Liquid Containing PCB", Chapter-

10, and USA Toxic Substance Control Act (TSCA) 15 USC 2605. The recommended guidelines for disposal of PCBs contaminated oil for the project shall be as follows:

Recommended Guidelines for Disposal

- Burn the oil in high temperature incineration. For concentrated wastes (having PCBs content more than 50 ppm) incineration at 1200^{o}C for longer than 2 seconds destroys PCBs. PCB waste oil should not be burnt at low temperature.

- Burn the oil in high temperature boiler with adequate stack height located in sparsely populated area like Al-Hiswa Power Plant in Aden. This is the most feasible and safe mode of disposal of PCBs contaminated oil in Yemen.

- The new transformers should be non-PCB type that contains oil/dielectric fluid containing less than 50 ppm PCB. Specification of transformers for its procurement should include this condition. If feasible, the existing transformers should be phased out by non-PCB transformers.

- Training programme should be conducted among the employees handling the PCB containing oils for making awareness about its safe storage, handling & disposal.

- Waste transformer oil containing more than 50 ppm PCB should not be sold as fuel to those local industries that burn it in low temperature.

- PCB oil storage site should be managed properly such that it does not escape to the environment through leaks in containers, drains, sewers, rainwater, flood, cracks/holes in the storage area or other openings. The storage site must be rainwater & flood proof. Its floor & curbing must be impervious and must be able to contain 2 times the volume of the largest PCB container or 25% of total storage volume, whichever is greater.

All efforts should be made to destroy PCB contaminated waste oil so that it does not escape into environment. The best way is to replace/ phase it out at the source by suitable substitute like Mineral Oil.

6.5.3 Impacts on Water Use & Water Quality

Operation of substations needs water for staff and will generate sewage from toilet. As there will be only 1 control staff in a shift to operate & control the substations water requirement will be negligible. The water will be taken from the local supply. The sewage from the toilet will be led to septic tank followed by soak pit to assure necessary treatment and it may therefore be concluded that no impact is likely on the surface or ground water quality.

6.5.4 Impacts of Humidity on Tower Structure

Hodeidah being coastal area & having very high humidity (annual mean relative humidity 73%) & moisture content in the air, the steel structure of the transmission towers gets corroded. To avoid the corrosion the steel structures following measures should be undertaken:

1) ***Initial galvanization***: Initially during erection, the steel members of the transmission towers should be given a treatment of high degree of galvanization.

2) ***Painting after few years when corrosion starts***: After few years of erection if & when corrosion of the members starts these should be painted as per the following specifications:

   For all structural steel work in the coastal area, epoxy primer and epoxy finish paint with total DFT 220-230 micron. For surface preparation Sand Blasting to achieve as per Swedish Standard: SIS – 05 5900 1967 Std. 2.5. After surface preparation apply one coat of High Build Epoxy Red Oxide Zinc Phosphate Primer of 50 micron DFT/ct and then two finishing coats of Acrylic Polyurethane Paint of 35-40 micron DFT/ct.

6.6 SUMMARY OF IMPACTS & MITIGATION MEASURES

A summary of the potential environmental impacts during construction and operation phase along with recommended mitigation measures is presented in matrix format in **Table-6.6.1**.

Table-6.6.1 Environmental Impacts and Mitigation Measures

Area	Impacts	Mitigation Measures	Scale of Impact
Construction	**Phase:**		
Earthquake	High earthquake frequency in the area	Suitable seismic design of the structures will be adopted to mitigate the earthquake impacts.	Negligible
Soil	Destruction of top soil	Construction activities would be confined to a very small area within the construction sites.	Negligible
Landuse, rehabilitation & resettlement	Loss of agricultural land, displacement of people & demolition of structures	*Expansion of power station:* Proposed expansion site is a piece of barren & vacant land existing within the plant premises, no additional land acquisition is necessary for the expansion. Therefore, no loss of agriculture, displacement of people or demolition of public properties.	Nil
		Substations: For expansion of existing Al-Hali and Dhamar substations necessary extension will be done in the vacant land within the existing boundary of the substation. The site earmarked for Kilo 16 substation is a barren land and located away from inhabited area. In case of Yarim substation the site has already been acquired and the boundary wall has already been constructed. Therefore, no loss of agriculture, displacement of people or demolition of public properties.	Nil
		Al-Hali to Kilo 16 new transmission line: The alignment passes through sandy barren area. No human settlement is found close to the route except the first 200 m where few squatters (rag pickers) are found. As they live within the ROW of the existing transmission line, PEC has the Govt. order to clear its ROW. Adequate compensation shall be given to the squatters as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.	Minor
		Dhamar to Hizyaz new transmission line: The alignment has been proposed almost parallel and on the right side of the existing Dhamar to Asser (in Sana'a) 132 KV transmission line upto Hizyaz. The proposed transmission corridor from Dhamar to Hizyaz, like the existing line, is passing through highly undulating hilly terrain. In most part of its 90 km travel it will pass through valleys and encounter some small patches of agricultural land like the existing line. The land required for footings of the transmission towers has to be acquired. As cultivation is permitted under the lines & within the base area of the towers, there will be only minor loss of agricultural land	Moderate

Area	Impacts	Mitigation Measures	Scale of Impact
		due to footings of the towers. As the ROW of the line will not pass through any human settlements, there is no impact like displacement of people. Adequate compensation shall be given to the owners of the agricultural land falling within the ROW as per the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.	
Solid wastes	Construction spoils	Small amount of construction spoils will be disposed of in suitable pre-identified dumping areas within the plant site.	Negligible
Construction camp	Construction camp	Construction camp with sanitary & health facilities will be provided to avoid indiscriminate settlement of construction workers.	Negligible
Drainage	Drainage of construction wastewater	Adequate drainage already exists in the plant to drain construction water.	Nil
	Water stagnation in construction site	Existing drains near the construction site will be regularly cleaned to avoid problems like formation of stagnant water pools, soil erosion & breeding of mosquitoes.	Negligible
Water use	Abstraction of groundwater	No ground water will be abstracted.	Nil
	Construction water demand	*Expansion of power station:* Construction water demand will be met from existing sources (piped supply) within the plant and, therefore, not likely to have impacts on other users.	Nil
		Substations & transmission lines: Construction water demand will be met from the existing local supply and, therefore, likely to have minor impacts on other users.	Minor
Water quality	Sediment load in construction wastewater	Sediment traps will be provided to reduce sediment load in construction wastewater.	Negligible
	Water pollution due to sewage from construction camps	Proper sanitation facilities will be provided to the construction personnel to prevent water & sanitation related health problems.	Negligible
Air quality	Fugitive dusts from construction activities due to excavation, backfilling & concreting, and handling of earth & construction materials & construction spoils	• Construction materials will be stored in enclosed spaces to prevent fugitive emissions. • Truck carrying soil, sand and stone will be duly covered to avoid spilling. • Adequate dust suppression measures such as regular water sprinkling on haul & unpaved roads particularly near habitation will be undertaken to control fugitive dust. • Stringent construction material handling/overhauling procedures will be followed.	Minor
	Gaseous emissions from construction equipment & vehicular traffic.	• Low emission construction equipment & vehicles will be used. • It will be ensured that all construction equipment & vehicles are in good working condition, properly tuned & maintained to keep emissions within permissible limits.	Minor
Noise level	Noise due to construction activities like operation of construction equipment & vehicular traffic	• Construction camp will be located away from the immediate vicinity of the construction sites. • Protective gears such as ear plugs etc. will be provided to construction personnel exposed to high noise levels as preventive measure. • Low noise construction equipment will be used. • Construction machinery would be in good working condition and engines turned off when not in use.	Minor
Floral & fauna	Loss of flora and disturbance to fauna	Proposed sites are pieces of vacant land with no flora & fauna. Therefore, there will no loss of flora or disturbance to fauna. Plantation (only in power station) and landscaping in the available open spaces will be undertaken to enhance the floral resources.	Negligible
Social benefits	Employment opportunities	Most of the construction labourers will be recruited from local areas to alleviate social tension of migration.	Moderate
	Trading opportunities	Some of the construction materials like stone chips & sand will be procured locally.	Moderate
Occupational health &	Health & safety related problems to construction	Adequate safety & health measures complying the occupational safety manuals will be adopted to prevent accidents/hazards to	Negligible

Area	Impacts	Mitigation Measures	Scale of Impact
safety	workers	the construction workers.	
Operation	**Phase:**	**Expansion of Power station:**	
Water use	Water requirement for the new boiler	The additional water requirement for the new boiler is only Demineralized water. As this additional water requirement for operation & maintenance will be met from the existing sources there will no impact on water use aspects outside the plant.	Nil
Water quality	Wastewater & cooling water discharge into the sea	• As all the effluents are completely treated in respective treatment plants (STP & Oil water separator) and their quality conforms to the prescribed discharge standards, no tangible impact is observed on the surface water quality in the study area due to the project. • The temperature of the return cooling water is only about 4°C more than the intake cooling water temperature. And when it discharged into the sea it gets huge dilution and no tangible negative impact on sea ecosystem has been observed near the discharge point.	Negligible
Air quality	Existing boilers emits 609 kg/h SO_2 per boiler i.e. 87.696 t/day at 125 MW load which is far above the World Bank permitted level of 25 t/day.	• As the SO_2 emission levels of the existing boilers is very high, it is desirable to use low sulphur fuel oil in the boilers to the maximum extent possible and switch over to natural gas when it is available. • Coastal high speed wind assists in a wide & quick dispersion of pollutants, thus lowering the GLCs, which is reflected in the relatively low monitored GLCs of SO_2 (maximum only 55.5 $\mu g/m^3$ which is permissible level of 125 $\mu g/m^3$) though its present emission rate is quite high.	Moderate
	Additional emission due to new boiler	• Proposed 7th boiler will be of latest technology & high fuel efficiency (7 t/h) and will emit only 0.16 tpd SO_2 per MW which is within the World Bank guideline of 0.2 tpd per MW. • As observed from modelling results, the predicted 24-hourly maximum GLCs for the future stack will be about 3.8 $\mu g/m^3$. When it is added to the maximum present background level (55.5 $\mu g/m^3$), the resultant maximum ambient SO_2 level is expected to about 59.3 $\mu g/m^3$, which is within the permissible limit of 125 $\mu g/m^3$. • New boiler should be of dual firing system (fuel oil as well as natural gas). • Regular monitoring of stack emission & ambient air quality at specified locations will be conducted.	Minor
Noise level	Noise pollution due to machinery noise	• Impacts of noise on workers are minimized through adoption of adequate noise protective measures. • For expansion project low noise equipment should be installed.	Moderate
	Safety valves of the existing boilers creates loud noise nuisance to local residents	Safety valves of the existing boilers should be augmented to reduce the noise level.	Major
Fire & safety	Fire hazard due to fuel oil storage	Adequate safety measures already exist in the plant for use during the fire emergency that consists of: - Fire water storage tanks & pumps - Fire hydrants throughout the plant - Fire fighting tenders & crews round the clock - Portable fire extinguishers ate strategic locations - Automatic foam injection system for fuel oil area - Flame & smoke detectors at strategic locations	Negligible
Operation	**Phase:**	**Substations & transmission lines:**	
Land use	Encroachment of ROW of transmission lines	No construction of building or growing of trees will be permitted within the ROW to avoid accidents.	Negligible
Safety from electrical hazards	Electrical hazards from accidental snapping of conductors, electro-magnetic induction	• All the standard protection measures like circuit breakers, PLC based protection relay, routine maintenance and routine line patrolling by line walkers will be taken. Therefore, the chances of such accidents are very remote.	Negligible

Area	Impacts	Mitigation Measures	Scale of Impact
	without minimum clearances, and unauthorized building or tree growth within ROW	• As minimum building clearance 5.1 m and ROW of 30 m will be maintained throughout the line length, there will be no hazards from electro-magnetic induction. • No construction of building or growing of trees will be permitted within the ROW to avoid accidents.	
Water use & water quality	Water requirement & wastewater disposal	Operation of substations needs water for staff and will generate sewage from toilet. As there will be only 1 control staff in a shift to operate & control the substations water requirement will be negligible. The water will be taken from the local supply. The sewage from the toilet will be led to septic tank followed by soak pit to assure necessary treatment and it may therefore be concluded that no impact is likely on the surface or ground water quality.	Negligible
PCB Oil	Health hazards due to improper disposal of PCB contaminated transformer oil	All efforts should be made to destroy PCB contaminated waste oil so that it does not escape into environment. The best way is to replace/ phase it out at the source by suitable substitute like Mineral Oil.	Negligible

6.7 PUBLIC CONSULTATION

Though the present project falls under the “Category B” as per the World Bank criteria, it is important to maintain effective public involvement throughout the project implementation to ensure that local environmental & social concerns are adequately addressed in the project design & implementation. Local residents are often in the best position to observe & report environmental & social concerns and therefore, public consultation & involvement is crucial to a sound decision making process. It also helps in eliminating any apprehensions regarding the project and gives in-sights to the problems faced by the public and also provides cost-effective solutions by participation of the affected people in the implementation stage.

Meaningful public consultation should typically include:

- Conveying information (on the projects & impacts) to the public
- Listening & understanding to public opinion & views
- Involving the public in decision making by incorporating their concerns into the project design

Public Consultation (socio-economic perception survey) jointly with PEC has been conducted to draw opinions about the project among the stakeholders around the power station, substations and the transmission lines. Emphasis has been laid on discussion with the plant personnel and local people in the impact zone. At the beginning of the consultation process, the participants have been given a brief about objective of the study, about scope, objective & details of the project, and about environmental & social impacts of the projects.

The consultation & discussions are intended:

- To understand the perception of the public about the project as they have an overall understanding of the present power situation of the area
- To identify the suggestions of the public for improvement of the project design
- To identify any other positive or negative environmental & social impacts as observed and anticipated by the public

Public consultations have been conducted at two places:

1) Public consultation near Al-Hiswa power station on the issue of the expansion of Al-Hiswa power station.

2) Public consultation in Hodeidah on issue of the expansion of Al-Hali substation, new substation at Kilo 16 and new transmission line from Al-Hali to Kilo 16.

The details of the public consultations are presented in **Table-6.7.1 and Table-6.7.2.**

Table-6.7.1 Details of Public Consultation in Aden

Location	**Aden (Meeting Hall, Al-Hiswa Power Station)**
Date & Time	30th July 2005, 10.30 AM
CES Representatives	Mr. Abhijit Dutta, Mr. Rajib Kumar
PEC Representatives	Mr. Asgarh Mohammad Hanif
No. of Participants	16 (consisting of local residents & plant workers. For name of the participants refer "List of Participants" attached in **Annex-3**.)
Issues Discussed	**Outcomes**
• Project scope & objective • Brief project details • Availability of electricity • Environmental impacts • Mitigation measures • Air pollution • Noise pollution • Plantation • Objection to the project • Periphery development • Enhancement measures • Environmental awareness	**Issues discussed in the Public Consultation:** • Some participants complained about their disturbance of sleep in night when the safety valves of the existing boilers of the power station create high noise. • Some participants expressed concern about their breathing trouble. But neither they nor their doctors are sure of the reason of breathing problems, whether it is due to SO_2 or due to high level of wind blown dust due to sandy area and high speed coastal wind through the year. They also mentioned that smokers have breathing trouble, but not the non-smokers. • It was explained to the participants that the maximum SO2 level monitored was 55 $\mu g/m^3$ with much below the permissible level of 125 $\mu g/m^3$, therefore the situation is not to be much worried about. • Some PEC workers wanted more plantations in the vacant area within the plant. • Some participants who live in the power house camp wanted that PEC should do some development of the existing school and hospital in their area. • Most of the participants expressed that there is lack of environmental awareness among people in the area. They suggested some awareness programs to be organized by the Al-Hiswa plant management. • None of the participants objected the expansion of the power station and expressed that expansion of the plant will have no additional problem to them and they are in favour of the expansion because of the power crisis in Aden.

Table-6.7.2 Details of Public Consultation in Al-Hodeidah

Location	**Al-Hodeidah (Meeting Hall, PEC Regional Office)**
Date & Time	7th August 2005, 10.00 AM
CES Representatives	Mr. Abhijit Dutta, Mr. Rajib Kumar
PEC Representatives	Mr. Monsoor
No. of Participants	10 (consisting of local residents & PEC Staff. For name of the

	participants refer "List of Participants" attached in **Annex-3**.)
Issues Discussed	**Outcomes**
• Project scope & objective • Brief project details • Availability of electricity • Environmental impacts • Mitigation measures • Trans. lines Control & protection system • Alternate routes of lines • Land acquisition • Resettlement policy • Objection to the project	**Issues discussed in the Public Consultation:** • All the participants expressed their grave concern about the power cut, low voltage & faults in Al-Hodeidah. And they want immediate solution of the problems of power distribution. • All the participants are in favour of the project (i.e. augmentation of Al-Hali substation and new substation to divert the load. Regarding location of the new substation they have no choice. • Some PEC staff's opinion is that the new transmission line should be from the Bajil to Hodeidah such that Hodeidah is connected from two grids. If one grid fails the others can supply. • Most of the participants are in favour of the Govt. order that the few illegal squatters occupying the ROW of the Al-Hali to Ras Katenib existing transmission line should be removed.

6.8 DISCUSSIONS WITH NGOS

Discussions were held with the following NGOs:

- Sustainable Improvement Association, Aden
- Mabrah Aden Association, Aden
- Al Yemen Al Khadhra, Hodeidah
- Supporters of the Environment, Hodeidah
- Yemeni Women Union, Sana'a
- Association for Environmental Communicator, Sana'a

The outcomes of the discussions are:

- Power cut is quite common in Yemen and the power supply situation should be improved.
- Govt. should debottleneck the electrical transmission system by expansion of thermal power station, and addition new substations & transmission lines.
- They are in favour of this project (i.e. expansion of Al-Hiswa power station, new transmission lines from Hodeidah to Kilo 16 & from Dhamar to Hizyaz, expansion of Dhamar & Al-Hodeidah substations, and new substations at Kilo 16 & Yarim).
- Their main concern is land acquisition for transmission lines. They suggested that the transmission lines should avoid human settlements & buildings and should be laid along the barren lands & hills.
- They stressed on proper compensation against loss of crop & land due to construction of transmission towers.
- Govt. should expedite the gas pipeline project from Marib to other cities of Yemen and the power stations should run by natural gas.

7.0 ENVIRONMENTAL MONITORING & ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. A plant/project may have taken proper pollution control measures but without a management plan to assure its proper function, the desired results may not be obtained. The present chapter on Environment Management Plan envisages the management plan which is going to be adopted for the project for proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities.

The following issues have been addressed in this EMP:

- Environmental mitigation measures during construction and operation stages
- Details of management plans
- Institutional set up identified/recommended for implementation of the EMP
- Environmental monitoring during the construction and operation stages
- Expenditures for environmental protection measures.

7.1 ENVIRONMENTAL MITIGATION MEASURES

The environmental impacts due to different project activities and their mitigation measures have been detailed in Chapter-5. These mitigation measures together constitute part of EMP. The environmental mitigation measures for construction and operation phases have been summarized below:

7.1.1 During Construction

In order to mitigate such impacts and restrict them within tolerable levels, the following measures shall be adopted during the construction phase:

General mitigation measures:

- Proper and prior planning of approach and access roads, and appropriate sequencing and scheduling of all major construction activities.
- Ensuring timely availability of infrastructural supports needed for the construction.
- Seismic factors to be taken care of in the design.
- Dust suppression measures such as regular sprinkling of water in the vulnerable areas of the construction sites.
- Stringent construction material transportation, storage & handling procedures.
- Use of properly tuned construction machinery & vehicles in good working condition with low noise & emission and engines turned off when not in use.
- Control of quality of construction wastewater within the construction site through suitable drainage system with traps for arresting the sediment load for its proposed disposal into the main natural drainage system around the site.
- Implementation of suitable disposal methods of construction debris at designated places in tune with the local condition.
- Adequate safety measures complying the occupational safety manuals to prevent accidents/hazards to the construction workers.
- Noise protective gears for construction personnel exposed to high construction noise and locating the temporary labour camp away from the construction site.
- For construction workers provision of construction camp facilities at pre-designated places for with proper sanitation, drinking water supply & primary health facilities.

Mitigation measures for the power station:

- Appropriate plantation & landscaping in available open spaces in & around the power station.
- Taller stack (110 m) for the new boiler in the power station.

Mitigation measures for the substations & transmission lines:
- No plantation in substation.
- Steel structures of the transmission towers particularly in coastal area to be highly galvanized during erection, and painted, if & when corrosion starts after few years.
- Compensation for land and loss of crop for construction of transmission towers in accordance with the Resettlement Policy Framework (RPF) formulated jointly by the PEC and the World Bank.

7.1.2 During Operation

The following environmental protection/mitigation measures shall be adopted during the operation stage of the project:

General mitigation measures:
- Adequate safety measures complying the occupational safety manuals to prevent accidents/hazards to the workers.
- Providing suitable human management and stable working conditions in order to alleviate socio-economic unrest.
- Undertaking some periphery & community development programs in the locality.

Mitigation measures for the power station:
- Current practice has to be continued regarding treatment of sewage & oily wastewater, disposal of combined treated effluent into the sea, disposal of sludge from the sludge drying bed into city solid waste dumping site,
- Undertaking all necessary pollution control measures to maintain the emissions and discharges within the prescribed/stipulated limits.
- Proper maintenance & acoustic enclosure for pumps, compressors & turbines, and personal protective equipment for people working in high noise areas
- For expansion project low noise equipment should be installed.
- Safety valves of the existing boilers should be augmented to reduce the noise level.
- Use of low sulphur fuel oil in the boilers to the maximum extent possible and switch over to natural gas when it is available.
- New boiler should be of dual firing system (fuel oil as well as natural gas).
- Maintenance of greenbelt properly round the year including replacement of the decayed trees and raising of seasonal flowering plants.

Mitigation measures for the substations & transmission lines:
- All standard protection measures like circuit breakers, PLC based protection relay, routine maintenance and routine line patrolling by line walkers will be undertaken.
- Minimum building clearance 5.1 m and ROW of 30 m (including conductor swing) will be maintained throughout the line length.
- No construction of building or growing of trees will be permitted within the ROW.
- The new transformers should be non-PCB type that contains oil/dielectric fluid containing less than 50 ppm PCB. If feasible, the existing transformers should be phased out by non-PCB transformers. All efforts should be made to destroy PCB contaminated waste oil so that it does not escape into environment.

7.2 DETAILS OF MANAGEMENT PLANS

7.2.1 Greenbelt Development Plan

Green areas not only improve the floral status, land use and the aesthetic look of an area, but also serve the dual purpose of filtering any fugitive dust from unpaved or open areas, help to abate noise effects through dampening, and replenish oxygen and ameliorate the surrounding temperature. Therefore, development of green belt is nowadays imperative as a part of development projects.

Power station

Substantial plantation in and around the Al-Hiswa power station have already been done and more plantation will be done in the unutilized open spaces in order to further enhance the aesthetic look of the area as well as to compensate for the loss of flora during construction of the new boiler, if any al all. Development of green belt in the power station will include:

- Plantation along the periphery for protection against fugitive dust and noise. Width of peripheral greenbelt will vary to suit the plant design requirement.
- Plantation along approach road and pathways for aesthetics.
- Block plantation in available open areas.
- Landscaping & grass plantation on open unpaved areas to prevent fugitive dust.

Substations

No tree plantation is recommended in the substation except landscaping with grass & flower beds. Development of green belt will include:

- Landscaping with flower beds along approach road and pathways.
- Grass plantation in patches in open unpaved areas to prevent fugitive dust.

The following general guidelines and measures have been adopted:

- Destruction of existing trees will be minimized.
- The plantation programme has been drawn to conform to natural climatic conditions and adaptability of the species.
- The plantations would consist of a mixture of carefully chosen locally available indigenous, fast growing and sturdy species of trees, shrubs and herbs having ornamental value.
- Proper drainage system and proper plantation techniques will be adopted.
- Plantation in the initial stage of 3 years will be properly maintained and protected by fencing from grazing and felling.

The plant species have been selected based on criteria such as:

- Indigenous, fast growing, sturdy, perennial & preferably evergreen having economic, medicinal or ornamental values
- Growth and morphological characteristics (height, crown and flowering) to suit the plant layout
- Other factors like availability of local species, resistance to pollutants & fire hazard (less littering in nature), and adverse environmental conditions
- Adaptability to local climatic conditions & water availability

The list of indigenous plant species suggested for plantation for the project is presented in **Table-7.2.1**.

Table-7.2.1 Species Suggested for Plantation

SN	Common Name	Scientific Name	Characteristics
			First row of trees along the sides of the road
1.	Amaltas	*Cassia fistula*	Medium size tree with conspicuous yellow flowers
2.	Benjamin tree	*Ficus benjamina*	Medium size tree with spreading canopy
3.	Bottle brush	*Callistemon viminalis*	Medium size ornamental tree, conspicuous red flowers
4.	Date palm		Medium tall palm with edible fruits
5.	Devdaru	*Polyalthia longifolia*	Conical Shaped tree
6.	Gulmohar	*Delonix regia*	Medium size ornamental tree, conspicuous scarlet flowers
7.	Kachnar (red)	*Bauhinea purpurea*	Medium size ornamental tree, conspicuous pink flowers
8.	Kachnar (white)	*Bauhinea variegata*	Medium size ornamental tree, conspicuous white flowers
9.	Lagerstroemia	*Lagerstroemia thorelli*	Ornamental tree bearing pink flowers.
10.	Mango	*Mangifera indica*	Medium size tree with large canopy
11.	Neem	*Azadirachta indica*	Shady tree with large canopy
12.	Nim-chameli	*Millingtonia hortensis*	Medium size ornamental tree, conspicuous white flowers
13.	Pink cassia	*Cassia nodosa*	Medium size ornamental tree, conspicuous pink flowers
14.	Royal palm	*Roystonea regia*	Medium tall palm with white bark
15.	Sisham	*Dalbergia sisoo*	Shady tree with large canopy
16.	Tecoma	*Tecoma argentea*	Medium size ornamental tree, conspicuous yellow flowers
			Hedge
1.	Bougainvillea	*Bougainvillea sp.*	Colourful hedge with pink flowers
2.	Chameli	*Jouminum grandiflorum*	Colourful hedge
3.	Kaner	*Thavetia nerifolia*	Colourful hedge
4.	Lantana	*Lantana camara*	Colourful hedge
5.	Musanda	*Musanda glabra*	Colourful hedge with red, white & other varieties
6.	Yellow Oleander	*Thevetia peruviana*	Colourful hedge with yellow flowers

7.2.2 Solid Waste Management Plan

Solid waste from the project during construction will be mainly domestic scraps & wastes from the construction camp and construction spoils from construction sites.

- The small amount of construction debris will be disposed of in suitable pre-identified dumping areas in tune with the local condition to avoid land degradation & water logging due to indiscriminate dumping.
- Dumping areas will be biologically reclaimed through top soil cover & plantation.
- Periodic inspection construction site & camp will be carried out to ensure regular and timely removal of construction debris to the dumping sites.
- Domestic solid wastes in the form of scraps & papers would be disposed as per the prevailing practice in the area.

7.3 INSTITUTIONAL SET UP

7.3.1 Key Players for Implementation of EMP

The responsibility for implementation and supervision of environmental mitigation measures is vested with three agencies, namely **PEC, Contractors and Supervision Consultant**. The “Contractors” herein mean the agency hired for execution of the construction works for the respective packages. The “Supervision Consultant” means the agency engaged by the PEC to supervise the construction work.

7.3.2 Institutional Arrangement & Responsibility

The responsibility for implementing the mitigation measures are delegated to the **PEC**, whose role in the present context, is to mobilize the appropriate expertise to mitigate the adverse impact through implementation the mitigation measures through the Contractors & the Supervision Consultants during the construction stage, and through PEC staff during the operation stage.

During the construction stage, the environmental mitigation measures issues arising out of the construction sites and labour camps are to be controlled by Construction **Contractors**. This includes implementation of mitigation measures contained in the EIA & EMP during construction and provision of proper sanitation facilities at the project site & labour camps. The **Supervision Consultant**, if any, engaged by PEC will supervise & ensure the implementation of the mitigation measures contained in the EIA & EMP by the contractor and report to the PEC.

To look after the environmental aspects in the Al-Hiswa power station an **Environment Unit** has to be formed. At present in Al-Hiswa power station there is a Fire Fighting & Safety Manager who is looking after the fire & safety aspects. He will be given the additional charge of the environment and his new designation will be **Fire Fighting, Safety & Environment Manager (FSEM)**. A full time officer of the minimum rank of **Supervisor** will be given the charge of the Environment who will assist the FSEM. During operation, the responsibility of environmental management of the Al-Hiswa power station will lie mainly with the **FSEM** at plant site, who will act as a coordinator for environmental matters.

The responsibility of environmental management of the transmission lines & substations during operation will lie mainly with the **Department Manager, Technical Coordination (Environment) at PEC**, who will act as a coordinator for environmental matters.

The institutional arrangement for Environmental Management in the Al-Hiswa power station is shown in **Figure-7.1**. The institutional arrangement for Environmental Management in the PEC Head Office is shown in **Figure-7.2**.

7.3.3 Responsibility of FSEM

FSEM at Al-Hiswa plant will act as a coordinator for fire, safety & environmental matters and supervise the proper implementation of the mitigation measures contained in the EIA&EMP. The SEO will act as a nodal officer for various groups at plant and head quarters as well as outside agencies like Govt. departments.

Functions of FSEM:

- Coordination with statutory bodies, various departments in the project site & head quarters.
- Environmental compliance with statutory guidelines and statutory requirements at the project site during construction and operation stages.
- Coordinating the testing/monitoring of functions of the pollution control systems & environmental field monitoring & analysis in and around the project during construction & operation under environmental monitoring programme.
- Ensuring the proper functioning of the wastewater treatment plants.
- Maintenance of environmental database, analysis of data, preparation of report, and transmission of report to statutory authorities, head quarters etc.
- Interactions for evolving and implementation of modification programs to improve the efficiency of pollution control devices/systems.
- Environmental appraisal (internal) and environmental audit.

- Procurement of equipment for pollution control & their testing
- Landscaping and greenbelt development in the project area.

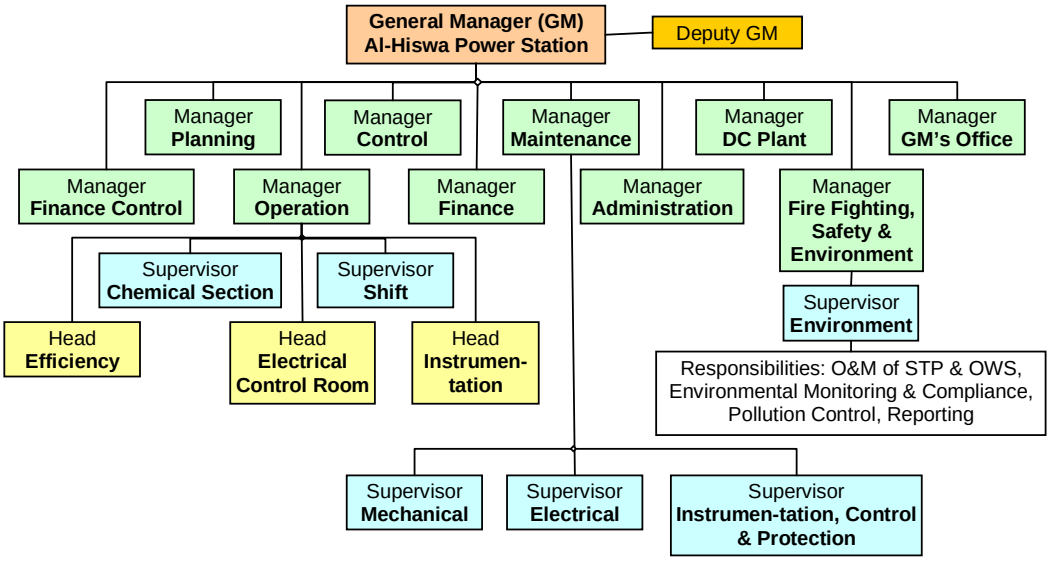

Figure-7.1 Organization Chart of Al-Hiswa Power Station

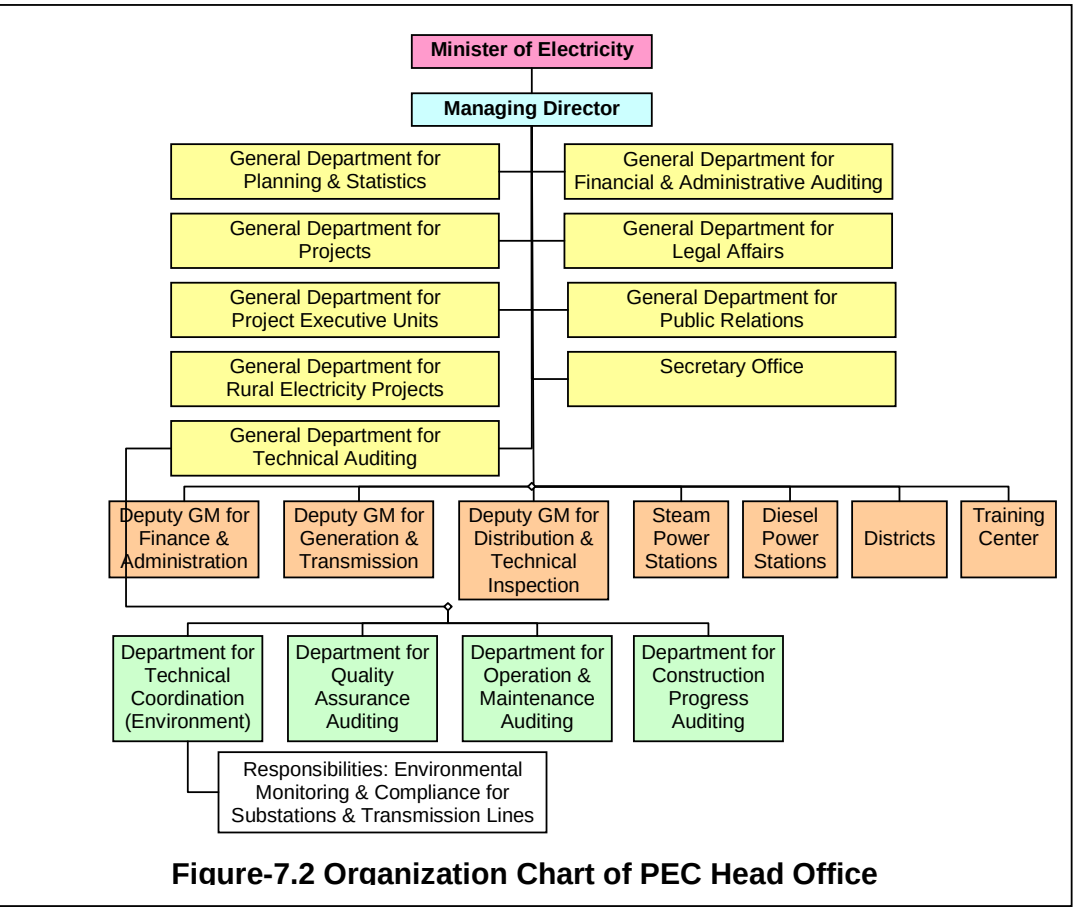

Figure-7.2 Organization Chart of PEC Head Office

- Water supply and sanitation at the project site
- Looking after occupational safety and health aspects
- To strengthen the public image of the company in respect of social aspects and maintain good relationship with community in the vicinity.
- Organizing environmental training, workshops, seminars etc.

7.4 ENVIRONMENTAL MONITORING

The purpose of the environmental monitoring plan is to ensure that the envisaged purpose of the project is achieved and results in desired benefits to the target population. To ensure the effective implementation of the EMP, it is essential that an effective monitoring plan be designed and carried out. The broad objectives are to:

- Verify the predictions on environmental impacts presented in the EIA study,
- Assist in detecting the development of any unwanted environmental situation, and thus, provides opportunities for adopting appropriate control measures, and
- Evaluate the performance of mitigation measures proposed in the EIA&EMP
- Suggest improvements in management plan, if required
- To satisfy the legal and community obligations
- To enhance environmental quality

The environmental monitoring plan contains:

- Performance indicators
- Environmental monitoring programme
- Institutional & Infrastructural Arrangements for Monitoring
- Progress monitoring and reporting arrangements
- Training

7.4.1 Performance Indicators

The physical, biological and social components identified to be particularly significant in affecting the environment at critical locations have been suggested as Performance Indicators (PIs). The Performance Indicators and monitoring plans are presented in **Table-7.4.1**.

Table-7.4.1 Performance Indicators

SN	Details	Indicators	Responsibility
A.	**Pre-Construction Stage**		
	Locations for dumping of wastes have to be identified and parameters indicative of environment in the area has to be reported	Dumping locations	Contractor
	Location of construction camps have to be identified and parameters indicative of environment in the area has to be reported	Construction camps	Contractor
B.	**Construction Stage**		
	The level of dust & noise pollution at the nearest residence/office during construction to be monitored	Air quality	Contractor
		Noise level	Contractor
C.	**Operation Stage**		
	The parameters to be monitored as per frequency, duration & locations of monitoring specified in the Environmental Monitoring Programme prepared	Air quality	PEC environment dept. in Al-Hiswa Power station
		Noise level	
		Effluent quality	
	The number of trees surviving during each visit will be compared with the number of saplings planted	Survival rates of trees	PEC environment dept. in Al-Hiswa Power station
	PCB content in waste transformer oil	PCB in waste transformer oil	PEC environment dept. in Head Office

7.4.2 Environmental Monitoring Programme

After commissioning of the new boiler, post project monitoring of environmental parameters will be carried out at regular intervals. The monitoring programme in different areas of the environment has been based on the findings of the impact assessment studies. The post project monitoring programme including areas, number and location of monitoring stations, frequency of sampling and parameters to be covered is summarized in **Table-7.4.2** and are elaborated in this section. The monitoring will be the responsibility of FSEM. The monitoring and analysis of various environmental parameters will be carried out as per the international standards.

Table-7.4.2 Post Project Environmental Monitoring Programme

SN	Component	Parameter	Monitoring Location	Frequency
1.	Ambient Air Quality	PM, PM_{10}, SO_2, & NOx	3 locations outside the plant at distance of 1 to 1.3 km along three predominant wind directions north, east & west	Two months in a year (1 month in summer & 1 month in winter) at a frequency of twice in a week.
2.	Stack emission	Particulates, SO_2, NOx	All the 4 stacks in the power station during the full load operation of the connected boilers	Once in a month
3.	Noise Levels			
a)	Outside plant boundary	Day & night time L_{eq}	3 locations outside the plant (nearest residence, nearest school & nearest office)	Twice a year
b)	In work zones within the plant	8-hourly L_{eq}	5 locations inside the plant (Administrative office, Main gate security office, Training center, Main control room, & Boiler house)	Twice a year
4.	Liquid effluents			
a)	Boiler blow down	pH, TSS, TDS, Oil & grease, Copper, Iron, Residual chlorine		Once a month
b)	Oily effluent	pH, Oil & grease	At entrance to oil water separator	Once a month
c)	Treated oily effluent	pH, Oil & grease	At exit of oil water separator	Once a month
d)	Raw sewage	pH, BOD, COD, TSS	At entrance to STP	Once a month
e)	Treated sewage	pH, BOD, COD, TSS	At exit of STP	Once a month
f)	Combined cooling water discharge	Temp, TSS, Oil & grease, Total chromium, Copper, Iron, Zinc, Residual chlorine	Just before discharge point into the sea	Once a month
g)	Sea water	Temp, TSS, Oil & grease, Total chromium, Copper, Iron, Zinc, Residual chlorine	At 100 m of the cooling water discharge point	Once a month
5.	Meteorology	Temperature, Relative humidity, Wind speed & direction	At top of any building, at 10 m height from the ground level & free from any obstruction of wind	Hourly (Continuously at every hour)

Ambient air quality: Ambient air quality would be monitored outside the plant boundary, in order to compare and ensure that the ambient air quality is maintained within the stipulated limits.

Stack emission: Monitoring of stack emissions for all the power plant stacks will be conducted on a regular basis to ascertain that emissions are within the stipulated limits.

Noise: Ambient noise levels would be monitored outside the plant boundary, in order to compare and ensure that the ambient noise levels are maintained within the stipulated limits. In addition, noise levels at appropriate locations close to the industrial noise sources within the plant will also be monitored to ensure that the noise levels in work zones is within the permissible exposure limits to workers.

Effluents: Quality of all disposable effluents would be monitored on a regular basis in accordance with the relevant parameters to ascertain that the effluent quality meets the stipulated limits for discharge.

Meteorology: As on-site meteorology is very important that directly controls the dispersion of air pollutants emitted from the stacks and levels of ground level air quality, a meteorological observatory would be set up at a suitable location within the plant for monitoring of temperature, relative humidity, wind speed & wind direction. Equipment of continuous recording type would be installed for continuous monitoring at hourly intervals.

7.4.3 Institutional & Infrastructural Arrangements for Monitoring

7.4.3.1 Staff

The post operational monitoring programme will be under the supervision of the FSEM at the power station site. For monitoring of environmental aspects in the Al-Hiswa power station an Environment Unit has to be formed with minimum:

- One supervisor
- One chemist
- One monitoring technician
- An Environmental Laboratory

7.4.3.2 Environmental Laboratory

One environmental laboratory has to be set up in Al-Hiswa power station for environmental monitoring. The list of equipments & its cost that has to procured for the laboratory is given in **Table-7.4.3**.

Table-7.4.3 List of Equipment for Environmental Laboratory in Al-Hiswa Power Station

SN	Parameter	Number of Equipment	Total Cost (US$)
	Ambient Air Quality Monitoring:		
1.	High Volume Respirable Dust Sampler along with impingers	4	9,600
	Stack Monitoring:		
1.	Stack monitoring kit with accessories	1	2,600
	Noise Level Monitoring:		
1.	Noise meter (continuously recording type)	2	6,600
	On-site Meteorology:		
1.	Weather station (continuous recording type)	1	8,000

SN	Parameter	Number of Equipment	Total Cost (US$)
	Effluent Monitoring:		
1.	pH meter	1	300
2.	Spectrophotometer	1	2,600
3.	BOD incubator	1	800
4.	COD Digester/Reflux apparatus	1	300
5.	Single pan balance (0.01 mg accuracy)	1	2,100
6.	Hot air oven	1	200
7.	Refrigerator	2	800
8.	Desiccators	1	25
9.	Distillation Apparatus	1	50
10.	Filter assembly	1	500
11.	Glass apparatus (beakers, flasks, bottles, cylinders, burettes, pipettes, test tubes etc.)	Lump sum	800
	Logistics:		
1.	Computers + Printers	2	1,600
	Total		**36,875**

7.4.3.3 Stack Monitoring Facilities for Existing Stacks

The existing stacks have no stack monitoring facilities. Stack monitoring facilities have to be constructed for the existing 3 stacks that will include the following:

Sampling port:

- Location of sampling port: Sampling port hole at a height of minimum 8 times the stack dia. downstream from the flow disturbance point i.e. minimum 30 m above the top of the ID fan duct entering the stack. Port should be installed 0.9 to 1.2 m above the working platform.
- Number of sapling port: Minimum two (2) nos. of mutually orthogonal (i.e. at 90°) ports should be installed.
- Dimension of sampling port: Sampling port should be a standard flanged pipe of 100 mm inside dia. with 150 mm bolt circle. Port should be installed with the interior wall of the stack and should be extended 50 mm outward of the exterior wall of the stack.

Working platform:

- Size & extent: The working platform should serve the entire circumference of the stack and should have a guard rail. Minimum width of the platform should be 1.2 m.
- Platform loading: The platform should be able to support at three men (average 80 kg each) and 90 kg of test equipment.
- Platform access: Safe & easy access to work platform should be provided via. stairway with guardrails.
- Power supply: At the working platform 2 nos. of 220V/15 amp single phase AC circuit with grounded weather proof outlets should be installed.

Note: One new 4th stack should be constructed as part of the package of supply & installation of the new 7th boiler. Cost of the new stack (including its stack monitoring facilities) should be included in the **civil cost** of the boiler package.

7.4.3.4 Infrastructure in PEC Head Office

For infrastructural strengthening of the Environment Unit at PEC Head Office, 2 sets of computers & printers are required along with office furniture. This will require about 4000 US$.

7.4.4 Progress Monitoring and Reporting Arrangements

The monitoring and evaluation of the management measures envisaged are critical activities in implementation of the Project. Monitoring involves periodic checking to ascertain whether activities are going according to the plans. It provides the necessary feedback for project management to keep the program on schedule. The rational for a reporting system is based on accountability to ensure that the measures proposed as part of the Environmental Management Plan get implemented in the project.

The Environment Unit in Al-Hiswa power station will prepare the monitoring report and send it to the PEC Head Office. For substations & transmission lines the Environment Unit in PEC Head Office will directly be involved for preparation of reports.

7.4.5 Training

The Environmental Unit in PEC Head Office and Environmental Unit in Al-Hiswa power station, who would be responsible for the implementation of the EMP, need to be trained on the effective implementation of the environmental issues. To ensure the success of the implementation set up proposed, there is a high requirement of training and skill upgradation. The training has to be given by reputed Consultants having experience of environmental monitoring of power station.

7.5 OTHER RELATED ASPECTS

7.5.1 Compensation

The project involves acquisition of land and loss of crop during placing of transmission towers through agricultural fields. The compensation will include:

- Compensation for land occupied by footings of the towers as per the **Resettlement Policy Framework (RPF)** prepared jointly by **the PEC and the World Bank**.
- 100% compensation for crop lost as per the RPF mentioned above.

7.5.2 Fire and Safety Management

The Fire Fighting & Safety Manager in the Al-Hiswa power station look after the fire & safety aspects. Necessary fire fighting facilities already exist in the plant to tackle any fire contingency. Strict rules and regulation are being followed to take care of workers health and safety. Workers are provided with necessary safety devices & personal protective equipment like safety jackets, helmets, boots, gloves, gas masks, ear plugs & ear mufflers etc. to protect them from any occupational hazard. Regular safety audits are carried out for improving safety performance. Mock drill is conducted at regular intervals to keep the fire fighting team in a state of full preparedness. In addition,

refresher training programs is conducted at regular intervals for new employees and selected contractor labourers to enhance their safety awareness and preparedness. Fire protection & safety system has been detailed in sections 4.1.11 & 4.1.12 in Chapter-4.

7.5.3 Legal and Statutory compliance

All the environmental standards/stipulations will be fully complied with. It will be supervised that all requirements under the environmental acts & standards are met, and if not met, the satisfactory explanations for it are sought. The officer in charge for environmental aspects will prepare these reports.

7.5.4 Documentation and Quality Assurance

All the monitoring data, environmental and safety & health related, will be stored in systematic manner so that the specific records are easily available as required. A quality assurance plan will be developed that includes all reference methods for monitoring, relevant analytical technique, calibration of equipment, standard of reagents, collection and presentation of results, frequencies of monitoring etc.

7.5.5 Information Dissemination and Public Relations

Everybody nowadays is concerned about environment. It is needed that people should be provided with environmental data related to the plant so that wrong apprehensions can be removed. This requires a well planned public relation and information dissemination process so that unnecessary public intervention is avoided. This can be done through organizing different programs with participation from local bodies, encouraging local community in environmental projects (like tree plantation) etc. The management in the project will be entrusted with all these responsibilities.

7.6 ENVIRONMENTAL BUDGET

A capital cost provision of about 135,720 US$ has been kept towards the environmental management measures in the EMP. The budgetary cost estimate for implementation of the environmental protection, mitigation & enhancement measures & environmental monitoring is elaborated in **Table-7.6.1**.

Table-7.6.1 Environmental Budget

SN	Item	Break up (US$)	Total Cost (US$)
	Capital Cost:		
1.	Pollution Monitoring:		96,875
	a) Monitoring facilities & equipment for Al-Hiswa power station (for details refer Table-7.4.3)	36,875	
	b) Construction of stack monitoring facilities in the existing stacks @ 20,000 US$ per stack (lump sum)	60,000	
2.	Plantation & landscaping including 3 years maintenance (lump sum)		5,000
3.	Institutional strengthening:		19000
	a) Infrastructure development of Environment Unit at PEC HO (lump sum)	4,000	
	b) Training of PEC staff for env. monitoring & management (lump sum)	15,000	
4.	Others (local development):		10,000
	a) Development of existing school near Al-Hiswa power station (lump sum)	5,000	
	b) Development of existing hospital near Al-Hiswa power station (lump sum)	5,000	
5.	Contingency @ 5% of total cost		6,545
	Total Capital Cost		**135,720**

	Recurring Cost per Annum:		
1.	Monitoring during operation (chemicals & spares)*		5,000
	Total Recurring Cost per Annum		**5,000**

* Cost of staff is not considered as the existing excess staff will be engaged for this job

7.7 CRITICAL AREAS AND CONCLUSION

Based on the findings of the EIA Study, following are deemed to be critical areas:

- Noise & dust during construction
- Air pollution due to stack emission during operation

It is understood that the PEC management will implement the dust & noise control measures during construction and air pollution control measures like use of low sulphur fuel oil in the boilers to the maximum extent possible and switch over to gas when it is available. It will also implement necessary and appropriate mitigation measures, environmental monitoring and safety measures as discussed in the EMP throughout the life cycle of the project. Given that commitment the project should not pose significant intolerable impact to the environment.

The expansion of the power station and construction of new substations & transmission lines will have **beneficial** impacts in terms of better availability & transmission of electricity in the country with incidental benefits like employment opportunities particularly in the construction stage. It can be concluded that proposed project will not have significant adverse impacts on existing environment of the project area.

Excerpt of Thermal Power Guidelines for New Plants

The following is an excerpt of the Thermal Power guidelines for New Plants, a complete version of which is found in the Pollution Prevention and Abatement Handbook.

These guidelines set forth procedures for establishing maximum emission levels for all fossil-fuel based thermal power plants with a capacity of 50 megawatts of electricity (MWe) or larger using coal, fuel oil, or natural gas. They focus on issues that should be addressed in arriving at project-specific emission standards and other requirements. See Annex A for plants below 50 MWe.

Environmental Assessment and Site-specific Requirements

An EA should be carried out early in the project cycle in order to establish emission requirements and other measures on a site-specific basis for a new thermal power plant or unit. It should also address other project-specific environmental concerns, such as emissions of cadmium, mercury, and other heavy metals resulting from burning certain types of coal or heavy fuel oil.

The emission levels selected must be justified in the EA and acceptable to the World Bank Group. The following maximum emission levels are normally acceptable to the World Bank Group.

Air Emissions

The maximum emission levels given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems. The maximum emission levels are expressed as concentrations to facilitate monitoring. Dilution of air emissions to achieve these guidelines is unacceptable. Compliance with ambient air quality guidelines should be assessed on the basis of Good Engineering Practice (GEP) recommendations[1]. Plants should not use stack heights less than the GEP recommended values unless the air quality impact analysis has taken into account building downwash effects. All of the maximum emission levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours [2] The five percent of the annual operating hours are assumed to be for startup, shutdown, emergency fuel use, and unexpected incidents. For peaking units where the startup mode is expected to be longer than five percent of the annual operating hours, exceedance should be justified by the EA with regard to air quality impacts.

Power plants in degraded airsheds. The following **definitions** apply in airsheds where there already exists a significant level of pollution.

An airshed will be classified as having ***moderate air quality*** with respect to particulates, sulfur dioxide, or nitrogen dioxide if:

Either the annual mean value of (i) PM_{10} exceeds 50 micrograms per cubic meter ($\mu g/m^3$) or 80 $\mu g/m^3$ for TSP or (ii) SO_2 exceeds 50 $\mu g/m^3$ or (iii) NO_2 exceeds 100 $\mu g/m^3$ for the airshed,

1 See, e.g., the US Code of Federal Regulations Title 40, Part 51.100 (ii). Normally, GEP Stack Height = H+1.5L, where H is the height of nearby structures and L is the lesser dimension of either height or projected width of nearby structures.

2 Assumptions – Coal: Flue Gas dry 6% excess O2 – assumes 350 Nm^3/GJ; Oil: Flue Gas dry 3% excess O2 – assumes 280 Nm^3/GJ; Gas: Flue Gas dry 3% excess O2 – assumes 270 Nm^3/GJ. Oxygen level in engine exhausts and combustion turbines is assumed to be 15 percent, dry.

Or the 98th percentile of 24 hour mean values of PM_{10} or SO_2 or NO_2 for the airshed over a period of a year exceeds 150 $\mu g/m^3$ (or 230 $\mu g/m^3$ for TSP).

An airshed will be classified as having ***poor air quality*** with respect to particulates, sulfur dioxide, or nitrogen dioxide if:

Either the annual mean of (i) PM_{10} exceeds 100 $\mu g/m^3$ (or 160 $\mu g/m^3$ for TSP)or (ii) SO_2 exceeds 100 $\mu g/m^3$ or (iii) NO_2 exceeds 200 $\mu g/m^3$ for the airshed;

Or the 95th percentile of 24 hour mean values of PM_{10} or SO_2 or NO_2 for the airshed over a period of a year exceeds 150 $\mu g/m^3$ (or 230 $\mu g/m^3$ for TSP).

Plants smaller than 500 MWe in airsheds with moderate air quality are subject to the maximum emission levels indicated below provided that the EA shows that the plant will not lead to *either* the airshed dropping into the category having poor air quality *or* an increase of more than 5 $\mu g/m^3$ in the annual mean level of particulates (PM_{10} or TSP), SO_2, or NO_2 for the entire airshed. If either of these conditions is not satisfied, then lower site-specific emission levels should be established which would ensure that they can be satisfied.

Plants greater or equal to 500 MWe in airsheds with moderate air quality and all plants in airsheds with poor air quality are subject to site-specific requirements that include offset provisions to ensure that: (a) there is no net increase in the total emissions of particulates and/or SO_2 within the airshed; and (b) the resultant ambient levels of NO_2 do not exceed the levels specified for moderately degraded airshed.[3] The measures agreed under the offset provisions must be implemented before the power plant comes fully on-stream. Suitable offset measures could include reductions in emissions of particulates, SO_2 and/or NO_x resulting from: (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed, (b) the installation of new or more effective controls at other large sources – district heating or industrial plants – in the same airshed, and (c) investments in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers.[4]

PARTICULATE MATTER. For all plants or units, PM emissions (all sizes) should not exceed 50 milligrams per normal cubic meter – Nm^3 measured at 1 atmosphere and 0°C (mg/Nm^3).[5,6]

Fine Particulates. The EA should pay specific attention to particulates smaller than 10 µm in aerodynamic diameter (PM_{10}) in the airshed, since these are inhaled into the lungs and are associated with the most serious effects on human health.

SULFUR DIOXIDE. The total SO_2 emissions from the power plant or unit should be less than 0.20 metric tons per day (tpd) per MWe of capacity for the first 500 MWe plus 0.10 tpd for each additional MWe of capacity over 500

3 Gas-fired plants (provided that the back-up fuel contains less than 0.3% sulfur), and other plants that achieve emission levels of less than 400 mg/Nm^3 for sulfur oxides and nitrogen oxides are exempt from the offset requirements since their emissions are relatively less.

4 Wherever possible, the offset provisions should be implemented within the framework of an overall air quality management strategy designed to ensure that air quality in the airshed is brought into compliance with ambient standards.

5 The additional cost of controls designed to meet this requirement rather than one of 150 mg/Nm^3 (e.g., <0.5% of total investment costs for a 600 MW plant) is expected to be less than the benefits of reducing ambient exposure to particulates. The high overall removal rate is necessary to capture PM10 and fine particulates which seriously affect human health). Typically, about 40% of PM by mass is smaller than 10µm, but the collection efficiency of ESPs drops considerably for smaller particles.

6 An exception to the maximum PM emission level may be granted to engine-driven power plants for which guarantee applications are received before January 1, 2001 for PM emission levels of up to 75 mg/Nm^3 provided the EA presents documentation to show that: (i) lower-ash grades of fuel oil are not commercially available; (ii) emission control technologies are not commercially available; and (iii) the resultant ambient levels for PM10 (annual average of less than 50 $\mu g/m^3$ and 24-hour mean of less than 150 $\mu g/m^3$) will be maintained for the entire duration of the project.

MWe.[7] As well, The concentration of SO_2 in flue gases should not exceed 2,000 mg/Nm³ (see footnote 2 for assumptions), with a maximum emission level of 500 tpd. Construction of two or more separate plants in the same airshed to circumvent this cap is not acceptable.

NITROGEN OXIDES: The specific emission limits are: 750 mg/Nm³ (or 260 nanogram per joule (ng/J) or 365 parts per million parts (ppm)) for a coal fired power plant (and up to 1,500 mg/Nm³ for plants using coals with volatile matter less than 10%); 460 mg/Nm³ (or 130 ng/J or 225 ppm) for an oil fired power plant; and 320 mg/Nm³ (86 ng/J or 155 ppm) for a gas fired power plant.

For combustion turbine units,[8] the maximum NO_x emission level is 125 mg/Nm³ (dry at 15 percent oxygen) for gas, 165 mg/Nm³ (dry at 15 percent oxygen) for diesel (No. 2 oil), and 300 mg/Nm³ (dry at 15 percent oxygen) for fuel oil (No. 6 and others). Where there are technical difficulties (such as scarcity of water available for water injection), an emission variance allowing a maximum emission level of up to 400 mg/Nm³ dry (@ 15 percent oxygen), is considered acceptable, provided there are no significant environmental concerns associated with ambient levels of ozone or nitrogen dioxide.

For engine-driven power plants, the EA should pay particular attention to levels of NO_x before and after the completion of the project. Provided the resultant maximum ambient levels of nitrogen dioxide are less than 150 µg/m³ (24-hour average), the specific emission guidelines are: (i) for guarantee applications received after July 1, 2000, the NO_x emission levels should be less than 2,000 mg/Nm³ (or 13 grams per kilowatt-hour (g/kWh) dry at 15 percent oxygen); and (ii) for guarantee applications received before July 1, 2000, the NO_x emission levels should be less than 2,300 mg/Nm³ (or 17 g/kWh dry at 15 percent oxygen). In all other cases, the maximum emission level of NO_x is 400 mg/Nm³ (dry at 15 percent oxygen).

Liquid Effluents

The following effluent levels (for applicable parameters) should be achieved daily without dilution.

7 The maximum sulfur dioxide emission levels were back-calculated using the US Environmental Protection Agency's (US-EPA) Industrial Source Complex (ISC) Model with the objective of complying with the 1987 WHO Air Quality Guidelines for acceptable 1-hour (peak) ambient concentration levels (350 µg/m³). The modeling results show that in general, an emission level of 2,000 mg/m³ (equivalent to 0.2 tpd per MWe) results in a 1-hour level of 300 µg/m³ which – when added to a typical existing background level of 50 µg/m³ for greenfield sites – results in a 1-hour level of 350 µg/m³ (see discussion of degraded airsheds). Compliance with the WHO 1-hour level is normally the most significant, as short-term health impacts are considered to be the most important; compliance with this level also in general, implies compliance with the WHO 24-hour and annual average guidelines. For large plants (greater than 500 MWe), the emission guidelines for sulfur dioxide were further reduced to 0.1 tpd per MWe for capacities above 500 MWe to maintain acceptable mass loadings to the environment and thus address ecological concerns (acid rain). This results in a sulfur dioxide emission level of 0.15 tpd/MWe (or 1.275 lb/mmBtu) for a 1,000 MWe plant.

8 Where nitrogen content of the liquid fuel is greater than 0.015 percent and the selected equipment manufacturer cannot guarantee the emission levels provided in the text, a NO_x emission allowance (i.e., added to the maximum emission level) can be computed based on the following as exceptions:

Nitrogen content (percent by weight)	Correction Factor (NO_x) percent by volume)
0.015 to 0.1	0.04 N
0.1 to 0.25	0.004 + 0.0067(N - 0.1)
>0.25	0.005

Note: A correction factor of 0.004 percent=40 ppm=80 mg/Nm³.

There may be some cases where cost-effective NO_x controls may not be technically feasible. Exceptions to the NO_x emission requirements (including the above) are acceptable provided it can be shown that: (1) the alternative emission level will not result in ambient conditions which have a significant impact on human health and the environment for the entire duration of the project; and (2) cost-effective techniques such as low NO_x burners, low excess air, water or steam injection, and reburning are not feasible.

Effluents from Thermal Power Plants

Parameter	*Maximum value milligrams per liter (mg/L)*
PH	6 - 9
Total suspended solids	50
Oil and grease	10
Total residual chlorine[a]	0.2
Chromium (total)	0.5
Copper	0.5
Iron	1.0
Zinc	1.0
Temperature increase at the edge of the mixing zone	less than or equal to 3^{0}C[b]

[a] So-called "chlorine shocking" may be preferable in certain circumstances. This involves using high chlorine levels for a few seconds rather than a continuous low level release. The maximum value is 2 mg/L for up to 2 hours, not to be repeated more frequently than once in 24 hours, with a 24-hour average of 0.2 mg/L (the same limits would apply to bromine and fluorine).

[b] The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution takes place. Where the zone is not defined, use 100 meters from the point of discharge when there are no sensitive aquatic ecosystems within this distance.

Coal pile runoff and leachate may contain significant concentrations of toxics (such as heavy metals). Where leaching of toxics to groundwater or their transport in surface runoff is a concern, suitable preventive and control measures such as protective liner and runoff collection and treatment should be put in place.

Solid Wastes

Solid wastes, including ash and FGD sludges, which do not leach toxic substances[9] or other contaminants of concern to the environment may be disposed in landfills or other disposal sites provided they do not impact nearby water bodies. Where toxics or other contaminants are expected to leach out, they should be treated, for example, by stabilization, before disposal.

9 A chemical or mixture that may present an unreasonable risk of injury to health or the environment.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

	Maximum Allowable L_{eq} (hourly), in dB(A)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Monitoring and Reporting

Maintaining combustion temperature and excess oxygen level within the optimal band in which PM and NO_x emissions are minimized simultaneously ensures the greatest energy efficiency and the most economic plant operation.

Monitoring should therefore aim toward achieving this optimal performance as consistently as possible. Systems for continuous monitoring of particulate matter, SO_x and NO_x in the stack exhaust can be installed and are desirable whenever their maintenance and calibration can be assured. Alternatively, surrogate performance monitoring should be performed, based on initial calibration.

Automatic air quality monitoring systems measuring ambient levels of PM_{10}, SO_x, (PM_{10} and SO_x measurements are not required for gas-fired plants), and NO_x outside the plant boundary should be installed where the maximum ambient concentration is expected, and/or where there are sensitive receptors such as protected areas and population centers.

The pH and temperature of the wastewater discharges should be monitored on a continuous basis. Levels of suspended solids, oil and grease, and residual chlorine should be measured daily, and heavy metals and other

pollutants in wastewater discharges should be measured monthly if treatment is provided.

Annex A -- Plants Smaller Than 50 MWe

For plants smaller than 50 MWe including those burning non- fossil fuels, the PM emission levels may be up to 100 mg/Nm^3. If justified by the EA, PM emission levels up to 150 mg/Nm^3 may be acceptable in special circumstances. The maximum emission levels for NO_x remain the same, while for SO_x the maximum emission level is 2,000 mg/Nm^3

Annex-2 Meteorological Data

Table-A.1.1 Hourly Meteorological Data (Collected from Aden Airport)

Date	Hour (IST)	Ambient Temperature (°C)	Wind Speed (km/hr)	Wind Direction (Degree of North)
17/07/2005	100	28.3	12.6	0
17/07/2005	200	28	18	170
17/07/2005	300	30.5	9	70
17/07/2005	400	29.5	14.4	90
17/07/2005	500	30.7	9	90
17/07/2005	600	30.6	7.2	90
17/07/2005	700	28.2	19.8	110
17/07/2005	800	31.1	7.2	170
17/07/2005	900	32.5	7.2	285
17/07/2005	1000	32.4	19.8	185
17/07/2005	1100	32.4	21.6	205
17/07/2005	1200	33.6	12.6	185
17/07/2005	1300	35.6	14.4	195
17/07/2005	1400	35.9	19.8	175
17/07/2005	1500	35.2	23.4	185
17/07/2005	1600	34.3	25.2	185
17/07/2005	1700	33.6	21.6	175
17/07/2005	1800	32.1	14.4	140
17/07/2005	1900	30	18	150
17/07/2005	2000	29.1	19.8	55
17/07/2005	2100	28.6	18	45
17/07/2005	2200	28.6	19.8	25
17/07/2005	2300	29.1	10.8	35
17/07/2005	2400	29.2	7.2	55
18/07/2005	100	29.6	0	0
18/07/2005	200	29.8	5.4	120
18/07/2005	300	28.2	10.8	270
18/07/2005	400	28.3	3.6	0
18/07/2005	500	28.5	3.6	0
18/07/2005	600	29	7.2	120
18/07/2005	700	28.4	7.2	140
18/07/2005	800	30	9	100
18/07/2005	900	31.6	12.6	135
18/07/2005	1000	32.3	19.8	145
18/07/2005	1100	33	21.6	165
18/07/2005	1200	33	21.6	175
18/07/2005	1300	32.4	19.8	195
18/07/2005	1400	32.9	19.8	195
18/07/2005	1500	32.9	18	185
18/07/2005	1600	31.7	18	155

Date	Hour (IST)	Ambient Temperature (°C)	Wind Speed (km/hr)	Wind Direction (Degree of North)
18/07/2005	1700	31.1	18	145
18/07/2005	1800	29.8	16.2	165
18/07/2005	1900	29.4	10.8	165
18/07/2005	2000	29.3	14.4	65
18/07/2005	2100	29.7	10.8	65
18/07/2005	2200	29.7	7.2	65
18/07/2005	2300	29.4	5.4	85
18/07/2005	2400	29.4	5.4	25
19/07/2005	100	31.6	7.2	125
19/07/2005	200	31.7	9	95
19/07/2005	300	29.7	9	85
19/07/2005	400	29	10.8	105
19/07/2005	500	29	7.2	95
19/07/2005	600	29.4	7.2	85
19/07/2005	700	29.5	0	325
19/07/2005	800	30.1	9	45
19/07/2005	900	31.4	3.6	205
19/07/2005	1000	32.2	9	205
19/07/2005	1100	32.8	14.4	175
19/07/2005	1200	32.9	32.4	205
19/07/2005	1300	32.9	37.8	195
19/07/2005	1400	33.9	34.2	195
19/07/2005	1500	33.3	30.6	175
19/07/2005	1600	33.4	32.4	175
19/07/2005	1700	33.6	28.8	165
19/07/2005	1800	33.9	12.6	155
19/07/2005	1900	31.7	12.6	165
19/07/2005	2000	30.6	21.6	45
19/07/2005	2100	30.4	27	45
19/07/2005	2200	31	21.6	45
19/07/2005	2300	31.3	14.4	35
19/07/2005	2400	31.3	5.4	125
20/07/2005	100	30.9	14.4	115
20/07/2005	200	30.1	14.4	105
20/07/2005	300	30.7	5.4	105
20/07/2005	400	31.6	9	50
20/07/2005	500	29.2	19.8	240
20/07/2005	600	29.2	5.4	240
20/07/2005	700	29.8	3.6	280
20/07/2005	800	30.7	7.2	280
20/07/2005	900	31.4	9	185
20/07/2005	1000	32	25.2	185
20/07/2005	1100	32.3	28.8	185

Date	Hour (IST)	Ambient Temperature (°C)	Wind Speed (km/hr)	Wind Direction (Degree of North)
20/07/2005	1200	32.5	27	185
20/07/2005	1300	33.5	23.4	185
20/07/2005	1400	33.8	21.6	185
20/07/2005	1500	34.2	21.6	185
20/07/2005	1600	36.1	9	140
20/07/2005	1700	34.8	12.6	160
20/07/2005	1800	34.8	10.8	140
20/07/2005	1900	33.1	7.2	160
20/07/2005	2000	31.9	5.4	65
20/07/2005	2100	31	7.2	15
20/07/2005	2200	30.9	3.6	15
20/07/2005	2300	31.8	3.6	95
20/07/2005	2400	31.6	5.4	95
21/07/2005	100	32	7.2	105
21/07/2005	200	32	1.8	85
21/07/2005	300	29.2	14.4	85
21/07/2005	400	29.8	14.4	95
21/07/2005	500	30.1	16.2	95
21/07/2005	600	30	16.2	105
21/07/2005	700	30.5	10.8	105
21/07/2005	800	31.4	12.6	105
21/07/2005	900	32.6	7.2	235
21/07/2005	1000	33.2	10.8	175
21/07/2005	1100	34.2	14.4	185
21/07/2005	1200	34.2	28.8	195
21/07/2005	1300	34.1	30.6	195
21/07/2005	1400	34.3	25.2	195
21/07/2005	1500	34.7	25.2	205
21/07/2005	1600	33.9	23.4	185
21/07/2005	1700	34.1	7.2	155
21/07/2005	1800	33.8	10.8	165
21/07/2005	1900	32.8	7.2	25
21/07/2005	2000	31.3	9	15
21/07/2005	2100	31.3	7.2	285
21/07/2005	2200	31.3	3.6	285
21/07/2005	2300	31.7	1.8	105
21/07/2005	2400	31.5	3.6	105
22/07/2005	100	30.9	0	0
22/07/2005	200	30.7	1.8	0
22/07/2005	300	31.3	3.6	265
22/07/2005	400	32.2	7.2	265
22/07/2005	500	32.2	19.8	295
22/07/2005	600	31	9	305

Date	Hour (IST)	Ambient Temperature (°C)	Wind Speed (km/hr)	Wind Direction (Degree of North)
22/07/2005	700	31.6	7.2	305
22/07/2005	800	32.6	10.8	305
22/07/2005	900	33	16.2	215
22/07/2005	1000	33.1	16.2	185
22/07/2005	1100	33.6	27	185
22/07/2005	1200	33.7	32.4	175
22/07/2005	1300	34	28.8	185
22/07/2005	1400	34.1	27	175
22/07/2005	1500	35.2	21.6	185
22/07/2005	1600	36	21.6	185
22/07/2005	1700	35.6	12.6	195
22/07/2005	1800	34.3	10.8	205
22/07/2005	1900	34.1	0	0
22/07/2005	2000	30.3	7.2	65
22/07/2005	2100	31.6	3.6	145
22/07/2005	2200	31.6	7.2	15
22/07/2005	2300	31.2	3.6	115
22/07/2005	2400	30.9	0	0
23/07/2005	100	30.1	7.2	290
23/07/2005	200	31.6	25.2	295
23/07/2005	300	31	1.8	295
23/07/2005	400	30.6	3.6	55
23/07/2005	500	30.2	5.4	55
23/07/2005	600	29.8	12.6	35
23/07/2005	700	30.9	12.6	55
23/07/2005	800	31.6	10.8	115
23/07/2005	900	31.8	9	40
23/07/2005	1000	32.1	27	195
23/07/2005	1100	31	25.2	215
23/07/2005	1200	34	1.8	205
23/07/2005	1300	34.1	32.4	205
23/07/2005	1400	34.5	37.8	195
23/07/2005	1500	34.5	41.4	195
23/07/2005	1600	34.6	41.4	195
23/07/2005	1700	35	37.8	195
23/07/2005	1800	34.9	36	195
23/07/2005	1900	34	32.4	185
23/07/2005	2000	33	28.8	275
23/07/2005	2100	33.4	19.8	275
23/07/2005	2200	31.6	12.6	340
23/07/2005	2300	31.9	3.6	200
23/07/2005	2400	30.3	10.8	90

Table-A.1.2 Hourly Mean Meteorological Data
(Based on Data Collected from Aden Airport for period 17/05/2005 to 23/05/2005)

Hour (IST)	Ambient Temperature (°C)	Wind Speed (km/hr)	Predomimant Wind Direction (from)
100	30.5	6.9	N
200	30.6	10.8	E
300	30.1	7.7	E
400	30.1	9	NE
500	30	11.6	E
600	29.9	9.3	E
700	29.8	8.7	ESE
800	31.1	9.5	ESE
900	32	9.3	SW
1000	32.5	18.3	S
1100	32.8	21.9	S
1200	33.4	22.4	S
1300	33.8	26.7	SSW
1400	34.2	26.5	SSW
1500	34.3	26	S
1600	34.3	24.4	S
1700	34	19.8	SSE
1800	33.4	15.9	SSE
1900	32.2	12.6	SSE
2000	30.8	15.2	ENE
2100	30.9	13.4	NE
2200	30.7	10.8	NNE
2300	30.9	6.2	NE
2400	30.6	5.4	E

Power Sector Project

List of Participants in Public Consultation

Place: Meeting Hall, Al-Hiswa Power Station   Date: 30/7/2005

SN	Name	Signature
1.	Mr. Abhijit Dutta	
2.	Mr. Rajib Kumar	
3.	RAID MAHMOOD ALi	
4.	Asghar Mohamed Hanif	
5.	Morad Hail Ganem	
6.	Nadim Saeed Nizam	
7.	Shaker Mohamad Awad	
8.	Mareed Abdo Salem	
9.	Gassan Ahmed	
10.	MKSEM Saif saif Ali	
11.	Mohammed FadHL Hamooda	
12.	Salem Lousnen mansoor	
13.	[illegible] G. M. O	
14.	Hanash Nagi Zain	
15.	Hassan G. M.	
16.	Abdulla Nasser BA-Suraid	

Power Sector Project

List of Participants in Public Consultation

Place: Meeting Hall, Al-Hiswa Power Station Date: 30/7/2005

SN	Name	Signature
1.	Mr. Abhijit Dutta	[signature]
2.	Mr. Rajib Kumar	[signature]
3.	RAID MAHMOOD ALI	[signature]
4.	Asghar Mohamed Hanif	[signature]
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8.	Mabeed Abdo Salem	[signature]
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15.	Hassan G. M.	[signature]
16.	Abdulla Nasser BA-Suraid	[signature]

APPENDIX A
Terms of Reference & Scope of Services

Appendix A consists of:

Appendix A1: Scope of Services
Appendix A2: Terms of Reference

Appendix A1

SCOPE OF SERVICES

The Scope of Services to be provided by the Consultants as specified in the Terms of Reference – ***Appendix A2***, but shall include:

- In general, look into the various effects of the new boiler and new transmission overhead lines and associated sub-stations technical design and prepare an environment management plan;

- Consider all significant impacts on the various medias of environment, namely air, water, soil, noise, plant life and neighhourhood residence;

- Elaborate proposal for the minimization of those effects;

- Discuss the findings of the impact assessment in the light of utility analysis;

- Propose mitigation measures based on the findings and analysis;

- Finally, evaluate the project according to categories of the weights of Yemen legislations and laws guidelines for Environmental Impact Assessment (EIA);

- The enclosed Terms of Reference (TOR) (***Appendix A2)*** forms part of the Consultant's Scope of Services (*Appendix A1).*

- The Client's letter Ref PSP/0010/2005 dated 25-5-2005 (***Annex-1)*** and clarification made by the Consultant vide letter no. SC/BP/1907 dated My 28, 2005 (*Annex-2) forms part of* the Consultant's Scope of Services.

Appendix A2

Terms of Reference

Environmental Impact Assessment (EIA)

Power Sector Project

A. Background

The Public Electricity Corporation (PEC), a state corporation, requested assistance to the power sector in Yemen through World Bank – IDA- financing , during the course of the project preparation and in compliance with the Bank safeguard policies on Environmental Impact Assessment (EIA) PEC is requested by the Bank to complete a limited environmental impact assessment for the project prior to project appraisal in order to provide a framework for identification, assessment and management of environment and social concern for the project.

B. Project Description and Objectives

The over all purpose and objective of the Power Sector Project is to improve the efficiency and quality of electricity supply through: (i) financing of critical investments for the rehabilitation of existing power stations; de-bottlenecking of the transmission system; loss reduction programs and strengthening of the distribution systems and (ii) assisting with the implementation of sector reforms and capacity building and training. The expected outcomes would include: (i) the further improvements in the efficiency of operations and financial position of the PEC: and (ii) the enactment of a new electricity law which would improve the industry structure, and the regulatory framework and facilitate private sector participation by encouraging local communities and private companies to engage in the electricity supply.

The construction of proposed 132 KV double circuits transmission lines and sub-stations suggest that PEC may need to acquire land and scene / survey rout lines for these infrastructure investments.

C. Investment Project Component

The Investment Component consists of the following sub-component:-

(i) Generation Rehabilitation sub- component: This sub-component consists of addition of a 160 ton per hour boiler at Al-Hiswa steam power station (Aden region). Details are included in Annex – 1 –TOR.

(ii) Transmission sub-component : This component consists of; (a) New transmission lines, new sub-stations, expansion of existing sub-stations in Hodeidah area; (b) new transmission lines, new sub-stations, expansion of existing sub-stations in Dhamar area. Details are included in Annex - 2–TOR. The proposed construction of a double circuits transmission lines 132KV system will be connected to the overall PEC grid that is supplied mainly from the steam power stations (Ras-Katnib; Al-Mukah and Al-Hiswa) and from some diesel power stations. Planed Right-of-Way maps prepared by PEC.

The proposed investments form part of the Public Electricity Corporation (PEC) least cost investment program.

D. Description and Objectives of the Environmental Impact Assessment (EIA)

The Bank's safeguards policy on Environmental Assessment Operation Policy 4.01 applies to all projects, the proposed project falls into environmental screening category " B " of Word Bank OP 4.01. An Environmental Impact Assessment (EIA) to be developed as an element of the project preparation process in order to be consistent with applicable state regulatory policies and with World Bank policies.

The preparation of an EIA will facilitate project investments, mitigate risks arising from investments, potential environmental impacts, identify proposed mitigation activities, enhance project design and implementation practices by insuring that the projects sub- components are environmentally and socially sound and sustainable throughout the project life.

The EIA is part of the loan agreement and is a condition for project appraisal.

E. Contents of the Environmental Impact Assessment (EIA)

The EIA shall be a concise document which evaluates issues in consistent with their relative significance and will elaborate consultation with various stakeholders involved power transmission including relevant state government officials, non governmental organizations etc.

In order to assess each of the project sub-components for their potential environmental impact(s), the EIA should include the following:

i) An environmental audit of one steam power stations to be rehabilitated that will include design recommendation for improving the stations environmental performance;
ii) An EIA for proposed rehabilitation work; transmission lines, and
iii) A detailed environmental management plan (EMP) that outlines the mitigation measures required for the two sub-components during the design, construction, and operation phases.

The EIA should be conducted as a separate (but related) study from the Resettlement Policy Framework (under preparation).

The following presents the table of contents of the EIA and explains the contents of the documents which can be followed but not limited to.

1. Executive Summary

2. Project Description (to be supplied by PEC).

3. Principles and Objectives of the EIA

4. Environmental Policy, Legal and Administrative Framework (draft to be supplied by PEC).

5. Environmental Monitoring and Auditing.

6. Analysis of Alternatives.

7. Proposed Environmental Monitoring Measures.

8. Environmental Management and Training Plan

Appendices

i. Detailed Analysis of Data Collected / Measurements

ii. List of Prepares

iii. References

iv. Record of Meetings and Public Consolations.

F. Scope of Services and Key Issues to be Addressed

1. Generation: Conduct an audit of Environmental Conditions at Al-Hiswa Steam Power Plants Site proposed for re-habilitation. The audit should include, but not be limited to:

(i) Current and Potential Air Quality Impacts;
(ii) Current and Potential Cooling Sea Water Impacts including discharge;
(iii) Waste Management and Disposal Practice (both oily and solid);
(iv) Worker Health and Safety;
(v) Emergency Management;
(vi) Environmental Impacts and Safety Risks associated with Residual Fuel;
(vii) Any others site-specific environmental issues; and
(viii) Proposed mitigation measures for any negative environmental impacts identified.

2. Transmission & Sub-Stations: conduct an environmental impact assessment (EIA) for the proposed and sub-station sub-components. The EIA will include but not be limited to:

(i) Identification and analysis of relevant environmental and social issues;
(ii) Identification and analysis of the most likely physical constraints;
(iii) Definition of international standards for height, distance from habitation (clearances), livestock, for transmission lines;
(iv) Route selection and right-of-way;
(v) Existing environment of the proposed project sites;
(vi) Territorial description around the lines; including any endangered natural habitats to be crossed;
(vii) Landscape of lines and sub-station sites;
(viii) Land use;
(ix) Economic and social benefits;
(x) Identification of any historical and cultural in the vicinity project sites;
(xi) Any others site-specific environmental issues;

3. Provide guide lines to PEC for disposal of PCB's contaminated oils;

4. Analyze potential of alternatives to proposed sub- components if major, negative environmental impacts are identified.

5. Identify necessary mitigation measures in all sub-components.

6. Prepare an environmental management and training plant that includes, but is not limited to:

   i- A detailed Environmental Management plan (EMP)
   ii- Costing of all mitigation measures and responsible party for financing those measures;
   iii- Party (ies) responsible for supervising EMP;and
   iv- Training plan for supervising engineers and contractors on the implementation of the EMPs.

7. Conduct public consultations with local stakeholders in conjunction with PEC on the contents of the EIA.

G. Task Responsibilities

The Consultant will prepare the report on the above outline of contents for the Generation, Transmission, and sub-stations sub-components. The EIA report shall be submitted as a draft for approval by the PEC . The final approved version will be publicly disclosed prior project appraisal scheduled in August, 2005.

H. Deliverables

Acceptance of Documents will be subjected to the Client approval

Task (1) First draft for discussion and consultation – not later than two weeks from the contract coming into force

Task (2) Second draft for review by PEC – within four weeks from the acceptance of the first draft report

Task (3) Final report document

1. Consultant Qualifications (**Not to be used for evaluation purpose**)

The consultant team should have signification international experience in preparing and supervising EIAs/ EMPs for Power sector projects including:

i. Steam generation;
ii. Transmission and Distribution;
iii. Hazardous waste disposal related to PCB oils.

The team would benefit by including members who speak Arabic.

J. Reporting

The Consultant will report to :-

Project Director
Eng. Ahmed BOKASH
Public Electricity Corporation (PEC)
P.O. Box No. 178
Airport Road, Sana'a
Republic of Yemen
Tel: 967-1- 328164 / 5 and 73783161 (Mobile)
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E-Mail: YPECNT@Y.NET.YE and
a.bokash@yemen.net.ye

Annex-1-TOR

Detailed of Generation sub-Components

Generation sub-component:

Background

PEC is short of generating capacity. It also has deficiencies in transmission and distribution capabilities in some areas. In July 1997, PEC with the energization of the 132-kV Aden-Taiz line interconnected its southern transmission system comprising of Al-Hiswa complex with northern transmission system comprising of Ras Katenib/Al-Mukha complex. This interconnection added flexibility in operations and provided some additional capacity on account of diversity of loads in the two systems. Under the ongoing Sana'a Emergency Power Project PEC added 30 MW of diesel generation at Dhaban-2, including a 5 MW of diesel generation at Al-Qa'a power station and rehabilitated 20MW of diesel at Dhahban-1 increasing the plant capacity from de-rated 8 MW to 18 MW. A new 70 MW of diesel power plant has been commissioned in October 2004 at Hizyaz.

The inter-connected system (oil fired steam as well as diesel plants, including the new Hizyaz DPS) has now 771 MW of installed capacity of which the effective capacity is 530 MW. In addition to the interconnected system, PEC has isolated diesels of 161 MW installed capacity at Mukalla, Sayoun, Ataq and Laouder; the effective capacity is 94 MW. The past and future estimated load demand as well as energy consumption of total system (interconnected plus isolated) are included in Annex-5. The details included indicate that during FY03, the maximum shortage was 21 MW (on November 15) of peak power. This was in addition to the suppressed and unmet demand as estimated by PEC of about 130 MW. For FY03, the load demand for the national grid was (580 +130) MW, the energy consumed during the year 2003 was 3169.4 GWh. The average load shedding was about 20% of peak demand.

Proposed components

The Project provides for rehabilitation of one oil fired steam plants at Al-Hiswa (5X25MW). The details are discussed below. The cost of this component is based on the estimates provided by PEC, based on previous experience and offers.

Power Station Details, Rehabilitation Plans, Cost Estimates

Al-Hiswa: There are five steam turbines of 25 MW each and six boilers of 160 tons/hr each for supply of steam to them. PEC has already carried out overhaul of turbine nos. 3 and 4. It now intends to overhaul the remaining three turbines nos. 1, 2 & 5 and boilers nos. 2, 4, 5 and 6. Rehabilitation of boilers 1 & 3 is in progress. PEC plans to replacing some old parts and modernizing its combustion control and firing systems, and rehabilitating the six boilers is. In

addition, PEC plans install a 7th boiler of 160 tones/hour capacity to meet the requirement of the plant expansion by addition of a 60MW turbine and to increase the power station reliability. PEC also plans to modernize its control/protection system.

Technical Justification As shown in the above tables, the overhaul and rehabilitation is justified because it will: (a) improve efficiency (b) increase the available rated MW capacity and finally increase the available running hours. All the plants are about 20 years old and can continue to provide useful service if maintained properly.

Annex-2-TOR

Detailed of Transmission and sub-stations sub-Components

Transmission Sub-component

Background

PEC, assisted by its consultant (Kennedy & Donkin, U.K.) carried out a series of system studies to identify least cost options to develop its transmission system. The consultant produced a Northern Loop Transmission Project Report (No.40201). Based on the recommendations of this report, PEC has submitted proposals for augmenting its transmission facilities related to two grid substations: (i) Hodiedah and (ii) Dhamar as follows:

CURRENT STATUS AND PROPOSED PLAN

Hodiedah Substation: This 132-kV Bulk Supply Point (BSP) substation is at present interconnected to Ras Katenib power station and 132-kV substation. The 33-kV load demand here has gone up to 78MW 70 MVAR (totaling 105 MVA), whereas 132/33kV transformer capacity is only 2X60 MVA. PEC proposal calls for creation of a new 132-kV substation at Kilo16 with transformers of 132/32-kV and 33/11-kV of 60 MVA and 20 MVA each. Kilo 16 substation will be fed through a 12 km 132-kV line from Hodiedah. About 36 MW of 33-kV load fed from Hodeidah DSP station (Kornish, Maraweah, Kilo 4 feeders) will be transferred to the new Kilo 16 sub-station resulting in improved performance. Alternatively, if the 33-kV loads continue to be fed from Hodeidah, it will result in poor voltage and increased system losses.

PEC is also proposing a new single Bus-Bar 132-kV substation at Hodiedah because on account of substantial commercial development in that area, it is not possible to acquire new land. The existing substation has enough land for the interlinking substation and no new land will be required.

Dhamar Sub-station: This is the second BSP substation proposed to be augmented under the project. A new 90 km of 132-kV double conductor d/c line from the existing Dhamar sub-station to Hiziaz is proposed. The sub-station at Hiziaz is proposed to be constructed under the Marib Transmission line project.

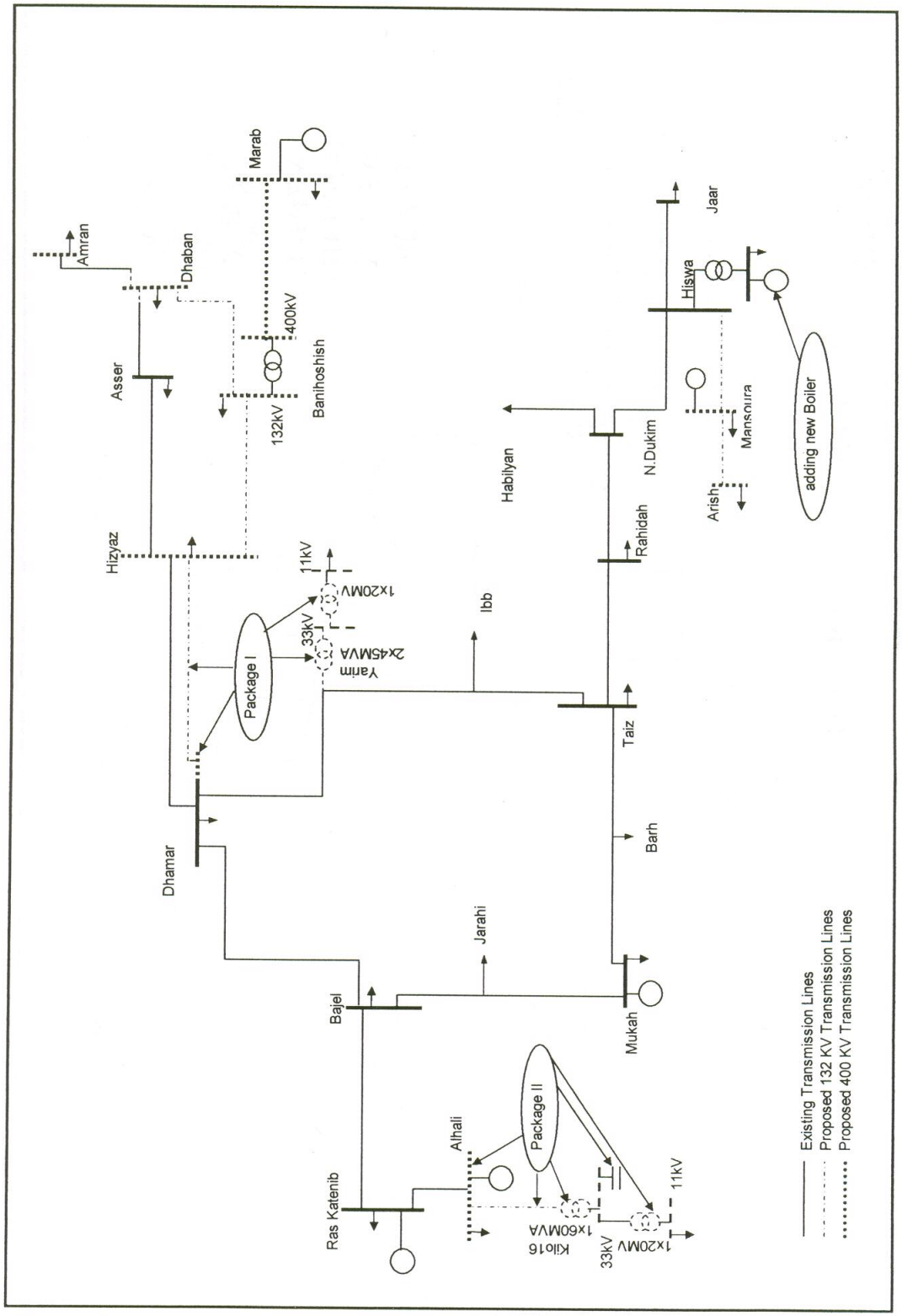
Yarim Substation: PEC is also proposing a new 132/33-kV substation at Yarim (2/45MVA 132/33kV transformers and 33/11kV, 20MVA transformer), by tapping the 132-kV existing double circuit lines between Dhamar and Ibb. The new Yarim substation will relieve over loading of Dhamar substation

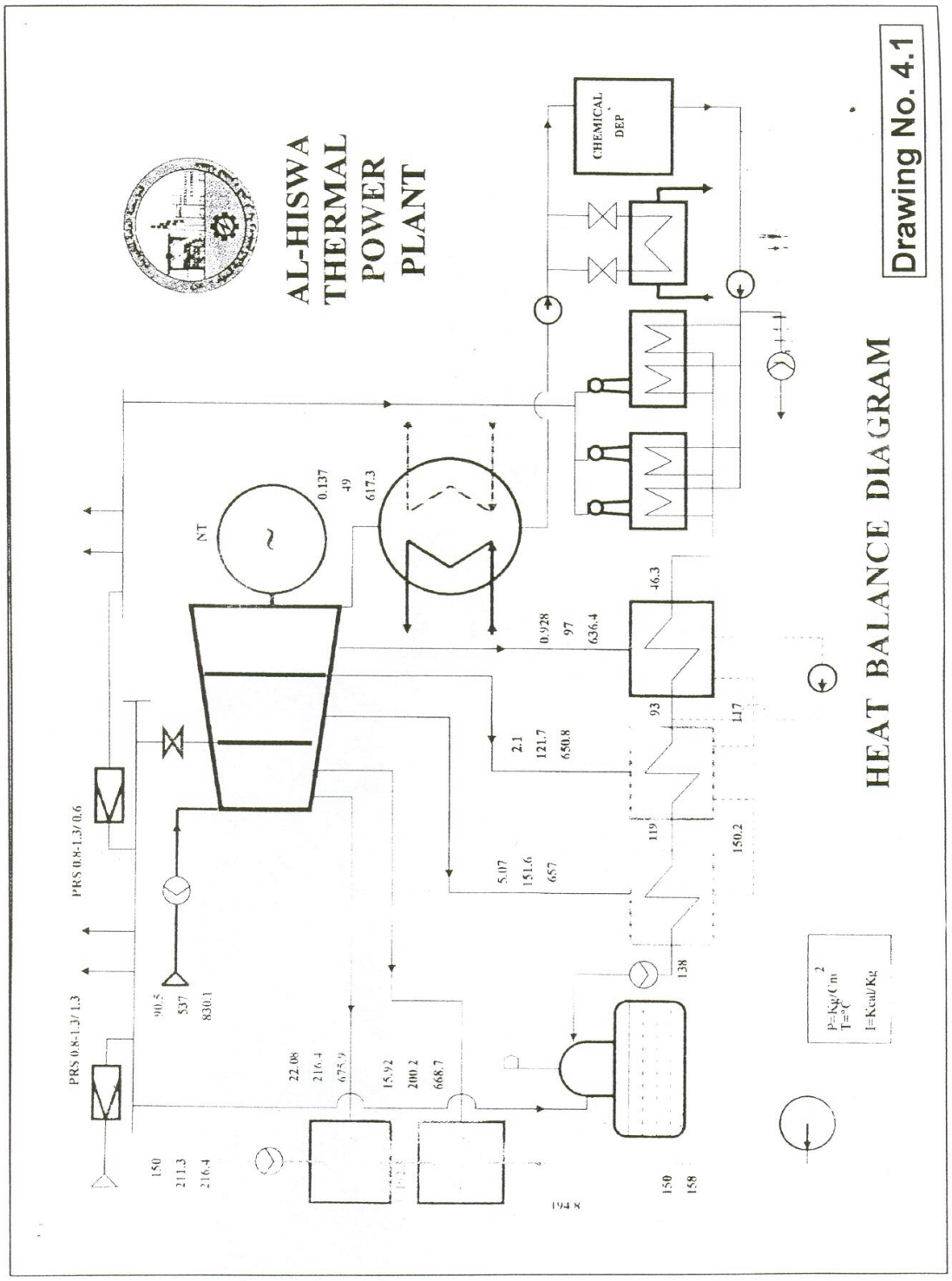
Technical Justification These works are least cost options to meet the increasing loads. If instead of these new 132-kV works, existing 33-kV facilities are augmented, system losses will increase and voltage regulation will become very difficult.

Procurement Packages and their costs

Based on above, there will be possibly ten (9) sub-packages including consultancy which could be re-grouped in three main packages as explained below. In addition there will be a consultancy package as well.

1. Supply and installation of 12 km of d/c 132kV line from Hodiedah to Kilo 16;
2. Supply and installation of 90 km of d/c 132 kV line from Dhamar to Hizyaz;
3. Supply and installation of a 132 kV new substation at Kilo 16;
4. Supply and installation of 132 kV new single busbar substation at Hodiedah;
5. Supply and installation of 132 kV (extension) Dhamar substation;
6. Supply and installation of 132kV new substation at Yarim; and
7. Reactive compensation at Hodiedah BSP.


Drg. No. 3.1 Line Diagram for Substations & Transmission Lines
Marab
Amran
Dhaban
400kV
Asser
Banihoshish
132kV
Hizyaz
11kV
1x20MV
33kV
2x45MVA
Yarim
Package I
Dhamar
Ibb
Habilyan
N.Dukim
Hiswa
Jaar
Mansoura
Arish
adding new Boiler
Rahidah
Taiz
Barh
Jarahi
Bajel
Mukah
Alhali
Package II
Ras Katenib
Kilo16
1x60MVA
33kV
1x20MV
11kV
Existing Transmission Lines
Proposed 132 KV Transmission Lines
Proposed 400 KV Transmission Lines


AL-HISWA
THERMAL
POWER
PLANT
Drawing No. 4.1
HEAT BALANCE DIAGRAM
CHEMICAL DEP
NT
PRS 0.8-1.3/ 0.6
PRS 0.8-1.3/ 1.3
0.137
49
617.3
0.928
97
636.4
46.3
93
117
2.1
121.7
650.8
119
150.2
5.107
151.6
657
138
90.5
537
830.1
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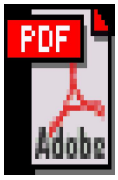
675.9
15.92
200.2
668.7
150
211.3
216.4
150
158
194.8



Drwg4.2-Hodeidah-Kilo16 TL-4.pdf

Drwg4.3-Dhamar-Hiyaz TL.pdf

(soft copy is not attached here but hard copy is available in the Final Report)