Energy That Moves Life

The Registrar,
National Electric Power Regulatory Authority (NEPRA),
NEPRA Tower, Attaturk Avenue (East),
Sector G-5/1,
Islamabad.

Ref # KE/BPR/NEPRA/2019/1339
December 24, 2019

SUBJECT: MODIFICATION OF GENERATION LICENCE [GL/04/2002]

Dear Sir,

K-Electric (KE) has been issued Generation Licence No. GL/04/2002 on November 18, 2002 **("Generation Licence")** under Section 15 and Section 25 of the NEPRA Act, 1997. In the past, Generation Licence has been modified by NEPRA as per the requests of KE with the latest modification **("Modification VIII")** granted vide NEPRA letter # NEPRA/R/DL/LAG-05/4338-42 dated March 13, 2019. Considering the current demand/supply situation along with growing electricity requirements of the Karachi City, KE is proposing to supplement its existing generation fleet through addition of a new power plant along with diversification of its existing fuel mix to reduce dependency on conventional fuels (Indigenous gas and furnace oil), as already approved in the investment plan under KE's MYT for the control period 2017-2023.

Pertinent to mention that, KE has added 1,057 MW of efficient power generation capacity and as a result, has been able to improve overall fleet efficiency from 30% in FY 09 to 37% in FY 19. With the growing power demand, peak demand within KE's service area during FY 20 is expected to be 3,392 MW[1] whereas the maximum supply expected is 3,155 MW[2]. Even though KE has added 1,057 MW in its generation capacity during the last ten years along with addition of around 400 MW from external sources, yet the shortfall expected in FY 20 is around 250 MW. To bridge this gap along with the growing power demand as well as to diversify the fuel mix, KE is proposing following modifications in its Generation License for the approval of the Authority:

- **Addition of RLNG based 900 MW (450 MW x 02) Combined Cycle Power Plant (BQPS – III); and**
- **Consequent decommissioning of units 3 and 4 of BQPS - I**

These proposed changes will help optimize the fuel mix, improve generation efficiency, enhance reliability and reduce reliance on old thermal based generation and Independent Power Producers (IPPs) which will ultimately benefit the consumers in the form of lower tariffs.

The Authority has already approved this project as part of investment plan under KE's Multi Year Tariff determination notified on May 22, 2019 (please refer clause xxiii(v), para 34.1). Accordingly, to bridge

[1] Peak demand is after adjustment for AT&C based load shed.
[2] Given the intermittent nature of renewable projects, supply from renewables has not been accounted for in projected supply for the purpose of comparison with peak demand.

KE House, 39-B, Sunset Boulevard, Phase-II, Defence Housing Authority, Karachi
www.ke.com.pk 92-21-3263-7133, 92-21-3870-9132, UAN: 111-537-211

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the gap between demand/supply, the management of KE is actively pursuing this project, and in this regard, contracts have been signed with Harbin Electric International and Siemens AG Germany.

Further, as requested earlier, KE understands that, in line with the process followed for IPPs, the adjustment of actual exchange rate variations in the cost of BQPS III Project will be accounted for in the mid-term review as part of KE's MYT.

In light of the above, this application is being submitted under Sub Rule (2) of the Rule 10 of the NEPRA Licensing (Application and Modification Procedure) Regulations, 1999 for Modifications of the Generation License. In relation, hereto, this is to certify that the following documents enclosed with this modification application are prepared and submitted in conformity with the provisions of the Regulations, and that the Company undertakes to abide by the terms and provisions of the Regulations.

a) Text of Proposed Modifications
b) Statement of Reasons and Specifications in support of Modifications
c) Statement showing the impact of tariff, quality of service and the performance by KE of its obligations under the License
d) Certified True Copy of Board Resolution
e) Power of Attorney
f) Affidavit

Additionally, please find enclosed cross cheque of Rs. 915,000 (net of withholding tax of Rs. 73,200) having number 10081569 dated December 16, 2019 of Habib Bank Limited being the license modification's fee calculated in accordance with Schedule II to the NEPRA Licensing (Application and Modification Procedure) Regulations, 1999.

At the end, we humbly request the Authority that modification in the Generation License of KE be allowed and approved as per the Regulation 10 (11) of the NEPRA Licensing (Application and Modification Procedure) Regulations, 1999.

Sincerely,

Ayaz Jaffar Ahmed
Director – Finance and Regulations

Enclosure:
- Documents as mentioned at serial (a) to (f) above.
- Annexures A & B (including a CD) comprising information to be included with LPM.

KE House, 39-B, Sunset Boulevard, Phase-II, Defence Housing Authority, Karachi
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Certified True Copy (CTC) of Resolutions
passed by K-Electric Board of Directors at its Minutes of 1210th
held on Wednesday 25th September 2019 at 10:00 am in KE Board Room
3RD Floor KE House 39-B Sunset Boulevard Phase-II DHA Karachi

Award of Project Contracts to Siemens - Harbin consortium to establish 900 MW combined cycle power plant at BQ III

IT IS HEREBY RESOLVED THAT K-Electric be and is authorized to execute the Equipment Supply Contract with Siemens-Harbin Consortium, Construction Contract with HE Harbin Electric Pvt. Ltd and Project Coordination Deed with all these parties to establish 900 MW Bin Qasim III Combined Cycle Power Plant and associated transmission projects; on mutually agreed terms and conditions.

RESOLVED FURTHER THAT Chief Executive Officer (CEO) jointly with anyone of Chief Financial Officer (CFO) and Chief Generation & Transmission Officer (CGTO) be and are hereby authorized to sign the aforesaid Contracts for and on behalf of the Company.

MUHAMMAD RIZWAN DALIA
Company Secretary
K-ELECTRIC LIMITED

Muhammad Rizwan Dalia
Chief People Officer & Company Secretary

Certified True Copy (CTC) of Resolutions
passed by K-Electric Board of Directors at its Meeting No. 1193
held on Wednesday, 09 August 2017 at 10:30 a.m. in KE's Board Room,
3RD Floor, KE House, 39-B, Sunset Boulevard, Phase-II, DHA, Karachi

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Licensee Proposed Modification (LPM) in K-Electric's Generation License

RESOLVED THAT K-Electric be and is hereby authorized to file a Licensee Proposed Modification (LPM) in Generation License (No.GI/04/2002) with the National Electric Power Regulatory Authority (NEPRA), pursuant to Sub Rule (2) of Rule 10 of NEPRA Licensing (Application & Modification Procedure) Regulations 1999, for (i) Addition of 900 MW generation (450 MW x 2) RLNG based Combined Cycle Power Plant at Bin Qasim Power Station Complex (BQPS-III), (ii) Decommissioning of Units 3 and 4 of BQPS-I and (iii) Modification in BQPS-II power plant of 560 MW to operate on RLNG as alternate fuel as and when available.

RESOLVED FURTHER THAT Chief Executive Officer (CEO) and Chief Generation & Transmission Officer (CGTO), K-Electric be and are hereby jointly authorized to nominate any officer of the Company, as they deem appropriate, to sign and file the LPM with NEPRA and such other deeds, documents, instruments etc. and take all necessary actions incidental and related to the LPM and appear before the Authority and admit execution thereof for and on behalf of the Company.

MUHAMMAD RIZWAN DALIA
Company Secretary
K-ELECTRIC LIMITED

MUHAMMAD RIZWAN DALIA
Company Secretary
K-ELECTRIC LIMITED

KE
Energy That Moves Life

Dated: December 12, 2019

AUTHORITY LETTER

We, Syed Moonis Abdullah Alvi s/o Syed Riazuddin Alvi, Chief Executive Officer (CEO) and Dale Roger Sinkler s/o Larry Roger Sinkler, Chief Generation & Transmission Officer (CGTO) of K-Electric Limited, having its Registered Office at the KE House, 39-B, Sunset Boulevard, Phase II, Defence Housing Authority, Karachi, are jointly authorized by the Board of Directors (BOD) of the Company through resolution passed in the Board Meeting of the Company held on 9th August 2017, to nominate any officer of the Company, as we deem fit, to sign and file the Licensee Proposed Modification (LPM) in Generation License (No.GL/04/2002) with the National Electric Power Regulatory Authority (NEPRA) and such other deeds, documents, instruments etc. and take all necessary actions incidental and related to the LPM and appear before the Authority and admit execution thereof for and on behalf of the Company.

Now, therefore, in exercise of powers vested in us by the BOD of the Company, we, hereby jointly authorize Ayaz Jaffar Ahmed s/o Jaffar Ahmed, having CNIC No. 42000-5311358-3, Muslim, Adult, and Resident of Flat No. 306, Barkati Mahel, Jamshed Road No.3, Karachi, Director Finance & Regulations, KE to sign and file the LPM with NEPRA and such other deeds, documents, instruments etc. and take all necessary actions incidental and related to the LPM and appear before the Authority and admit execution thereof for and on behalf of the Company.

Syed Moonis Abdullah Alvi
Chief Executive Officer
K-Electric Limited

Dale Roger Sinkler
Chief Generation and Transmission Officer
K-Electric Limited

Authorized Person:

Ayaz Jaffar Ahmed
Director Finance & Regulations
K-Electric Limited

MUHAMMAD RIZWAN DALIA
Company Secretary
K-ELECTRIC LIMITED

100
Rupees

13 SEP 2019

AZAM ALAM STAMP VENDER Licence No. 59
G-7, Spanish Homes, Phase-1, D.H.A. Karachi

13 SEP 2019

RUPEES ONE HUNDRED ONLY

S. No.......... Date..........
Issued To With..........
Through With Address..........
Purpose..........
Value Rs.......... Attached..........
Stamp Vendor Signature..........

S.M. Ramzan Gillani
(MA, LLB & LLM)
Advocate High Court

NOT VALID FOR DIVORCE & FREE WILL

LICENSEE PROPOSED MODIFICATION (LPM) IN GENERATION LICENSE (NO. GL/04/2002) BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY (NEPRA)

AFFIDAVIT

I, Ayaz Jaffar Ahmed s/o Jaffar Ahmed, having CNIC # 42000-5311358-3, Muslim, Adult, resident of Flat No. 306, Barkati Mahel, Jamshed Road No.3, Karachi, Director Finance & Regulations, KE, do hereby solemnly affirm and declare as under:

1. That I am the applicant in the subject matter and well conversant with the facts of the Licensee Proposed Modification (LPM).

2. The contents of the enclosed modification to the Generation License under Regulation 10(2) of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, are true and correct to the best of my knowledge and belief.

3. I affirm that all further documentation and information to be provided by me in connection with the aforesaid modification to the Generation License shall be true and correct to the best of my knowledge and belief.

4. That, I am authorized to sign and file the LPM with NEPRA and such other deeds, documents, instruments etc. and take all necessary actions incidental and related to the LPM and appear before the Authority and admit execution thereof for and on behalf of the Company.

Dated: December 17, 2019

Deponent

SWORN BEFORE ME

M. AKHTAR NASIM
Advocate & Oath Commissioner
Karachi

M. AKHTAR NASIM Advocate & Oath Commissioner Karachi

19 DEC 2019

- **ADDITION OF RLNG BASED 900 MW (450 MW X 2) COMBINED CYCLE POWER PLANT AT BIN QASIM POWER STATION COMPLEX (BQPS – III)**

AND

- **CONSEQUENT DECOMMISSIONING OF UNITS 3 AND 4 OF BIN QASIM POWER STATION – I (BQPS – I)**

A. Text of Proposed Modification

K-Electric (KE), as part of its business plan, and the investment plan approved under the Multi Year Tariff (MYT) for the control period 2017 to 2023, is setting up a new Re-Gasified Liquefied Natural Gas (RLNG) based Combined Cycle Generation Facility, at Bin Qasim (**"BQPS - III"**) with consequent decommissioning of units 3 and 4 of BQPS – I.

B. Statement of Reasons and Specification in Support of Modification

1. Addition of 900 MW Bin Qasim Power Station – III (BQPS -III)

KE has the sole responsibility of providing electric power services in the metropolitan city of Karachi and its adjoining areas. In this regard, the Authority has granted three (03) separate licences to KE for generation, transmission and distribution services.

With growing power demand, Peak demand within KE's service area during FY 20 is expected to be 3,392 MW[1] whereas the maximum supply expected is 3,155 MW[2]. Even though KE has added 1,057 MW in its generation capacity during the last ten years along with addition of around 400 MW from external sources, yet the shortfall expected in FY 20 is around 250 MW. Further, the rapid growth in city's population along with setting up of Special Economic Zones (SEZs) and Industrial parks within KE's service territory is expected to result in significant increase in electricity demand, such that KE's peak demand is expected to reach around 4,700 MW by 2023. To address the existing power shortfall and considering the rising demand of the city and its suburbs, KE has planned additions of around 2,800 MW of generation capacity including renewables, in the next four years through its own as well as external sources. In addition, KE is in discussions with GoP for additional supply from the National Grid.

The addition of 900 MW RLNG plant is an integral part of the business plan, aimed at bridging the power shortfall and providing smooth and reliable supply of power to the consumers.

The proposed power plant will be set up at Bin Qasim with an installed capacity of 900 MW (Gross). It is intended that BQPS-III shall be constructed in the most expeditious manner by commissioning the first unit in summer of 2021 (within nineteen months from commencement – Dec 19) followed by another unit's commissioning within twenty-four months from the commencement. Further, to ensure reliable evacuation of power from BQPS-III, the system load flow has also been reviewed and for this, simultaneous investments are proposed in transmission projects based on the geography of the load demand requirement.

[1] Peak demand is after adjustment for AT&C based load shed.

[2] Given the intermittent nature of renewable projects, supply from renewables has not been accounted for in projected supply for the purpose of comparison with peak demand.

K-ELECTRIC LIMITED

Benefits:

The benefits associated with the project are entailed below:

- BQPS -III will help to meet the growing electricity demand of the city and bridge the demand-supply gap
- Aid in improving the operational reliability of the generation fleet by periodically decommissioning old units
- Will improve the fuel diversification within KE's generation fleet as the new combined cycle plant will operate on RLNG
- Will enhance transmission evacuation capacity by offloading EHT network through conversion of KCCP interconnection to 132 kV
- Will replace the old grid stations / HV Substation(s) to enable provision of operating at N-1 contingency

Scope of Work:

The basic details for BQPS-III project are given below:

Generation Plant
02 x 450 MW CCGT (1+1+1) configuration Fuel : RLNG / HSD
Generation / Transmission HV Substations
Replacement of old 220 kV GIS at BQPS with new 63 kA, 4,000 Ampere GIS & Addition of Series Reactors
Replacement of old 132 kV AIS at KPC with new 132 kV GIS / Generation Transformation Capacity from 220 kV to 132 kV as Embedded Generation for load flow
Replacement of 220 KV ICI Grid with 63 kA / 4000 Amperes AIS Replacement of 132 kV GIS at Landhi with new 50 kA GIS Replacement of 132 kV AIS at Korangi West with new 50 kA GIS

Estimated Capex:

The total planned investment for addition of BQPS III is estimated at USD 641 million[3].

Fuel:

The Primary fuel for BQPS III Plant is RLNG and the total RLNG requirement for BQPS III is 150 MMCFD. KE is pursuing dedicated supply of RLNG to be delivered to its Bin Qasim Power Complex to meet the gas requirement of BQPS-III plant.

In this regard, the scope of desired Gas Infrastructure (interconnection pipelines, metering, pressure reduction and heating systems) has already been covered within the project contracts of BQPS-III. In this regard, Front End Engineering Design (FEED) of the project has already been completed. The infrastructure under the project shall incorporate all the requirements to ensure uninterrupted and smooth operation of facilities at BQPS complex.

[3] Includes estimated ancillary costs, interest during construction and financing costs which are subject to change.

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KE expects that RLNG can be timely supplied through any of the two existing LNG import terminals in Pakistan for which 150 MMCFD excess regasification capacity is already available at the Gasport Terminal, whereas Engro terminal is planning for expanding its capacity by 150 MMCFD.

With the assistance of renowned international consultant "Poten & Partners" and international law firm "Norton Rose", KE has initiated a structured international bidding process for the procurement of RLNG. The bidders have proposed 150 MMCFD RLNG supply from the existing terminals and KE is in the process of evaluating bids and selection of the preferred bidder. Initially, a binding HoA will be signed with the preferred bidder to be selected through the undergoing bidding process. This HoA will be then be expanded into a fully termed GSA and negotiation of GSA will commence promptly after the HoA is signed. KE will submit the terms for approval of NEPRA in due course.

The secondary Fuel is HSD which will be supplied by PSO/BYCO or equivalent as the case may be.

Consequent Decommissioning of Units 3 and 4 of Bin Qasim Power Station-I (BQPS – I)

Considering low plant availability due to frequent forced outages, high cost of fuel and low efficiencies of Unit 3 & 4, KE has planned to decommission these units with the addition of BQPS - III in KE's generation fleet. In this regard, Unit 4 is proposed to be decommissioned within 13 months from Project commencement, followed by decommissioning of Unit 3 within 15 months from commencement. However, these timelines may vary keeping in view the demand supply situation.

Further, for BQPS-III, once-through cooling system has been adopted. Accordingly, the original water channel and CW pump facilities of decommissioned units (unit 3 & 4) of BQPS-I will be reused for the two new units of this project. Moreover, the power evacuation system of Unit 3 & 4 will be utilized for BQPS-III.

C. Impact on Tariff

In view of the increasing power demand in the city and after having evaluated possible alternatives, KE has proposed addition of 900MW RLNG plant with consequent decommissioning of units 3 & 4 of BQPS – I, which are less reliable and low efficient units in KE's existing generation fleet.

This project is already part of KE's investment plan allowed under KE's MYT 2017-2023 and will not result in any additional impact on the tariff, however, it will help optimize the fuel mix resulting in improved generation efficiency and reliability of supply. Further, BQPS III running on RLNG with higher efficiency will also result in fuel cost savings as compared to units 3 & 4 of BQPS - I running on Furnace Oil (FO).

Fuel Type	Fuel price (PKR / kWh)
RLNG	9.20[4]
Furnace Oil (FO)	14.52[5]

[4] Based on planned net efficiency of BQPS-III and RLNG prices of December 2019 (SSGC – Transmission) – PKR 1,452 / MMBTU

[5] Based on average net efficiency of Unit 3 and Unit 4 of BQPS I plant determined by NEPRA in MYT decision dated July 5, 2018 and FO price of PKR 53,526 / M ton.

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Therefore, the proposed changes would result in lower tariff through reduced fuel cost of existing generation fleet which is passed-through as per the variation mechanism under the MYT.

D. Impact on Quality of Service and the Performance by KE of its Obligations Under the License

The proposal of adding 900 MW RLNG Power Plant in the Generation Portfolio of KE along with proposed decommissioning of less efficient units 3 and 4 of BQPS- I will ultimately increase the capacity of KE's generation fleet and will therefore enable KE to reduce the demand supply gap. Additionally, the proposed modifications will resultantly improve the quality of service through reduced outages, enhanced network and system reliability etc. subsequently improving KE's performance as per its obligations under the License.

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Please see brief comparison of both scenarios i.e. situation of demand supply with and without addition of 900 MW into KE's system:

	Plan with 900 MW				Plan without 900 MW			
	FY 20	FY 21	FY 22	FY 23	FY 20	FY 21	FY 22	FY 23
Peak Demand[6]	3,392	3,816	4,228	4,650	3,392	3,816	4,228	4,650
Available Supply								
Own generation – Existing plants	1,990	1,843	1,300	1,295	1,990	1,843	1,300	1,295
Existing IPPs	300	230	230	230	300	230	230	230
Supply from National Grid								
650 MW	650	650	650	650	650	650	650	650
150 MW	54	54	-	-	54	54	-	-
	704	**704**	**650**	**650**	**704**	**704**	**650**	**650**
KE New Projects								
BQPS III RLNG Plant *(Own Generation)*								
Phase 1	-	442	442	442	-	-	-	-
Phase 2	-	-	442	442	-	-	-	-
Coal Project - as IPP								
700 MW Coal IPP	-	-	637	637	-	-	637	637
Renewable Project								
Uthal, Bela and Vinder Solar	-	40	40	40	-	40	40	40
	-	**482**	**1,561**	**1,561**	**-**	**40**	**677**	**677**
Other IPP Projects under Planning / Approval								
Tapal *[Note]*	127	127	127	127	127	127	127	127
Gul Ahmed *[Note]*	128	128	128	128	128	128	128	128
K2 / K3 Project *[Note]*	-	-	-	500	-	-	-	500
450 MW RLNG Project *[Note]*	-	-	-	442	-	-	-	442
Burj Wind Project	-	-	36	36	-	-	36	36
Solar Projects *(3 x 50MW each)*	-	-	60	60	-	-	60	60
Wind Project	-	-	36	36	-	-	36	36
	255	**255**	**387**	**1,329**	**255**	**255**	**387**	**1,329**
Total Supply	**3,249**	**3,514**	**4,128**	**5,065**	**3,249**	**3,072**	**3,244**	**4,181**
Less: Supply from renewables[7]	94	134	212	212	94	134	212	212
Supply excluding renewables	**3,155**	**3,380**	**3,916**	**4,853**	**3,155**	**2,938**	**3,032**	**3,969**
Gap	**(237)**	**(436)**	**(312)**	**203**	**(237)**	**(878)**	**(1,196)**	**(681)**

Note: *The Authority has currently extended Tapal and Gul Ahmed for a maximum period of three years (till 2022). KE is in engagement with Government of Pakistan for additional supply from the National Grid along with supply from K2/K3 projects. In the event, additional supply from the National Grid does not materialize, KE will pursue for other options including earlier than planned commissioning of 450 MW RLNG project etc.*

Accordingly, KE is submitting this LPM to NEPRA which would enable KE to service its obligation of ensuring reliable and uninterrupted supply of power at least possible cost to the consumers.

[6] Peak demand is after adjustment for AT&C based load shed.

[7] Given the intermittent nature of renewable projects, supply from renewables has not been accounted for in projected supply for the purpose of comparison with peak demand.

K-ELECTRIC LIMITED

ADDITIONAL SUPPORTING DETAILS FOR RLNG BASED 900 MW (450 MW X 2) COMBINED CYCLE POWER PLANT AT BIN QASIM POWER STATION COMPLEX (BQPS – III)

A. PLANT DETAILS

PARTICULARS	DETAILS	
LOCATION	Bin Qasim	
TECHNOLOGY	Combined Cycle Power Plant	
NUMBER OF UNITS	**GAS TURBINES**	**STEAM TURBINES**
	2 units x 300 MW	2 units x 150 MW
PLANT SIZE INSTALLED CAPACITY (GROSS ISO)	900 MW	
EXPECTED LIFE OF POWER PLANT	30 Years	
COOLING WATER SOURCE	Sea Water (*once through cycle)*	
INTERCONNECTION DETAILS	220 kV Gas Insulated Substation of 63 kA, 4000 Amperes Rating Bus Bar. The new GIS will replace the old 220 kV GIS of BQ-1 Plant with addition of Two Series Reactors of 10 ohms each. I. 220 kV Double Circuit Short Lines with Series Reactors II. 220 kV Single Circuit Pipri West Line 1 III. 220 kV Single Circuit Pipri West Line 2 IV. 220 kV Single Circuit Pipri West Line 3 V. 220 kV Single Circuit ICI / Pipri West Line 4	

B. PLANT CHARACTERISTICS

PARTICULARS	DETAILS	
GENERATION VOLTAGE	**GENERATOR**	
	18.5 KV	
FREQUENCY	50 Hertz	
POWER FACTOR	0.80 lagging / 0.95 leading	
AUTOMATIC GENERATION CONTROL	Yes	
RAMPING RATE	10 MW Per Minute	
TIME REQUIRED TO SYNCHRONIZE TO THE GRID	**GAS TURBINES**	**STEAM TURBINES**
	20 Minutes	30 Minutes Approximately *(Hot Start)*

C. FUEL DETAILS

PARTICULARS	DETAILS	
FUEL SOURCE	**PRIMARY FUEL**	**ALTERNATE FUEL**
	Imported	PSO/BYCO *(Imported/Indigenous)*
PRIMARY FUEL	Re-Gasified Liquefied Natural Gas (RLNG)	
ALTERNATE FUEL	HSD	

D. EFFICIENCY PARAMETERS

PARTICULARS	RLNG		HSD	
	EFFICIENCY IN LHV[1&2]	EFFICIENCY IN HHV[1&3]	EFFICIENCY IN LHV[1&2]	EFFICIENCY IN HHV[1&3]
DESIGNED / GROSS EFFICIENCY OF POWER PLANT AT MEAN SITE CONDITIONS (%)	60.47 %	54.97 %	55.62%	51.98%
NET EFFICIENCY OF POWER PLANT AT MEAN SITE CONDITIONS (%)	59.23 %	53.85 %	54.04 %	50.50%

NOTES:

1. *Efficiencies are subject to degradation curve, which is to be decided by Project contractor at the time of commissioning*
2. *Net Efficiency is based on Guaranteed value in LHV, whereas Gross Efficiency has been calculated using Net Efficiency and Auxiliary consumption*
3. *Efficiencies in HHV calculated using LHV-HHV conversion factor of 1.1 for RLNG and 1.07 for HSD*

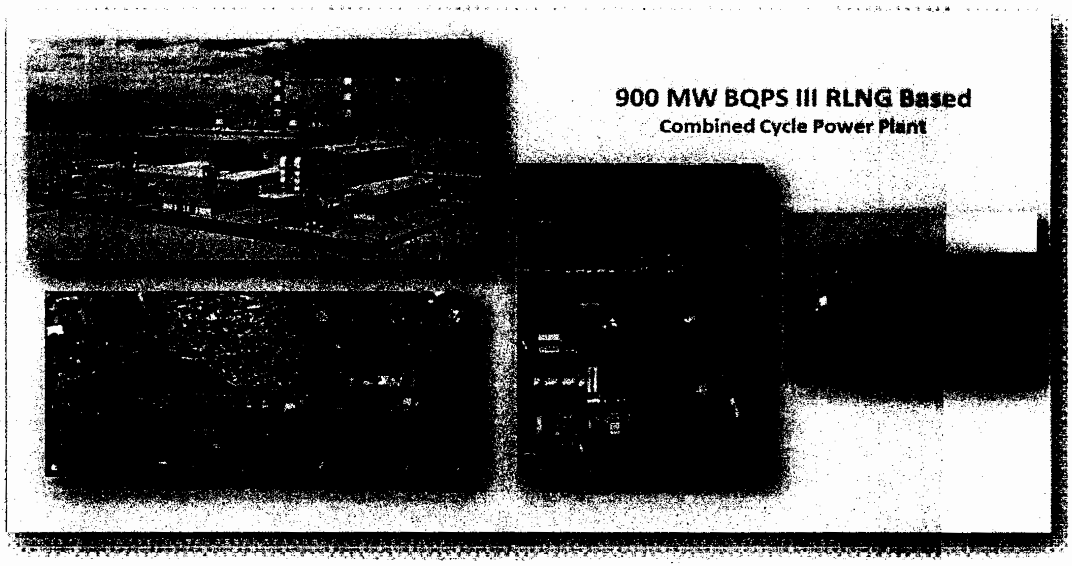
K-ELECTRIC LIMITED

Annexure B

KE Letter with Reference # KE/BPR/NEPRA/2019/1339
dated December 24, 2019

BQPS III - 900MW RLNG BASED CCPP

INFORMATION / DOCUMENTS REQUIRED FOR PROCESSING OF LPM



INDEX SHEET

S. Nos.	NEPRA Queries	Remarks	Comments
1	Expression of interest to provide credit or financing along with sources and details thereof	Annexure-B1	-
2	Type, Technology, Model, Technical Details, Design	Annexure-B2	-
3	Feasibility Study	Annexure-B3	Please refer to Note 1
4	Location Maps, Site Maps and land	Annexure-B4	Please refer to Note 1
5	Technology, Size of Plant, Number of Units	Annexure-B5	-
6	Fuel	Annexure-B6	-
7	Emission Values	Annexure-B7	-
8	Cooling Water Source	Annexure-B8	-
9	Infrastructure: roads, rail, staff colony, amenities	Annexure-B9	-
10	Project cost, information regarding sources and amounts of equity, debt	Annexure-B10	-
11	Project commencement and completion schedule with milestones	Annexure-B11	-
12	ESSA (Environmental and Social Soundness Assessment)	Annexure-B12	Please refer to Note 1
13	Safety plans, emergency plans	Annexure-B13	-
14	System studies, load flow, short circuit stability, reliability	Annexure-B14	Please refer to Note 1
15	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Annexure-B15	-
16	Control, metering, instrumentation and protection	Annexure-B16	-
17	Training and development	Annexure-B17	-
18	Efficiency Parameters	Annexure-B18	-

Note 1: Owing to the quantum and size of data, soft copies of the following Annexures are being enclosed in Compact Disk
-Annexure B3
-Annexure B4
-Annexure B12
-Annexure B14

K-ELECTRIC LIMITED

Volume Retrieval No.			
F007101K-A-01			
Version	1	Status	DES

Pakistan BQPS-III 2×450MW Combined Cycle Power Plant project

Feasibility Study Report

East China Electrical Power Design Institute Co. Ltd (ECEPDI) of China Power Engineering Consulting (Group) Corporation
Engineering Design Integrated Qualification Class-A A131000025, Engineering Survey Integrated Qualification Class-A B131000025

Feb. 2017 Shanghai China

Pakistan BQPS-III 2×450MW Combined Cycle Power Plant and Supporting Renovation Project

Feasibility Study

Major Content

No	Name	Volume Retrieval No
Volume I	Grid Interconnection Study	
	Section I: Grid Interconnection Study for 2×450MW BQPS-III Power Plant Project	100-XA04431K-A01
	Section II: Grid Interconnection Study for Alteration of KPC Evacuation System	100-XA04421K-A01
Volume II	Pakistan Karachi KE KPC-I 248MW Power Evacuation System Alteration Feasibility Study Report and Drawings	100-FA05671E01-A-01
Volume III	Pakistan Karachi ICI 220kV Switching Station,LANDHI,QAYYMABAD/K-WEST 132kV Substations Equipments Capacity Modification Feasibility Study Report	30-B003900E1K-A01
Volume IV	**Pakistan BQPS-III 2×450MW Combined Cycle Power Plant project Feasibility Study Report and Drawings**	**30-F007101K-A**

Volume Retrieval No.			
F007101K-A-01			
Version	1	Status	DES

Pakistan BQPS-III 2×450MW Combined Cycle Power Plant project

Feasibility Study Report

Approved by: 2017.2.23

Reviewed by: 2017/23

Prepared by: 2017.2.22 2017.2.2

Pakistan BQPS-III 2×450MW Combined Cycle Power Plant project

Staff List

Title	Name		
Chief engineer	Xu Qing		
Project manager	Tang Min		
Project manager	Xue Jinan		
Business manager	Gan Chao		
Profession	Name	Section chief	Engineer in charge
Power system	Zhang Kai	Tao Yanfeng	Yuan Yizi
Mechanical	Zhao Yumin	Yao Jun	Chen Xumin
HAVC	Sheng Huicong	Chen Meihua	Xu Jun
Chemical	Zhou Jin	Chen Xiaowei	Cai Guanping
Electric	Huang Fen	Lei Youkun	He Ping
Civil	Gu Zhiqiang	Cao Xidong	Zhao Jianhua
General lay out	Tian Jianjun	Yu Ling	Liu Kaihua
Hydraulic work	Zhao Kaiwei	Cao Xidong	Zhao Jianhua
Hydraulic structure	Qian Hao	Wu Jun	Wang Zhengyu
Enviroment protection	Shen Yiting	Cao Lihong	Chen Jian
Hydro-meteorological	Cai Bing	Li Shun	Yao Peng
Geological	Qiu Jiarong	Wu Jian	Wu Gang
Survey	Wu Shaohao	Zhuang Sujun	Yao Qiling

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1 Project Overview

1.1 Background

K-Electric, formerly known as Karachi Electric Supply Company Limited (KESC) and commonly referred to as"KE," is a Pakistani vertically integrated electric corporation involved in generating, transmitting, and distributing power to millions inhabitants spread over 6,500 km^2 across Karachi and its adjoining areas.

According to its business plan, KE is considering the construction of two sets of F class combined-cycle power plant inside the boundary of BQPS-1. This project is called the KE power plant project in the Purchase Order from KE. The whole project is divided into 3 phase:

Phase one:

It plans to construct the gas turbine house, bypass stack, CCR, transformers, GIS, gas compressor station, gas condition station and other auxiliary systems of the new F class unit (refer to UNIT 7). Then the UNIT 7 can operate in open cycle.

Phase two:

It plans to construction the steam turbine, HRSG, and other auxiliary systems of the UNIT 7. After decommission of unit 4 of BQPS-I, CW system of unit 4 will be used for the UNIT 7. Then the UNIT 7 can operate in combined cycle.

Phase three:

Construction the gas turbine house, bypass stack, CCR, transformers, gas condition station, steam turbine, HRSG and other auxiliary systems of the second F class unit (refer to UNIT 8). After decommission of unit 3 of BQPS-I, CW system of unit 3 will be used for the UNIT 8. Then the UNIT 8 can operate in combined cycle.

1.2 Profile of investor

This project will be invested and led by KE.

1.3 Scope of study

This feasibility study will cover the conditions for construction of the combined cycle power plant (including access system, fuel supply, transport, water source, geology, environmental protection, etc.) in accordance with the contents depth regulation, development of reasonable preliminary construction scheme in accordance with the requirements of labor safety, industrial health, and energy saving, etc., as well as demonstration on necessity, feasibility, and economical efficiency of the Project.

1.4 Not included in scope of feasibility study report

Environmental impact assessment report and Field geotechnical investigation report are not included in the scope of this feasibility study report.

1.5 Process

In Jan.16 2017, ECEPDI received "Feasibility Study Quotation Invitation of Pakistan KE Power Plants Project" from KE.

In Jan. 19 2017 ECEPDI sent reply letter of Quotation to KE.

In Jan. 30 2017KE issued Purchase order to ECEPDI for this Feasibility study.

Between Feb.8~Feb.16 of 2017 KE arranged a site visit. ECEPDI, KE and SEP discussed major technical principles and collected data for feasibility study.

1.6 Main principles

The main principles based on which this report is prepared are as follows:

(1) Two set of F class combined cycle units will be constructed inside the boundary of BQPS-1 power plant. Each unit will be comprised of a gas-turbine-based 1x1x1 configuration with a heat recovery steam generator and a steam turbine. Gas-steam combined cycle unit is laid out as a Multi-shaft transverse arrangement.

(2) Two sets 9F generators in BQPS-3 will connect to the new 220kV GIS, and evacuate power to KE system through the existed transmission lines. Build a new GIS with 50kA equipments for BQPS-3 generators, and transfer the generators. Outgoing lines and short link lines in BQPS-1 GIS will be connected to the new GIS one by one. The BQPS-1 GIS will decommission after all the modification finish.

(3) In this project, one-through cooling system will be adopted. The original water channel and CW pump facilities of decommissioned units(unit 4&3) of BQPS-I will be reused for the UNIT 7 and UNIT 8 of this project.

(4) Demi water，service water and source of firefighting water are supplied by existing facilities of BQPS-I..

(5) According to the information given by KE, the utilization hours of this project is 7000 h.

(6) The environmental protection facilities must be constructed to meet local environmental protection requirements.

(7) The engineering design and construction standards adopted Chinese standards excluding Electrical and control system which should be based on IEC.

(8) Design of the fire fighting system is based on the codes of NFPA.

(9) Redundancy concept:

- Mechanical

  All major pumps/motors will be designed on sufficient redundancy.

- Electricial

  There will be sufficient redundancy in MV Switchgears/LV Switchgears/panels/control/DCS/PLC,etc.

- DCS

  There should be two independent communication channels with double/redundant servers.

(9) Tools and spares

Special tools shall be provided for installation、commissioning、maintenance. Spare Parts are consist of three parts, spare parts for two years warranty period after COD, recommended additional spare parts, consumables and consumable spare parts.

2 Power system

2.1 Overview of Existing Karachi Power System and BQPS

2.1.1 Overview of Existing Karachi Power System

At present, the maximum voltage level of Karachi Power Grid is 220 kV, and a 220 kV double-circuit looped grid structure has been formed and connected to the main grid of Pakistani NTDC through four 220 kV lines (BALDIA—NKI, KDA—NKI and KDA—JAMSHORO, double-circuit). The maximum load demand of Karachi Power Grid in 2015 was 3,056 MW, its power demand was 18,213 GWh, and the actual on-grid power was 16,111 GWh.

By the end of 2015, the total installed capacity of Karachi Power Grid was 3,339 MW (effective capacity 2,973 MW), including independent installed capacity of 2,267 MW (effective capacity 1,966 MW), IPP installed capacity of 422 MW (effective capacity 357 MW), and also power of 650 MW received from NTDC. See details in Table 2.1.1-1. There are six 220 kV transformer substations, 12 main transformers, the total power transformation capacity of which is 3,000 MVA, and twenty 220 kV lines, the total length of which is 338.02 km, including 323.3 km overhead lines and 14.71 km cable lines. There are sixty 132 kV transformer substations and 130 main transformers, the total power transformation capacity of which is 4,809.5 MVA, and ninety eight 132 kV lines, the total length of which is 761.9 km, including 611.203 km overhead lines and 150.697 km cable lines.

Table 2.1.1-1 2016 Installed Capacities of Karachi Power Grid

Category	S/N	Name of Power Plant	Installed Capacity (MW)	Effective Capacity (MW)
Self-Installed Capacity	1	BQPS-1	1260	985
	2	BQPS-2	560	557
	3	CCPP	247	239
	4	SGTPS	100	97
	5	KGTPS	100	97
Total			2267	1975
IPP	6	APGL	12	12
	7	Gul Ahmad	127.5	127.5
	8	KANUP	137	75
	9	Tapal	123.5	123.5
	10	IIL-1&2	22	19
Total			422	357
Power from Outside	11	NTDC	650	650
Total			3339	2982

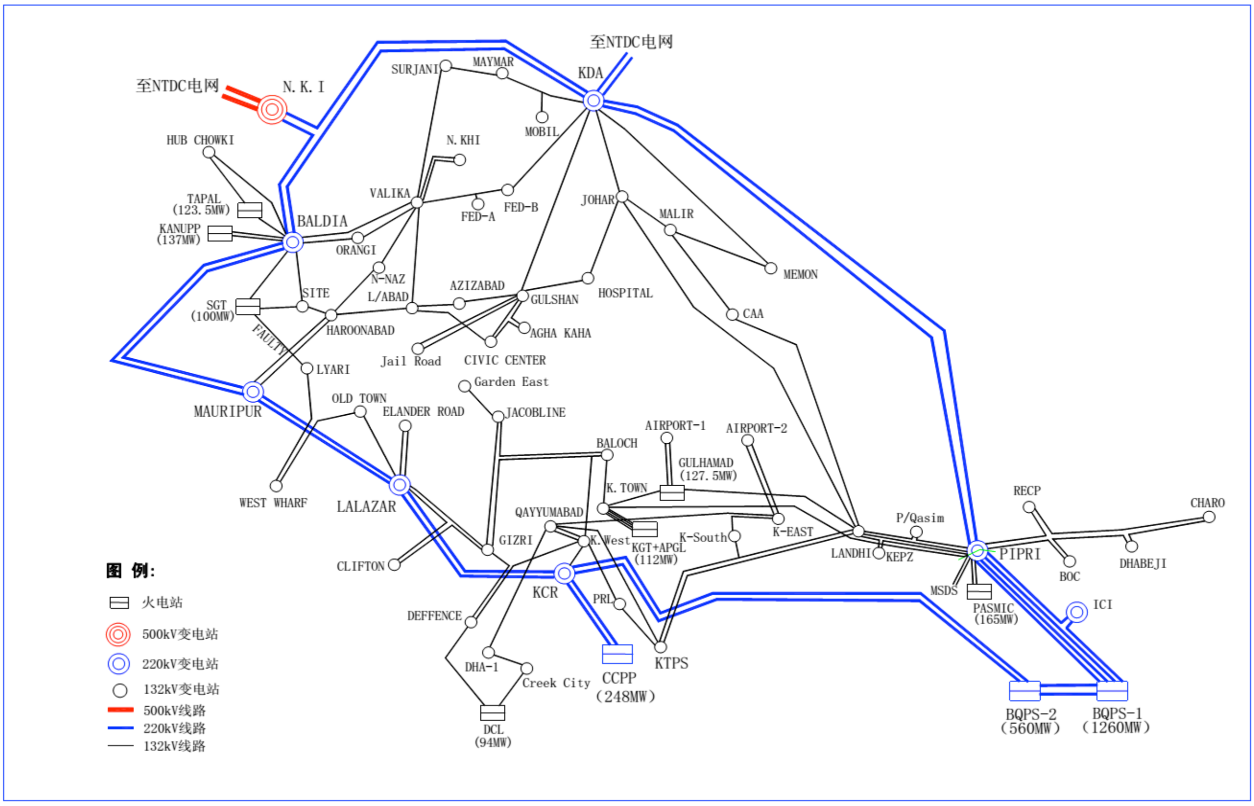


Fig. 2.1.1-1 Grids Map above 132 kV of Karachi Power System in 2016.

2.1.2 Overview of BQPS Power Plant

At present, the maximum voltag

BQPS is located beside Phitti Creek at Bin Qasim area in the southeast of Karachi, Pakistan, with its current installed capacity of 1,820 MW, including 1,260 MW (6×210 MW) for BQPS-1 which is connected to 220 kV BQPS-1 switchyard (GIS), and 560 MW (3×129.1 MW + 182.2 MW) for BQPS-2 which is connected to 220 kV BQPS-2 switchyard (GIS). The 220 kV switchyard of BQPS-1 and BQPS-2 are both installed inside BQPS-1, and connected to each other by 2 short lines, one of which is 1,600 mm2 XLPE cable that has 1,800 A current-carrying capacity, and the other is GIL that has 3,150 A current-carrying capacity. The 220 kV electrical connection of BQPS-1 is double-bus double-section connection with 6 outgoing lines: 3 are connected to PipriWest, 1 is connected to ICI, and the other 2 are connected to BQPS-2. The 220 kV electrical connection of BQPS-2 is double-bus connection with 4 outgoing lines: 2 are connected to KCR, and the other 2 are connected to BQPS-1. In this phase, it is planned to build two 9F-Class gas-steam combined cycle sets of 2×450 MW installed capacity in the open space in the plant, and the open cycle part of unit 7 is estimated to complete and put into commission in 2018.

The SLD of BQPS is show in Fig. 2.1.2-1.

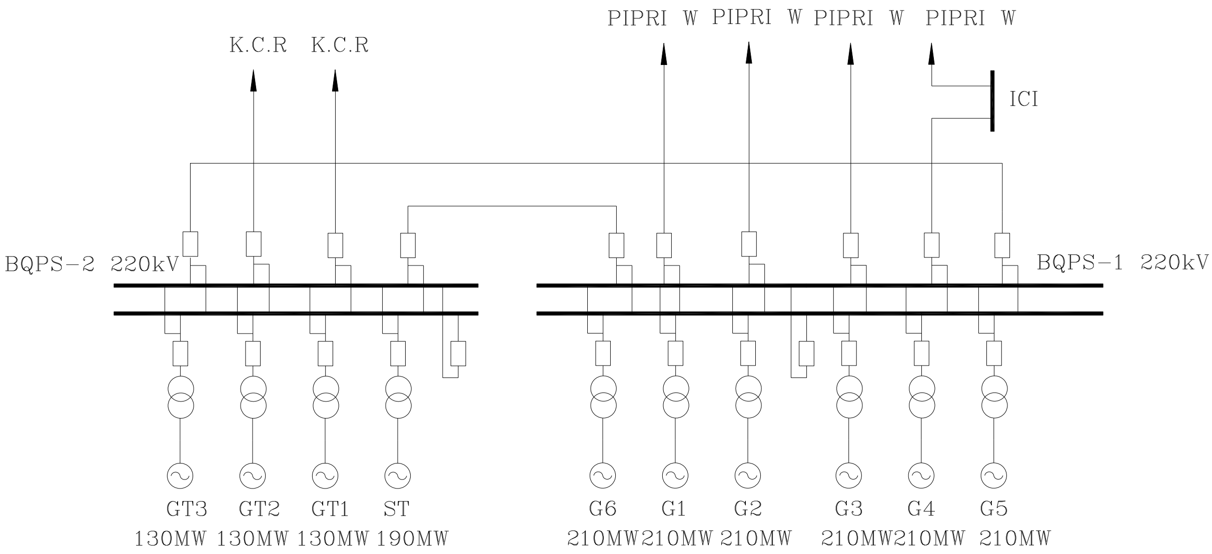


Fig. 2.1.2-1 The SLD of BQPS

2.2 load forecast

Located in the south coast of Pakistan, the northwest of Indus Delta and the south of Arabian Sea, Karachi is populated by about 20 million and covers an area of 3,527 km. As the largest city of Pakistan, Karachi has 30% manufacturing business and 95% overseas trading of the country done there. According to the load forecasting results of KE, the maximum load of Karachi Power Grid will be more than 4,700 MW in 2023, with an average growth rate of 5.7% per annum from 2016~2023. See Table 2.2-1 for detailed power load forecast of Karachi.

Table 2.2-1 2016~2023 Power Load Forecast of Karachi

Year	Maximum Load (MW)
FY2017	3377
FY2018	3569
FY2019	3773
FY2020	3988
FY2021	4215
FY2022	4455
FY2023	4709
Average Growth Rate Per Annum	5.7%

2.3 Power grid development planning

In order to ensure safe transmission of newly added power, KE plans to implement TP1000 power grid reformation project, by adding six new 220 kV transformers, the transformation capacity of which is 1,500 MVA, and build and transform about 96 km 220 kV lines; add twenty five 132 kV transformers, the transformation capacity of which is 1,000 MVA, and build and transform about 39 km 132 kV lines. See Fig. 2.3-1 for planned grids map above 132 kV of Karachi power system in 2020.

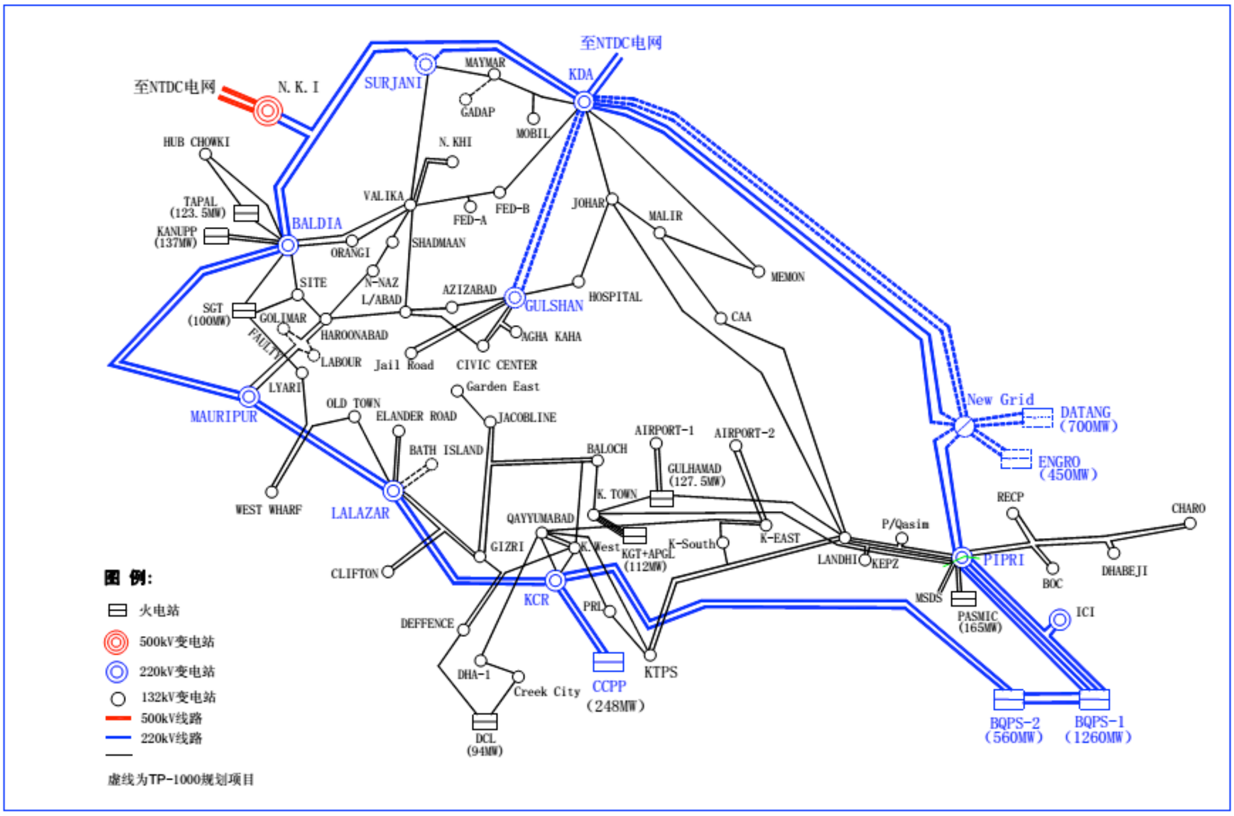


Fig. 2.3-1 Planned Grids Map above 132 kV of Karachi Power System in 2020.

2.4 Power sources expansion planning

In order to solve power supply shortage of Karachi Power Grid, KE plans to build new installed capacity of 2,750 MW before 2020, see details in Table 2.4-1. 700 MW installed capacity will be connected to 132 kV power grid in an embedded manner and be consumed nearby to relieve the power supply pressure of 220 kV; the other installed capacity of about 2,050 MW (Datang Coal-fired Power Plant and ENGRO Gas-fired Power Plant) will be connected to the 220 kV power grid.

Table 2.4-1 Planned Installed Capacities of Karachi Power Grid

Project Name	Owner	Installed Capacity	Category	Year of Commissioning
DPKPG	CDTO/CMEC/KE	700MW	Coal	2020
BQPS-3 (this project)	KE	2×450MW	GAS	2018/2019
ENGRO	ENGRO/KE	450MW	RLNG	2019
Western Electric	Tapal	295MW	HFO+GAS	2018
Baldia Power	Orient/KE	200MW	RFO+RLNG	2019
FPCL	FFBL	52MW	Coal	2017
SNPC	GOS/TK	100MW	Gas	2017
Oursun	MG/NB/AA	50MW	Solar	2018

2.5 Power balance

According to above power source and power grid construction plan, power balance of 2017~2023 Karachi Power Grid was analyzed. See Table 2.5-1 for calculation results. It can be learned from balance result that Karachi Power Grid can maintain its basic break-even in 2018 if all planned power source projects can be put into operation as scheduled without backup included. By 2020, the surplus installed capacity of Karachi will be about 726 MW after power source projects are put into operation one after another.

Therefore, power source projects and supporting power transmission projects should be constructed in a faster speed so as to guarantee the power demand of Karachi.

Table 2.5-1 2017~2023 Power Balance of Karachi Power Grid

Year	Maximum Load	Self-Installed Capacity	IPP Power Plant	Newly-added Self-Installed Capacity	Newly-added IPP	Total Power Sources	Surplus & Loss
FY2017	3377	1953	953		167	3073	-304
FY2018	3569	2003	893	280	456	3632	63
FY2019	3773	1853	893	690	740	4176	403
FY2020	3988	1703	243	820	1948	4714	726
FY2021	4215	1703	243	820	2396	5162	947
FY2022	4455	1703	243	820	2396	5362	907
FY2023	4709	1703	243	820	2396	5362	653

2.6 Construction Scale

(1) The construction scale of BQPS -3 is two sets 9F generators, and the generators will be commissioned by stages.

(2) Build a new GIS with 50kA equipments for BQPS-3 generators, and shift the generators, outgoing lines, short link lines in BQPS-1 GIS to the new GIS one by one. The BQPS-1 GIS will decommission.

(3) Add two series reactors(10Ω) in short lines between new GIS switchyard and BQPS-2 GIS switchyard。

2.7 Interconnection Scheme

The interconnection scheme and commission schedule of BQPS-3 is considered as below：

Two sets 9F generators in BQPS-3 will connect to the new 220kV GIS, and evacuate power to KE system through the existed transmission lines.

In the first half year of 2018, two short link lines (with series reactors) and one outgoing line to ICI in BQPS-1 GIS will be transferred to the new GIS, meanwhile there will be another short line between the new GIS and BQPS-1 GIS. Then the first 9F gas turbine (300MW) with open cycle operation will be connected to the new GIS. Unit-3 and unit -4 will remain in operation.

In the last half year of 2018, the first 9F steam turbine (150MW) with combined cycle will be connected to the new GIS and unit-4 will be considered to decommission.

In 2019, the remaining generators and outgoing lines in BQPS-1 GIS will be transferred to the new GIS one by one. And after unit-3 decommission, the second 9F generators (300+150MW) with combined cycle will be connected to the new GIS.

The aboved planning should be confirmed with respect to Demand and Supply requirement

2.8 The Requirement of BQPS-3 GIS

The new GIS bus bar is consider being double bus with two bus section CBs and two bus coupler CBs. The GIS bus bar SLD is show in Fig 2.8-1 to Fig2.8-3.

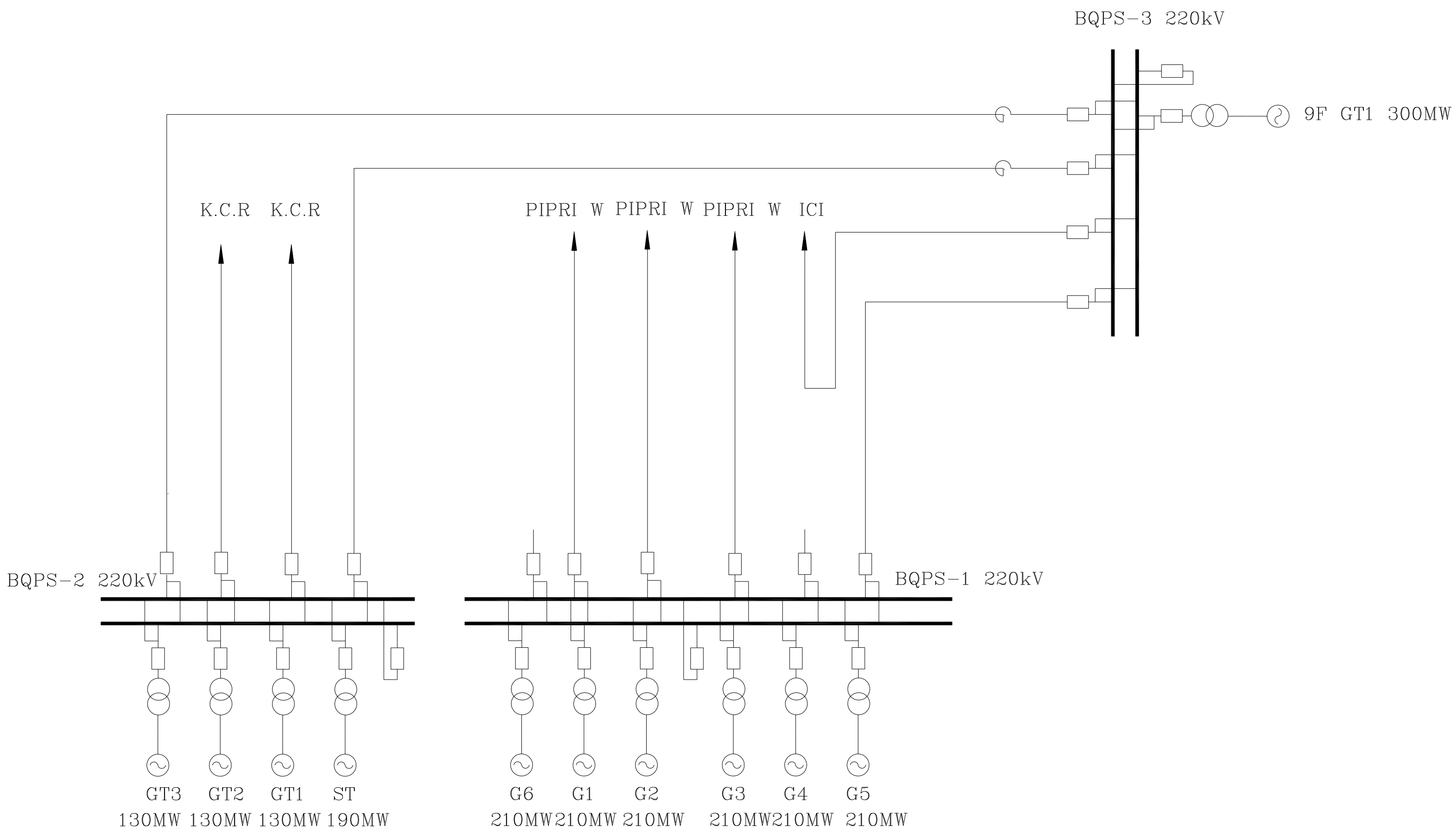


Fig 2.8-1 The SLD of 220 kV GIS with 1st 9F Open Cycle in Phase one

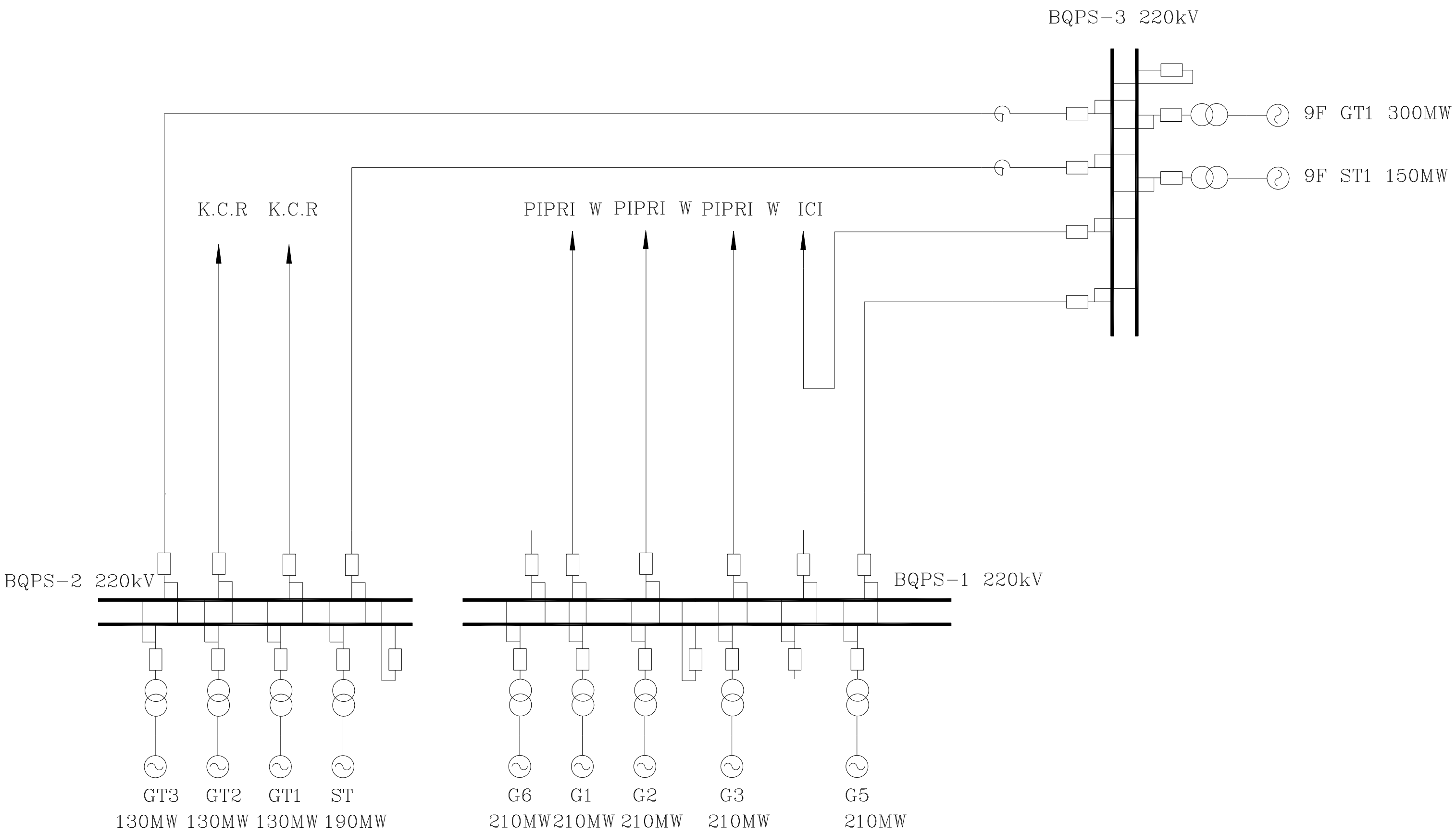


Fig 2.8-2 The SLD of 220 kV GIS with 1st 9F Combined Cycle in Phase two

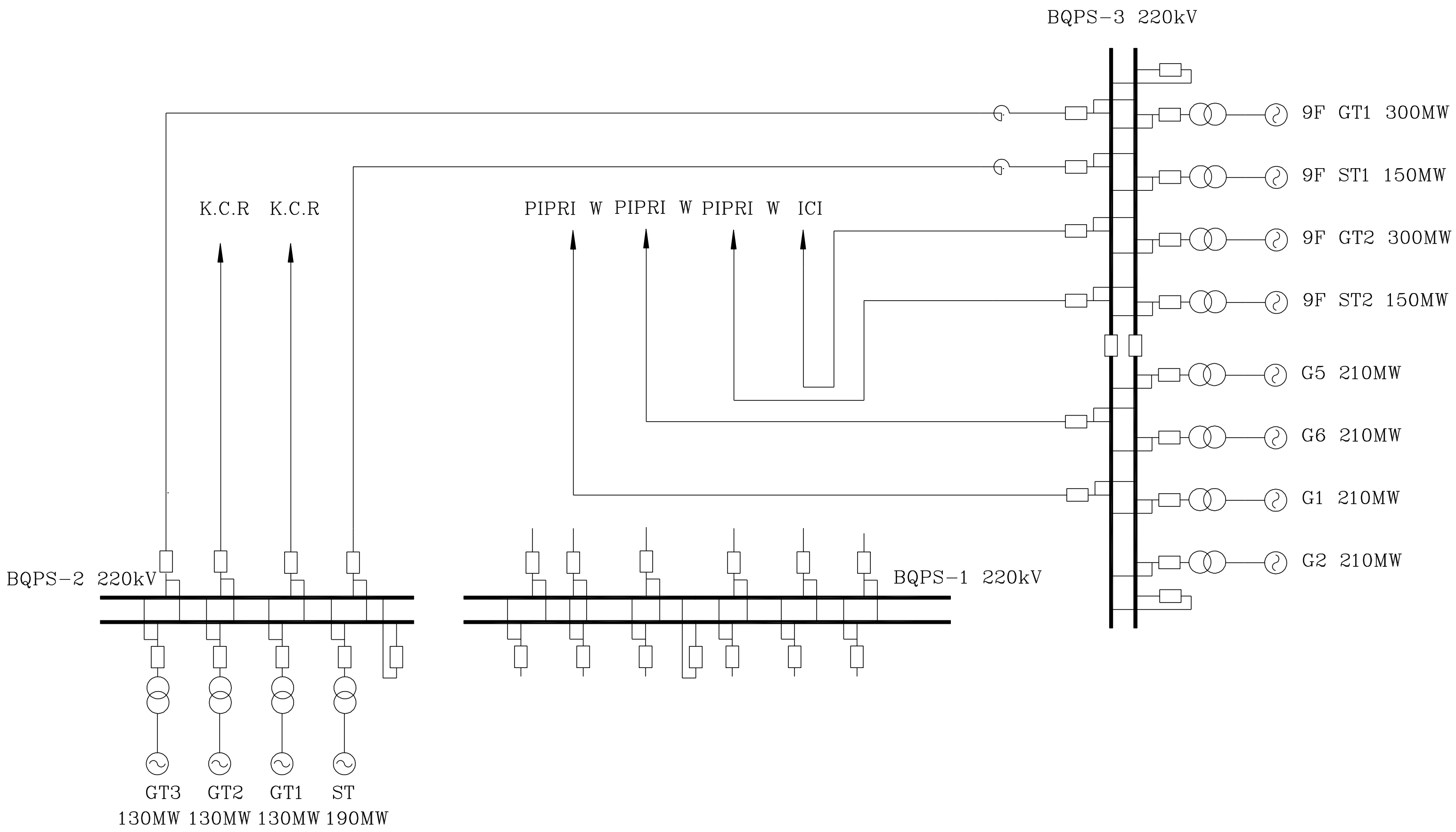


Fig 2.8-3 The SLD of 220 kV GIS with 2nd 9F Combined Cycle in Phase three

2.9 The Requirement of Main Equipments

(1) The Requirement of Equipments in BQPS-3

Generator: power factor is 0.85 lagging and 0.95 leading.

Main Transformer: the capacity should be meet the maximum continuous power of the generator, the impedance is consider being not less than 18%, the neutral pointer is consider to be 2 operate models: solid grounding and ungrounded, the tap changer is considered to be OLTC, the rated voltage and ranger is considered being 232(+8×1.25%~-16×1.25%)kV.

The 220kV new GIS bus bar rated current is considered to be 4000A.

The 220kV new GIS outgoing CBs rated current is considered to be 2500A, bus section CBs and bus coupler CBs rated current is considered to be 4000A.

The 220kV new GIS CBs rated short circuit current is considered to be 50kA.

The series reactors impedance is considered to be 10Ω, the rated current is considered to be 2500A.

The 6 outgoing lines in 220kV new GIS will use UG cable connection, the rated current of cable should be not less than 1780A.

3 Fuel supply

3.1 Source of Natural gas

BQPS phase I and II have been built gas pipeline SSGC. Currently SSGC pipe has been laid to the northwest of the project. Pipeline design parameters are 12bar, DN750. Due to lack of gas, SSGC pipeline can only meet the gas consumption of one F-class gas turbine. Natural gas from SSGC will be pressurized using Natural Gas Compressor prior to utilization in Gas Turbine.. Pressure to about 40bar and then sent to #1 and #2 gas turbine. #1 gas turbine use SSGC gas first. After the completion of the #2 gas turbine, #1 gas turbine stop using SSGC gas. #1 and #2 gas turbine will use RLNG as gas source. RLNG shall be delivered to CMS which is not in the Battery Limit of BPQS-III, then send to the pressure regulating station by pipeline, and transported to the two F class gas turbine. At the same time, SSGC switch to the standby gas source. The gas turbine can transfer gas source from RLNG to SSGC online.

3.2 Fuel Quality

For the project in question, the SSGC natural gas fluctuates a lot in its constituents, and only a fluctuation range can be given for the percentage by volume. Therefore, the gas consumption of the project will be calculated as per the natural gas in its best quality and worst quality respectively. The constituents of the natural gas are listed in the following table:

Constituent	Minimum Percent by Volume	Maximum Percent by Volume
Methane (CH_4)	80.0	100.00
Ethane (C_2H_6)	0	6.00
Propane (C_3H_8)	0	5.00
Butane (C_4H_{10})	0	3.00
Pentane (C_5H_{12}) and higher	0	2.00
Hydrogen Sulphide (H_2S)	0	0
Carbon dioxide (CO_2)	0	2.00
Nitrogen		3.00
Oxygen (O_2)	0	1.0
Inert (the total combined Nitrogen, Oxygen, Carbon dioxide and any other inert compound)	0	5.00

When the quality of the natural gas is at its worst, the low heating value is 29616kJ /Nm^3; while the quality of the natural gas is at its best, the low heating value is 37446kJ /Nm^3.

The constituents of RLNG natural gas are listed in the following table:

RLNG Gas Specification			
Component	**Formula**	**Mol %, Dry**	**Comments**
Methane	CH_4	93.42%	[87% to 100%]
Nitrogen	N_2	0.29%	Cap of 1.5%
Carbon-di-oxide	CO_2	0.00%	Cap of 2%
Ethane	C_2H_6	6.25%	[Cap of 12%]
Propane	C_3H_8	0.04%	[Cap of 3.5%]
i-Butane	i-C_4H_{10}	0.00%	Cap of 2%
n-Butane	n-C_4H_{10}	0.00%	
Pentane	C_5H_{12}	0.00%	Cap of 0.3%
LHV	30637~42552kJ/Nm^3		

According to the requirements of KE, RLNG is used as the design gas source of this project.

3.3 Natural Gas Consumption

For the project in question, the natural gas consumption is calculated temporarily as per the arrangement of two sets of combined cycle generating units, in “one-plus-one” configuration, i.e. with one gas turbine and one steam turbine in a set. Under the rated operating conditions (with the temperature of 20℃ and pressure of 101.325KPa), the gas consumption of the gas turbines are:

SSGC Hourly Gas Consumption for One Generating Unit Nm^3/h	SSGC Daily(24 hours) Gas Consumption for One Generating Unit MMCFD	SSGC Annual Gas Consumption for One Generating Unit ten thousand Nm^3/a	RLNG Hourly Gas Consumption for One Generating Unit Nm^3/h	RLNG Daily(24 hours) Gas Consumption for One Generating Unit MMCFD	RLNG Annual Gas Consumption for two Generating Units ten thousand Nm^3/a
73962~93697	62.68~79.41	51774~65588	64997~90295	55.08~76.53	90996~126384

Note: According to the information provided by KE Company, in calculating the annual gas consumption, the operation hours of the generating units will be taken as 7000 hours. The gas consumption under the rated operating conditions will be taken as the datum consumption for the project, and the dynamic gas consumption during start-up and shutdown of the gas turbines will not be considered (if taken into consideration, another 10% shall be added into the total gas consumption).

For the project in question, SSGC natural gas consumption of one sets of F class gas-steam combined cycle generating units will be about 0.59~0.74 billion Nm^3. RLNG natural gas consumption of two sets of F class gas-steam combined cycle generating units will be about 1.34 billion Nm^3.

4 Site construction condition

4.1 Introduction to plant site

Karachi as the first largest city of Pakistan is located at southern coast of Pakistan and northwest part of Indus delta, close to the Arab Sea at the south; on the plain between Jurali and Mariel, there are about 20 million population and 3527km2 area. Qasim Port is the top 2 biggest and busiest port of Pakistan. Qasim Port located at old channel of Indus River is 35km away from east of Karachi city.

BQPS power plant of KE Electric Power Company is about 5.6km away from Qasim, Karachi, Pakistan. There is an open site at north of the site. Over the open site, there are several buildings spattered here and there. PAK.steel mill is located to the north. To the west at the space of a road, there are PSO and P.O.Z. In the south neighboring is Arabic Sea; at the space of an open channel to the east, there is a port coal power plant under construction.

4.1.1 Existing condition of plant site

BQPS power plant has BQPS-I and BQPS-II projects. At present, it is planned to expand this project on spare site of BQPS-I. The BQPS-I is located at north of the engineering site. There are six 210MW fuel oil sets which has been put into production successively from 1983 to 1996. The BQPS-II is located at west of the project land. Only at the space of an open channel, there are 3 Gas Turbines and 1 Steam Turbine for construction of BQPS-II which were put to construction in year 2012. In six fuel oil sets of BQPS-I, No.3 and 4 sets have low utilization rate, the annual utilization durations are respectively 1746.4h and 712.6h. To construct efficient grade F gas turbine gradually substitutes for No.3 and 4 sets and improve average efficiency of the power generation side and reduce the power generation cost of KE Company.

BQPS power plant land is like a tipsily arranged rectangle. The length is along south and north direction and the width is along east and west direction. Along the length direction, the east is parallel to the water intake open channel of steel plant. Regarding the width plan, the west is parallel to highway of Qasim harbor district.

For the BQPS-I, 6 units are arranged in middle part of the whole plant. They are No.1 to No.6 units eastwards; with respect to the power plant, water is taken via open channel. Water intake pump houses are arranged in two areas. Water intake pump houses of No.1 and No.2 units are arranged in south of No.1 and No.2 units. Water intake pump houses of No.3 to No.6 are arranged in south of No.4 and No.5 units; some auxiliary facilities are arranged in northwest corner of the plant area, including regulator station, etc.; building GIS is arranged in north of No. 2 and No.3 units; the electric outlet is northwards; Demineralized water plants, hydrogen plant, etc. are arranged in east of building GIS; the oil tank area is arranged in middle west of the power plant. The designed ground floor elevation of buildings is 5.50m in the BQPS-I.

BQPS-II is arranged in southwest corner of the whole plant area. The main plant is arranged in northeast corner of the area. Other auxiliary facilities are arranged along south, north and west of main plant. BQPS-II projects also adopt GIS indoor power distribution unit. Building GIS is arranged in west of building GIS in BQPS-II and the outgoing line is distributed northwards. The designed ground floor elevation of buildings is 5.50m in the BQPS-II.

4.1.2 Construction site

Based on the owner’s requirement, project of this project is built in south space of BQPS-I based on 2×450MW class gas-steam combined cycle unit. On the basis of the project’s construction characteristics, in combination with general layout of the plant, it is required to use existing land of the plant while no new land is expropriated so as to realize reasonable distribution. It is suggested to consider the construction site as below:

4.1.2.1 Project construction land

Construction land of this phase of project is of a strip shape, the length direction is along south-north direction, about 600m and the width direction is along east-west direction, the widest point about 150m, and the narrowest about 15m. The available area is about 6hm^2. In northwest corner of the site, there are daily used oil pump house and circulating water dosing room for No.6 unit. Other areas are arranged with some temporary builds. There is a drainage open channel near the fence. On the right side of the northeast, there is a workshop. In addition to 6 # machine oil pump cannot be removed at this stage, the construction of other buildings on the land can be removed according to need.

Natural ground elevation of the construction site is 3.50~4.93m and downward from north to south. Moreover, it is slightly lower than elevation of existing site in whole. Therefore, certain civil work and fill work are required

4.1.2.2 Construction and living land for construction

Owing to less expansion site and space for the whole power plant, construction land must be reasonably arranged and scientifically planned. It is preliminarily considered to take the space in north of BQPS-I as construction and production land. However, the space is less than 2hm^2. The long-term planning land and the spare construction land in this period may also be used as construction land. The temporary construction site at south of BQPS-II shall be taken as construction living land where skilled workers and foreign experts can live. Specific plan for construction site shall be further defined according to the old plant's general layout by the owner.

About water, electricity, communication, etc. required during construction period, BQPS power plant is an expanded project, there are complete original facilities including road. It is unnecessary to construct such facilities.

4.1.3 House removal and compensation condition on plant site

For original buildings and structures in the engineering construction land, most buildings in the area shall be removed. The workshop and circulating water dosing room of No.6 unit with a total construction area of about 1700m^2 will be removed. Other buildings on the construction land covers about 2000 m^2 area. The fence is about 700m in length. According to the general layout plan, there are some buildings and structures needed to be removed, including a warehouse about 3500m^2 areas, a abandoned construction distribution room about 150m^2 areas, three lighthouse and a fire hydrant demolition and so on.

Removed or relocated facilities

Description	**Relocated / Removed**
Ware House at North Side of Unit 6	Relocate
Ware House at East Side of Unit 6	Relocate
Chlorine Generating Plant	Removed
Abandoned Construction Distribution Room	Removed
Three Lighthouses	Relocate
Fire Hydrant	Modify
Air Element Washing Area, Soakage Pit, Scrap Yard	Relocate

4.2 Communication and transportation

This is an expansion project for old plant. The power plant has good external traffic condition, convenient and efficient waterway transportation.

(1) Railway

The power plant is 6km to national railway trunk of Pakistan. The railway network is connected with Qasim Port in the west of the power plant.

(2) Highway

Pakistan highway is located about 8km from north of power plant. It is connected to north of the power plant from Qasim port highway. There are several accesses in existing plant of the power plant, which are all connected to Qasim port highway. During construction of the project, general middle and small equipment and construction buildings can be transported to power plant via highways. Roads in power plant have formed a network.

(3) Water route

The power plant is in east of Qasim port is the second busiest port of Pakistan, which handles about 35% Pakistan goods (about 17 million tons annually). The port is not only a good connection with the sea, but also good connection with inland area via good railway and highway transportation network. It is only 15km to Pakistan via expressway and 14km to state railway trunk. Furthermore, there are 6 railway networks connected with port wharf. It is 22km to Ginna International Airport. It is also convenient to use waterway transport.

4.3 Hydro-meteorological Conditions

The elevation in this section refers to the mean sea level (MSL) of the port of Bin Qasim. As indicated in the data provided by the Client, the relationship between the height datum of the port of Bin Qasim (PIPRI) and mean sea level (MSL) can be described in the following formula:

MSL= Height datum of the port of Bin Qasim (PIPRI) +2.03m.

Figure 4.3-1 Schematic Diagram of Topographic Conditions around Project Area

The BQPS project of Pakistan is situated at about 2km on the east of the port of Bin Qasim, which is to the southeast of Pakistan's southern city of Karachi. The project area is right within the bounding walls, in the south, of the existing Bin Qasim Power Station of the Karachi Power Supply Company. The straight-line distance from the project area to the center of Karachi is about 38km. There is an intertidal zone of about 25km between the south of the project area and the Arabian Sea. The intertidal zone is scattered with long and narrow bays and small islands. Most of the islands are covered with vegetation. The project area is adjacent to the port of Bin Qasim on the west. At the port, there is a long and narrow sea-lane going directly into the Arabian Sea. Such a sea-lane was designed and constructed by a Chinese company. On the east of the project area is a bay, and on the north is a flat ground.

Generally speaking, the project area is rather flat with proper drainage. There is vegetation, but not much.

4.3.1 Hydrologic Conditions

4.3.1.1 Characteristics of Tide Levels

On the basis of the summary of tides in Pakistan in 2009, the tides happened in 2009 at the ports of Karachi and Bin Qasim are summarized in Table 5.3-1 in the below:

Table 4.3-1Summary of Tides

Item	Karachi	Bin Qasim (Intake)	Bin Qasim(PIPRI)
Types of Tides	0.54(Mixed type)	0.52(Mixed type)	0.45(Mixed type)
Shallow Water Effect	0.02	0.07	0.16
Highest Tide (m)	1.73	1.94	2.05
Lowest Tide (m)	-2.02	-2.15	-2.48
Max. Tide Range (m)	3.63	3.93	4.5
Avg. Flood Tide Time	06Hr13Min	06Hr19Min	06Hr42Min
Avg. Falling Tide Time	06Hr11Min	06Hr6Min	06Hr42Min
Fastest Flood Tide Time	03Hr46Min	02Hr49Min	03Hr41Min

The tide levels at the ports of Karachi and Bin Qasim in 2009, when converted into the elevation system with MSL datum, are summarized in Table4.3-2 in the below:

Table5.3-2 Summary of Tide Levels

Tide Level	Height (m)		
	Karachi	Bin Qasim (Intake)	Bin Qasim(PIPRI)
Highest Astronomical Tide	1.73	1.86	1.98
Mean Higher High Tide Level	0.73	1.03	1.37
Mean Lower High Tide Level	0.63	0.43	0.67
Mean Sea Level	0	0	0
Mean Higher Low Tide Level	-0.57	-0.67	-0.63
Mean Lower Low Tide Level	-1.27	-1.27	-1.03
Lowest Astronomical Tide	-2.27	-2.47	-2.63

4.3.1.2 Study of Waves in Adjacent Sea to Project Area

In consideration of the nautical chart of the adjacent areas, it is clear that, in the surrounding waters of the project area, there is just one narrow sea-lane going directly into the Arabian Sea. Between the project area and the open sea is an intertidal zone of about 25km, scattered with small islands and long and narrow canals occasionally. The intertidal zone will submerge under the water at the high tide level. At the low tide level, it will emerge above the water. Even at the high tide level, the water at the intertidal zone is only 0.5m~1.0m deep. Therefore, the waves of the Arabian Sea will have little effect on those in the waters adjacent to the project area. Even if there is a big storm, the waves in the adjacent waters are rather small, presenting no risks to the project area.

4.3.2 Meteorological Conditions

Situated at the northwest corner of the Karachi Airport in the center of the city of Karachi, the Karachi Airport Meteorological Station enjoys a geographical location of 67°09'E and 24°45'N. The airport is to the northwest of the project area at a distance of about 25km, as indicated in Figure 5.3-2. The continuous observation data ever since 1970 are available at the meteorological station, and are well representative for the meteorological conditions of the project area.

Figure 4.3-2 Location Plan of Karachi Airport & Project Area

4.3.2.1 Summary of General Meteorological Parameters

The general meteorological parameters are summarized in the below:

Average temperature	30℃
Average max. temperature	36 ℃
Average min. temperature	23.8 ℃
Extreme max. temperature	47.8℃
Extreme min. temperature	5℃
Average air pressure	1013.2 hPa
Average relative humidity	70%
Average precipitation	203mm

Max. occurrences of thunderstorm	25 occurrences per year
Min. occurrences of thunderstorm	07 occurrences per year
Monthly average relative humidity (max.)	88.7%
Monthly average relative humidity (min.)	35%
Average relative humidity (max.)	77%
Average relative humidity (min.)	45%
Max. instantaneous wind speed	140 km/h
Design max. ambient temperature	50 ℃
Max. precipitation in one day	143mm (on July 19, 2009)

From July 18 to July 20, 2009, Karachi experienced the heaviest storm since 1973, with a cumulative precipitation of 205mm, and on July 19 alone, the precipitation was 143mm.

The month-to-month meteorological parameters over the years measured at the Karachi Airport Meteorological Station are summarized in Table 4.3-3.

4.3.2.2 Design Wind Speed & Wind Rose

The highest wind speed measured at the Karachi Airport Meteorological Station is 140km/h, while the highest design wind speed is 160 km/h. Such a design value is the speed of an instantaneous (3s) wind of 10m high in a 50-year return period.

It is recommended that, in wind load calculations as per the applicable Chinese standard, the wind pressure corresponding to the average highest speed for 10min for a wind of 10m high in a 50-year return period shall be taken as 0.83kN/m2.

Wind observations at the Karachi Airport Meteorological Station were conducted to the winds in 8 directions along with the calm wind. The rose diagrams of wind direction frequencies in winter and summer at the Karachi Airport Meteorological Station are given in Figure 4.3-3.

4.3.2.3 Rainstorm Intensity Formula

As indicated in the precipitation data provided by the Karachi Airport Meteorological Station, the average annual precipitation at the city of Karachi is 203mm, with the maximum daily precipitation of 142.5mm (on July 19, 2009). On that day, most of the rainfall came in 3~4 hours from the night of July 18 to the early morning of July 19. The cumulative precipitation was 142.5mm, and the maximum precipitation in ten minutes was about 10mm. On the basis of the above data, the following rainstorm intensity formula is recommended for the project in question:

$$q = \frac{1600(1+0.81\mathrm{g}\,p)}{(t+5)^{0.76}}$$

of which, the symbols mean:

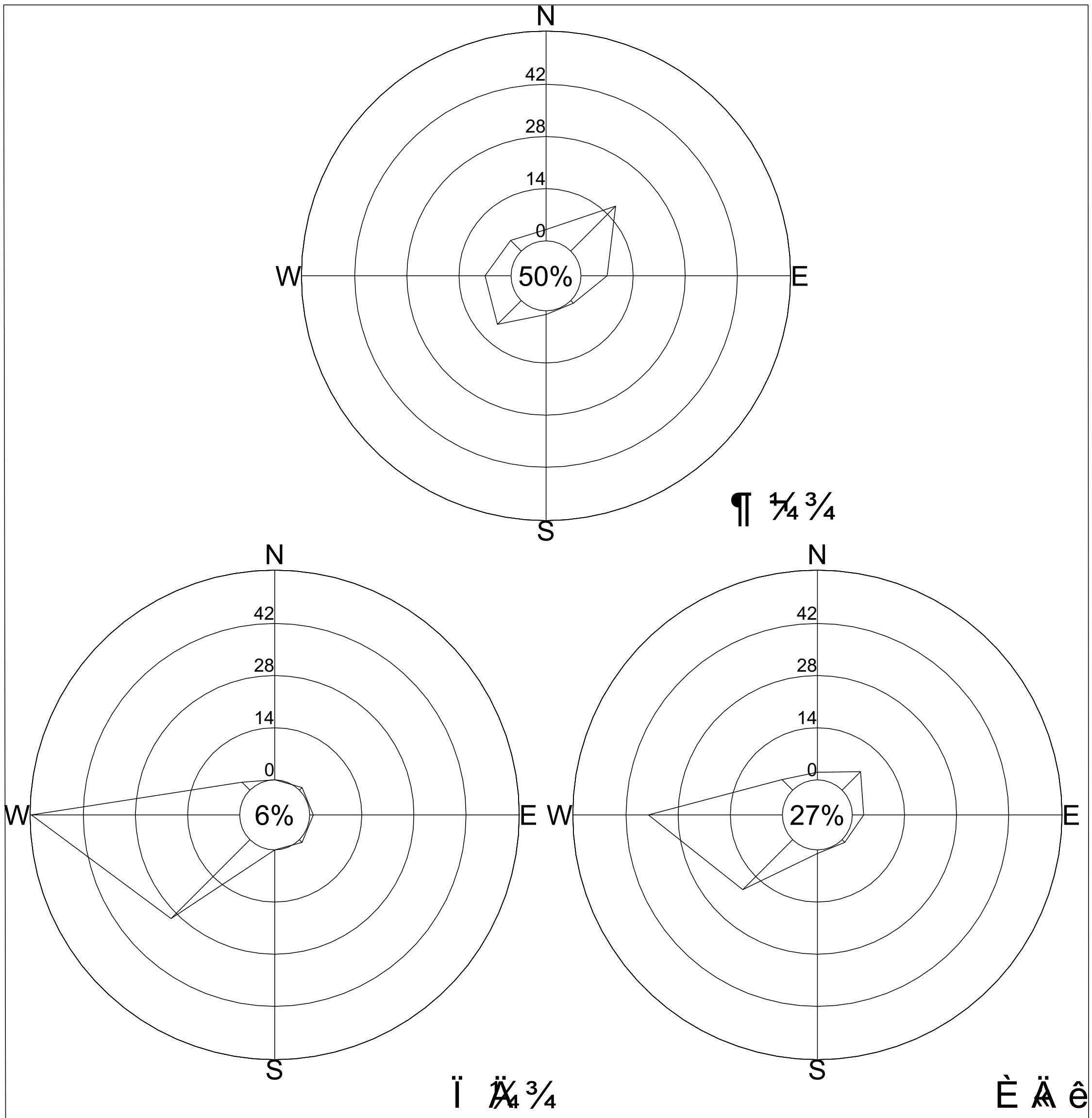
q – the year with the rainstorm intensity (a)

t – duration, minute, liter/second•hectare L/ (s.hm^2)

P - recurrence interval, minute (min).

Table 4.3-3 Summary of Month-to-month Meteorological Parameters over Years at Karachi Airport Meteorological Station

Meteorological Factors	Month												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year-round
Avg. Temp. (℃)	18.9	20.3	24.4	27.5	30.0	30.9	30.0	28.6	28.1	27.5	24.2	20.3	25.9
Avg. Max. Temp. (℃)	25.0	26.1	29.4	32.2	33.9	33.9	32.8	31.1	31.1	32.8	30.6	26.7	30.6
Avg. Min. Temp. (℃)	12.8	14.4	19.4	22.8	26.1	27.8	27.2	26.1	25.0	22.2	17.8	13.9	21.1
Extreme Max. Temp. (℃)	31.7	33.9	41.1	43.9	47.8	45.6	43.3	37.2	41.1	42.2	37.8	32.8	47.8
Extreme Min. Temp. (℃)	4.4	6.1	8.3	13.9	18.3	20.0	22.8	22.8	20.6	13.9	8.9	3.9	3.0
Avg. Relative Humidity (%)	54	61	58	75	78	78	81	82	80	70	59	55	70
Avg. Precipitation (mm)	13	10	8	3	3	18	84	41	13	2	3	5	203
Max. Precipitation (mm)	69	51	56	131	60	183	392	428	252	69	41	66	676
Avg. Hours of Sunshine (h)	279	244	295	306	319	213	118	130	225	301	279	273	2982
Avg. Wind Speed (m/s)	3.3	3.6	4.3	5.1	6.1	6.7	6.7	6.2	5.2	3.5	2.8	3.1	4.7
Dominant Wind Direction	NE	SW	W	W	SW	SW	SW	SW	W	SW	SW	SW	SW



ÆµÂ Ð ¨ ·Ç ò (%) Ê ±¶Î	N	NE	E	SE	S	SW	W	NW	C
¶ ¼¾	3	17	7	1	1	9	7	4	50
Ï Ä¼¾	0	1	1	1	0	30	56	3	6
È Ä ê	2	7	3	1	1	19	36	4	27

Figure 5.3-3 Rose Diagrams of Wind in Winter & Summer &Year-round at Karachi Airport Meteorological Station

4.3.3 Floods in Project Area

The BQPS project of Pakistan is planned within the bounding walls, in the south, of the existing Bin Qasim Power Station. The project area is in the Bay of Arabian Sea. On its east is an open channel for water intake of a nearby steel mill, while on its west is the open channel for water intake of the existing Bin Qasim Power Station. From the south of the project area to the seaside is a distance of about 300m, as indicated in Figure 5.3-1. To the southwest of the project area for about 2.0km is the port of Bin Qasim. The area planned for the project used to be a sea before 1972, and it was converted into a relatively flat land through sea reclamation. The natural elevation of the land is about 4.0m. At the port of Bin Qasim (PIPRI) nearby, the high tide level in a 50-year return period is 2.47m. On the basis of the currently available data of the tides, the high tide level near the project area in a 100-year return period is estimated to be 3.0m.

The elevation of the existing Bin Qasim Power Station is about 5.2m. As the currently available data of the tide levels are not sufficient, the Client is suggested to collect further data of the tides near the project area.

4.4 Water Sources for Power Plant

4.4.1 Water demand

The project adopts once-through cooling water supply system and main cooling water consumption required by two grade F gas turbine is 2×26195m^3/h and auxiliary cooling water consumption is 2×2,500m^3/h. Production and domestic water required in the new plant will come from the pipe network of the old plant. The water quantity for the new plant is 55m^3/h.

4.4.2 Water source

(1) Cooling water

The previous plant has six 210MW gas turbine units and all circulating water systems adopt once-through cooling water supply systems. The water supply source is taken from open channel. Owing to restricted site condition, it is unable to establish new water intake facilities. Based on existing data, No.3 and 4 units have low power generation efficiency and annual utilization hours. After the project is completed, it is planned to exit No.3 and 4 units. Therefore, it is temporarily to adopt the water intake plan: use the water intake structures and facilities of No. 3 and 4 units.

Based on existing data, both No.3 and No.4 units are respectively equipped with two main circulating water pumps and one auxiliary cooling water pump. For the main circulating water pump, the parameter is Q=18,745m^3/h and H=14m, and the parameter of auxiliary cooling water pump is Q=2600m^3/h and H=23m. The original water intake structure scale designed in accordance with 2×18,745m^3/h circulating cooling water quantity of No.3 and 4 units and water intake quantity for auxiliary cooling water can meet combined cycling water demands of one grade F gas turbine.

(2) Service & potable water

There are 4 water basins with capacity of 3000 m^3, which are make-up by the KWSB & Steel Mills near the plant. The water quantity for each unit of the old plant is about 40m^3/h, and the water quantity for the new plant is about 55m^3/h. After the retired of the unit 3 & 4, the available water quantity is about 80m^3/h， which is enough for service and potable water of the new plant。

In conclusion, it is feasible to meet water demands of the project by using original water intake facility. Water source for the project is practicable.

4.4.3 Quality of water

The seawater quality in 2014 is analyzed on the basis of the data provided by the Client. Please refer to Table 4.4-1 and Table 4.4-2 in the below for details.

Table5.4-1 Sea Water Fortnightly Analysis Record 2014(January -June)

Month		January		February		March		April		May		June	
Date		1-Jan-14	16-Jan-14	3-Feb-14	14-Feb-14	5-Mar-14	16-Mar-14	4-Apr-14	18-Apr-14	3-May-14	20-May-14	3-Jun-14	18-Jun-14
pH	ph	7.7	7.8	7.7	7.6	7.8	7.7	7.8	7.9	7.8	7.9	7.8	7.9
Conductivity	µs/cm	58400	58700	58500	58800	58300	58500	58100	58300	62700	62900	64700	64900
Turbidity	NTU	18	19	14	15	15	16	16.1	17	17.1	15	16	17
Chlorides	PPM	22700	22500	22400	22800	22600	22900	22700	22500	22700	22900	23100	22900
Total Hardness	PPM	7200	7300	7500	7400	7300	7200	7400	7500	7300	7200	7300	7200
Calcium Hardness	PPM	11,00	11,00	10,50	1150	11,00	11,00	11,50	11,50	11,00	1050	11,00	1050
Magnessium Hardness	PPM	6100	6200	6450	6250	6200	6100	6250	6350	6200	6150	6200	6150
M-Alkalinity	PPM	135	140	130	125	130	135	140	135	130	140	135	130
Sulfate	ppm	2356	2342	2344	2399	2456	2366	2455	2466	2474	2498	2510	2541
Silica	PPM	1.25	1.2	1.15	1.2	1.3	1.2	1.2	1.25	1.3	1.2	1.3	1.2
Free Chlorine	PPM	0.15	0.12	0.14	0.1	0.12	0.11	0.12	0.16	0.18	0.15	0.12	0.1
BOD	ppm	31	32	29	28	29	31	30	33	35	36	34	35
COD	ppm	160	162	165	162	160	154	165	154	165	145	145	175
Oil and Grease	ppm	NIL	NIL	Trace	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Trace	NIL
Iron	PPb	85	95	70	60	65	45	49	76	85	80	76	84

Table5.4-2 Sea Water Fortnightly Analysis Record 2014(July -December)

Month		July		August		September		October		November		December	
Date		2-Jul-14	19-Jul-14	1-Aug-14	16-Aug-14	4-Sep-14	18-Sep-14	6-Oct-14	24-Oct-14	6-Nov-14	22-Nov-14	2-Dec-14	23-Dec-14
pH	ph	7.8	7.9	7.8	7.8	7.9	7.9	7.8	7.9	7.8	7.9	7.8	7.9
Conductivity	µs/cm	60700	58600	58400	58200	57300	57700	57200	57800	58100	57900	58100	57900
Turbidity	NTU	15	14	15	19	20	18	17	18	15	14	13	12
Chlorides	PPM	22700	22900	22700	22900	22400	22700	22300	22900	23300	23700	23300	23700
Total Hardness	PPM	7300	7400	7200	7200	7100	7200	7100	7200	7300	7200	7300	7200
Calcium Hardness	PPM	1100	1100	1050	1100	1000	1050	1000	1050	1100	1100	1100	1100
Magnessium Hardness	PPM	6200	6300	6150	6100	6100	6150	6100	6150	6200	6100	6200	6100
M-Alkalinity	PPM	135	140	130	135	138	140	135	138	140	140	140	140
Sulfate	ppm	2510	2542	2500	2540	2540	2410	2460	2540	2450	2366	2399	2354
Silica	PPM	1.2	1.15	1.2	1.3	1.2	1.2	1.25	1.3	1.3	1.3	1.3	1.3
Free Chlorine	PPM	0.1	0.15	0.13	0.15	0.12	0.13	0.12	0.13	0.13	0.13	0.13	0.13
BOD	ppm	29	29	31	32	29	28	32	36	34	31	31	30
COD	ppm	145	156	152	228	275	153	159	160	165	165	162	144
Oil and Grease	ppm	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Trace
Iron	PPb	91	48	49	85	75	85	58	75	80	68	95	85

Water specification of Make-up Water for Existing Plant at BQPS I from KWSB & Steel Mills:

Specification	Present Water Quality
Chloride	116 ppm
Mg	131 ppm
Ca	114 ppm
T.Hardness	245 ppm
Silica	7.8 ppm
PH	7.9-8.0 ppm
Conductivity	873 ìs/cm
TDS	472

4.4.3 Seawater Temperature at Intake

The average maximum and minimum temperatures of the seawater at the circulating water intake from July, 2005 to June, 2006 are shown in Table 4.4-3.

Table 4.4-3 Max. & Min. Temperatures at Circulating Water Intake Unit ℃

Month	Year 2005						Year 2006					
Item	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Min. Temp.	28.3	27.2	25	26.7	21.1	18.9	18.9	18.9	22.2	24.4	27.2	29.4
Max. Temp.	31.1	28.9	28.9	28.9	28.3	22.2	21.1	25.6	26.7	28.3	31.7	31.7

4.5 Geological and Geotechnical Earthquake Engineering

4.5.1 Seismic Geological

According to the seismic zoning map of Pakistan, the proposed site is located in Zone 2B. The Peak Ground Acceleration with 10% probability of exceeding in 50 years (475 years return period) is 0.18 ~ 0.24 g, and 0.24g is recommended, which is corresponding intensity of Ⅷ degrees.

4.5.2 Engineering Geological Conditions

4.5.2.1 Topography

The project site is located in the east of Karachi, Pakistan, about 40 km near the Port of Muhammad Bin Qasim, south shore of the Arabian Sea, with long coastline, which has overall flat terrain with shallow tidal flats and a large area of mangroves.

4.5.2.2 Strata

According to 《Onshore and Offshore Geotechnical Investigation for Fuel Conversion Facility at KESC BQPS-I, Port Qasim, Karachi》, the main strata from top to bottom as follows:

① Backfill: The backfill were mainly composition of the fine sand, coarse sand, gravel sand and construction waste. It exists in most of the site, backfill thickness generally between 0.50m~2.00m.

② Silt fine sand: Slightly dense state, some is loose and medium dense state. Brown and grey, silt fine sand is mainly, with some soft plastic silty clay. Thickness is generally between 1.00m~2.50m.

③ Silty fine sand: Slightly dense state~Medium dense state. Brown and grey, silty fine sand is mainly, some is medium to coarse sand. Thickness is generally between 3.00m~5.00m.

④ Silty clay/silt: Stiff, grey, with some silty fine sand and medium coarse sand. Thickness is generally between 3.50m~4.50m.

$⑤_1$ Sandstone: Completely weathering~stronge weathering and core were massive or sandy gravel, brown and grey; argillaceous, calcareous cement. Thickness is generally between 14.00m~16.50m.

$⑤_2$ Sandstone: Mod. Weathering and core were massive or sandy gravel, brown and grey; some is conglomerate and clay stone, argillaceous, calcareous cement, coarse-grained structure, massive structure. It's being general in the site. The general depth is 26.00m~28.50m.

Table 4.5-1 Soil geotechnical parameters recommended value

Itern / Strata	State	Unit weight γ (kN/m^3)	Cohesion c (kPa)	Internal friction angle Φ(度)	Constrained modulus $E_{S\ 0.1\text{-}0.2}$ (MPa)	Bearing capacity f_{ak}(kPa)
② Silty fine sand	Slightly dense	18.0	0	27.0	6.0	140
③ Silty fine sand	Slightly dense~Medium dense	18.5~20.0	0	27.0~30.0	11.0~20.0	160~240
④ Silty clay	Stiff	19.5	25.0	22.0	10.0	230
$⑤_1$ Sandstone	Completely~Strong weathering	-	-	-	-	350~500
$⑤_2$ Sandstone	Mod. weathering	-	-	-	-	1300

4.5.2.3 Hydrogeological Conditions

The depth of groundwater varies from 2.4 to 5.0 meters below the existing ground level. However, the groundwater conditions are affected by the tidal levels.

According to 《Onshore and Offshore Geotechnical Investigation for Fuel Conversion Facility at KESC BQPS-I, Port Qasim, Karachi》, the data shows that soil and water samples encountered at the site have been found to be highly corrosive for steel, therefore, Migrating Corrosion Inhibitors (MCI) admixtures should be used to protect the steel from corrosion.

4.5.3 Unfavorable Condition

As there is soft silty clay in the field, the engineering properties is bad, which will affect future construction and operation. What is more, the site may have a hidden creek distribution or dark pond, which needs to be found out in the next stage survey.

There are saturated silty fine sand and silt in the site within 20 meters, intensity Ⅷ(PGA,0.20g) so liquefaction of sand is possible. Further investigation should be taken to get appropriate decision.

4.5.4 Geotechnical Engineering Analysis and Evaluation

4.5.4.1 Natural Foundation

For the buildings which bearing capacity meets the requirements, raft foundation is recommended. However, for the areas which may have liquefaction, mitigation measures need to be carried out to improve soil conditions at these locations or provide pile foundations to support these structures and prevent structural damage in the event of a seismic event which triggers liquefaction.

4.5.4.2 Pile Foundation

Pile foundations are recommended for main factory building area such as Gas turbine, Steam turbine house, GT main transformers, ST main transformers, other main subsidiary structure and for locations susceptible to liquefaction and where imposed loads exceed the given allowable bearing pressure for raft foundation.

According to the available data, ⑤$_1$ layer of completely~strong weathering sandstone and ⑤$_2$ layer of weathering sandstone are suitable bearing layer. A diameter of 800 mm bored piles pile type is recommended. The type of pile will be determined base on the result of Geological survey

Considersing the engineering data and the reference of China's national industry standard "code for building pile foundation technology (JGJ 94-2008)", the recommended pile foundation design parameters of all the strata are shown in table 4.5-2, and the vertical ultimate bearing capacity of single pile estimates are shown in table 4.5-3

Table 4.5-2 Recommended pile foundation design parameters

NO.	Name	State	Bored Pile(kPa)	
			Standard values of ultimate flank of a pile q_{sik}	Standard values of end face resistance of a pile q_{pk}
①	Backfill	Loose	20	—
②	Silty fine sand	Slightly dense	35	—
③	Silty fine sand	Medium dense	35~60	—
④	Silty caly	Soft~stiff	60	—
⑤$_1$	Sandstone	Completely~Strong weathing	75~90	1500~1600
⑤$_2$	Sandstone	Mod. weathing	140	2000

Table 4.5-3 the vertical ultimate bearing capacity of single pile estimates

Type of Pile	Depth of pile(m)	NO. of bearing stratum	Depth of entering into the bearing stratum(m)	Standard value for vertical ultimate bearing capacity of single pile Q_{uk}(kN)
ϕ600mm bored pile	19.0	⑤$_1$	7.0	2513
ϕ800mm bored pile	28.0	⑤$_2$	2.0	5353

Annotation：The data in the table are calculated which is based on the hole BHON - 6 of BQPS -I, for reference only. The actual single pile vertical ultimate bearing capacity of bored piles value will be subject to project the results of the test pile。

When constructing, should adopt some measures such as reasonable design of pile spacing, controling the flow of piling pile driving speed and sequence and rest time, to reduce the amount of soil compaction, reduce excess pore water pressure, and avoid adverse impact on pile foundation construction on the surrounding environment

4.6 The Vulnerability Analysis

4.6.1 Seismic and geological disaster effects and preventive measures

According to the seismic zoning map of Pakistan, the proposed site is located in Zone 2B. The Peak Ground Acceleration with 10% probability of exceeding in 50 years (475 years return period) is 0.18 ~ 0.24 g, and 0.24g is recommended, which is corresponding intensity of Ⅷ degrees.

The possible geological disasters of this project are: earthquake liquefied sand, land subsidence and flow.

Earthquake liquefaction protective measures should be taken after the possible liquefaction depth found out. The most effective method for soil improvement in this type of soil is vibroflotation and/or installation of Stone Columns.

During the period of project construction, especially in the process of excavation of pile foundation, Monitoring special settlement, displacement, piling vibration and pore water pressure are recommended at the space of gas turbine, turbine main workshop, gas turbine main transformer, turbine main transformer and other important buildings, which can monitor the construction process and completion settlement dynamic at any time.

Prevention of sand flow should be controlled in engineering before construction. After finding out the distribution features of the shallow silty sand ground, corresponding drop and drainage measures should be taken at the time of excavation, with corresponding containment measures according to the circumstance when necessary.

4.6.2 Flood and water-logging disaster effect and preventive measures

On the basis of the currently available data of the tides, the high tide level near the project area in a 100-year return period is estimated to be 3.0m. The area planned for the project was converted into a relatively flat land through sea reclamation. The natural elevation of the land is about 4.0m. At the site of rainwater drainage condition is good, does not produce water-logging. The power plant can reach 100 years flood and water-logging control standard，also can achieve the requirements of *Technical code for designing fossil fuel power plants*.

The elevation of the existing Bin Qasim Power Station is about 5.2m. As the currently available data of the tide levels are not sufficient, the Client is suggested to collect further data of the tides near the project area.

5 Project outlines

5.1 Overall planning and General layout

5.1.1 Overall planning of plant

5.1.1.1 Design principle

The project mainly use the space in south of BQPS-I to expand 2×450MW class gas-steam combined cycle unit. Major principle for overall planning of the whole plant:

(1) The plan shall be made based on the principle of saving and full taking advantage of land resources. While assuring reasonable technology, it is required to save the land as far as possible.

(2) For general layout, considering addition of least auxiliary facilities, including Hydrogen generation plant, relay room, GIS, air compressor room, gas condition plant, firefighting pump house, diesel generator set, warehouse and workshop, etc.. Most of facilities including chemical water treatment facilities, waste water treatment facilities, etc. from the old plant can be used. Materials storage and pre-plant area will not be built. The circulating water will come from the 3 # 4 # machine circulating water pipes in this program, and circulating water drainage connected to the old plant drainage lines. No new circulate water pump house will be constructed.

5.1.1.2 Fuel source

BQPS power plant is divided into two phases. In phase I project, there are 6 fuel oil units. In BQPS-II project, there are 3 Gas Turbines and 1 Steam Turbine. Natural gas condition station is respectively constructed in Phase II.. Natural gas pipelines can be connected to this phase of project from BQPS I. However, it is required to solve the pressure problem of natural gas. A gas booster station will be constructed. In the future the other way is to connect a natural gas pipeline to this project directly from RLNG coming from north face. Fuel source and interface position shall be further defined by owners.

5.1.1.3 Water source and water supply and drainage way of power plant

Circulating water cooling system of this project adopts once-through circulation. The Circulating water of this project is taken from Circulating water pump station of No.3 and No.4 units. The drained water is connected to drainage pipe of old plant. In this project, no new circulating water pump room is constructed.

5.1.1.4 Outlet of power plant

A GIS distribution device house will be constructed on the north side of the open space in the old plant in this project. Set a return line, a contact line. Contact line and the original GIS of BQPS-I will be connecting. In the current a return line and three return lines are used to send by the original 220kV line, a total of four return lines.

5.1.1.5 Construction area and construction living quarter

In this project, $5hm^2$ construction site is required. In combination with practical condition of this phase of project, only the existing space in north of old plant can be used as construction production land. When this stage of project is implemented in different stages, some construction lands of this phase can be taken as construction and production lands. For construction and living land, consider temporary construction of old BQPS-2 plant. The further plan shall be defined according to the old plant general layout by the owner.

5.1.1.6 Facility of old plant can be used

This is a reconstruction and extension project. Auxiliary facilities should make the most use of the old factory.

The original facilities of BQPS-I that can be used include: raw water pretreatment facility, chemical water treatment facility, circulating water pump house, etc.; some facilities need to be constructed comprise: GIS, hydrogen generator station, air compressor house, etc.

5.1.2 Plant General layout

As the reconstruction and extension project, in combination with overall plot plan and external condition of the plant, fully consider arrangement condition of existing facilities on the construction site, and opinions and suggestions of the owner's opinion on the Early Design. The general layout is considered as following:

(1) Main building

The project due to land conditions, the joint plant can only be arranged in the middle of the main construction land, the joint plant from north to south followed by the main gas turbine house – steam turbine house - gas turbine house.

The total length of the main building is 192m, and the length between the gas turbine house A row to the chimney center of H.R.S.G is 104.5m. Steam turbine house A row relative to the combustion engine room A row move westward, leaving the transformer layout space.

(2) Indoor distribution system

The new GIS indoor distribution system will be built in the open area north of BQPS-I. The GIS indoor distribution system is in the north, and the relay room is in the south. The West side of GIS is nearly the outlet tower of BQPS-I. In the open cycle time, two outgoing cable will join up to GIS by tunnel. In the combine cycle phase, three outgoing cable will join up to the cable trench tunnel. The new GIS and the old GIS will be connected with trench tunnels. The detail layout of the tunnel was provided in the general layout, which is 30-F007101K-A-08. The dimension of the most of the tunnel is 3.0m width and 3.2m depth the length of the cable trench tunnel is 980m.

(3) Circulating water facilities

There is no new circulating water house. The old plant circulating water pump room layout beside of the main construction site will be used. In order to shorten the length of the circulating water pipes, the interface of circulating water supply pipes and drainage pipes are in the west side of the main turbine house.

Due to not open a new water discharge, drainage pipes need to access the old factory drains. The old factory facilities underground is intensive layout, drainage pipe path to maximize the use of the old factory path. To solve the problem of circulating water drainage and supply, In the project, the 3 # 4 # machine circulating water pipe will be divided into two, the current project of the circulating water supply pipe connected to the pump station near the pump house, the circulating water drainage pipe connected to the 3 # 4 # main buildings. The length of Circulating water supply pipes and drainage pipes are both 850m.

(4) Auxiliary affiliated facilities

The gas condition station for RLNG is arranged in the north of the BQPS-I where the original 4 # machine warehouse locates, taking account of the natural gas source and the status of the site. As the pressure of SSGC is low, a new natural gas booster station for SSGC will be built in south of the main construct area in this project. The booster station will be arranged close to 1# gas turbine.

In Chinese standards, the required distance between the gas condition station and the gas turbine building shall be more than 30m. The new hydrogen supply station and firefighting pump house will be located in the area between the natural gas booster station and gas turbine building, in order to rational use of the land of the plant.

(5) Entrances and exits

Major road of this phase is connected with road network of old plant. Access of original plant is utilized for external contact. A new temporary gate will be built in the east-north face for construction purpose.

(6) Construction site

The space in north of BQPS-I can be utilized as the construction production site, and some open space in the construction site can also be utilized. The construction living site can use temporary buildings of BQPS-Ⅱ. Specific plan shall be further defined.

Engineering land of this project covers about 5.35 hm^2 area.

It is calculated based on existing hydrological data that once-in-a-century flood stage is 3.00m(MSL elevation system shall be further defined). This project of site has about 4.40~4.93m elevation which can meet flood prevention and drainage requirements. Along vertical direction of this phase of plant area, we mainly consider balanced earthwork and stonework which shall be basically consistent with old plant. At present, we refer to field design elevation of BQPS - Ⅰ. Indoor design elevation of this phase of engineering building is 5.5m. Outdoor design elevation is 5.20m. Design elevation of road centerline is 5.00m. About the plan, the required amount of cut of factory area is about 0 ten thousand m^3, the amount of fill is 91 thousand m^3. The produced surplus soil of foundation trench is 36.4 thousand m^3. The total amount of purchase soil of the whole factory is about 54.6 thousand m^3. All of the volumes about earthworks were estimated. Earthwork shall be further defined after the detail topographic map is achieved.

5.1.3 Major technical and economic index of plant

No.	Content		Unit	Plan
1	Current Land area of plant		hm^2	5.35
2	Unit capacity land area of this phase of project		m^2/kW	0.064
3	Circulating water pipeline length in plant	Water supply pipe	m	850/30
		Water drainage pipe	m	850/30
4	Volume of earthwork in plant	Excavation	10^4m^3	0
		Fill	10^4m^3	9.10
5	Remaining soil of foundation trench		10^4m^3	3.64
6	Land area of buildings and structures in plant		m^2	19530
7	Building factor		%	36.5
8	Site utilization area of plant		m^2	35580
9	Utilization factor		%	66.5
10	Plant road and terrace area of square		m^2	9630
11	Road and square factor		%	18.0
12	Land area for greening of plant		m^2	8025
13	Greening rate of plant		%	15

5.1.4 Conclusion

The plan has following two obvious advantages:

(1) The general layout is structured, compact layout, clear partition, and the land utilization is high.

(2) Main building is close to the circulating water pump house, and circulating water pipe is short.

(3) The project has less impact on the old plant, and it does not affect the original unit operation.

5.2 Installation options

5.2.1 Model Selection of Generating Units

(1) The generating units shall be characterized by operational flexibility and a fast start-up and shutdown, and can satisfy the requirements of a quick regulation of peak load in the power grid.

(2) The generating unit with a high efficiency shall be selected as much as possible, so that the energy can be made full use of and the price of power supply can be reduced as a result.

(3) The standard series of products with advanced and mature technology shall be selected in order to increase the localization rate of the equipment.

(4) The products to be selected shall enjoy remarkable technological and price advantages.

(5) Requirements of environmental protection shall be satisfied.

5.2.2 Configuration of Generating Units

5.2.2.1 Selection of Single Shaft & Multiple Shaft Arrangement

In the gas-steam combined cycle system, the exhaust from the gas turbine will be sent to the waste heat boiler and bring about water steam; and the high pressure steam from the waste heat boiler will go into the steam turbine to work.

In the single shaft arrangement, the gas turbine, generator and steam turbine will be all installed on the same shaft, with the generator driven by both the gas turbine and steam turbine. The generator can be placed between the gas turbine and steam turbine, or, it can also be placed at the exhaust end of the steam turbine. Such an arrangement applies only to the case in which the single gas turbine, single waste heat boiler and single steam turbine match with each other, or the so-called 1+1+1 single shaft arrangement. Each set of Grade F single shaft gas-steam combined cycle generating unit is composed of a single shaft unit of a gas turbine, a triple pressure reheating waste heat boiler and a reheating condensing steam turbine with three cylinders.

In the multiple shaft arrangement, the steam turbine will be connected only with the water conduit with steam on the waste heat boiler equipped for the gas turbine. With no mechanical connection with the gas turbine, the steam turbine can be arranged separately from the latter, giving rise to a relative flexibility in the layout arrangement. Regular layout of the steam turbine station in the conventional thermal power generating unit can be cited as reference for the layout of the steam turbine workshop. The steam turbine can be arranged in a separate workshop, or, it can also be arranged in the open air.

In the single shaft unit, the gas turbine is installed on the same shaft with the steam turbine and both the turbines drive the same generator. Tripping of the steam turbine will definitely lead to tripping of the gas turbine and, that’s to say, the whole unit. However, in the dual shaft unit, the steam turbine and gas turbine will drive a generator separately. If the steam turbine trips, the gas turbine can still work properly to generate electricity.

For the project in question, the #1 gas turbine is required to generate electricity from May, 2018, and the rest of the generating units will be constructed in steps and then put into operation. As a result of the time limit for electricity generation, the gas turbine and steam turbine must be constructed separately for the project. Therefore, only the multiple shaft arrangement applies. The gas turbine can be completed before construction of the steam turbine so as to guarantee the milestones of electricity generation.

In view of the above, in order to satisfy the requirements of construction cycle and milestones of electricity generation, the generating units with a multiple shaft arrangement will be selected for the project in question.

5.2.2.2 Comparisons of Multiple Shaft Arrangement Options

Currently, there are two options for the multiple shaft arrangement, i.e. “one-plus-one” arrangement and “two-plus-one” arrangement.

“One-plus-one”: 2 sets of Grade F gas turbine with multiple shaft “1+1” combined cycle generating units will be arranged in the power plant. Each set of generating units is composed of a gas turbine generator unit with a waste heat boiler. The steam produced at the waste heat boiler will then be used by a steam turbine generator unit to work.

"Two-plus-one": 1 set of Grade F gas turbine with multiple shaft "2+1" combined cycle generating unit will be arranged in the power plant. Each set of generating unit is composed of 2 gas turbine generator units with two waste heat boiler. The steam produced at the 2 waste heat boilers will then be used by a steam turbine generator unit to work.

In the below, a comparative analysis will be conducted on the two options in terms of the system and equipment configuration, system complexity, equipment reliability, operational flexibility and economy.

I. System & Equipment Configuration

The combined cycle generating unit will be equipped with a steam circulation system at a grade corresponding to the grade and exhaust gas temperature of the gas turbine. Normally, the Grade F gas turbine will be equipped with a triple pressure reheating circulation system.

The major equipment of the combined cycle generating unit includes the gas turbine, waste heat boiler, steam turbine, generator and associated auxiliary facilities.

Plan A: for the project in question, there will be 2 Grade F gas turbines, 2 triple pressure steam turbines, 4 generators and 2 triple pressure waste heat boilers. Bypass chimney will be arranged. The steam system will be equipped with 100% bypass. There will be two sets of combined cycle generating units for the project. Each set of combined cycle generating unit is composed of 1 gas turbine and 1 steam turbine, each turbine is designed with independent generator and main transformer and will be arranged separately.

Plan B: for the project in question, there will be 2 Grade F gas turbines, 1 triple pressure steam turbine, 3 generators and 2 triple pressure waste heat boilers. Bypass chimney will be arranged. The steam system will be equipped with 100% bypass. There will be one set of combined cycle generating unit for the project. The combined cycle generating unit is composed of 2 gas turbines and 1 steam turbine, each turbine is designed with independent generator and main transformer and will be arranged separately.

As indicated in the equipment configuration, the configuration of the systems and equipment in Plan B is relatively more complicated.

II. System Complexity

(1) Water-Steam System

Plan A: all the steam produced from one waste heat boiler will be sent completely to one steam turbine, and the steam turbine will only accept the steam produced from the said boiler. The cooled condensate that the steam turbine exhausts will be sent only to the said boiler.

Plan B: the steam produced from the two waste heat boilers will be combined together and then sent to one steam turbine, and the condensate exhausted from the steam turbine will be sent to the two boilers. Because of additional combination of the steam and distribution of the condensate, the related pressure, temperature and balance in the flow rate need to be taken into consideration, thus increasing the operational difficulties and start-up/shutdown time.

(2) Control System

The control system in Plan A covers a gas turbine, a steam turbine and a waste heat boiler. It is relatively easier to match with the load changes for each turbine. The control system is rather simple and logic programming is easy.

The control system in Plan B covers two gas turbines, a steam turbine and two waste heat boilers. The steam turbine will be affected by the loads of the two gas turbines. They are mutually dependent on each other. Therefore, in terms of the structural design and actual operation of the control system, Plan A is relatively simpler and more reliable.

As indicated in the general systems of the power plant, the water-steam and control systems in Plan B are relatively more complicated.

III. Equipment Reliability

The availability and forced shutdown rate of the generating unit are mainly dependent on the quality of the associated equipment and operating staff, and the complexity of the system as well.

The water-steam system, control system and electrical system in Plan B are more complicated than the systems in Plan A. Therefore, the operational reliability of Plan B is less desirable than that of Plan A.

IV. Operational Flexibility

Plan A: although the generating unit is in a multiple shaft arrangement, it is almost the same in system configuration as the generating unit in a single shaft arrangement. The one-to-one correspondence between the gas turbine, boiler and steam turbine makes it faster to start up and shut down, and in operation, its load increasing and reduction capacity in response to system scheduling is rather strong. Yet, as the major equipment involved is more than that in a single shaft arrangement, the operational flexibility of the multiple shaft arrangement is less desirable than that of a single shaft arrangement.

Plan B: As the steam turbine accepts steam from the two waste heat boilers, its volume is relatively bigger. Connection of the water-steam system is relatively more complicated. When the two waste heat boilers start up, their bypass will be directed to the pipe of the condenser for the steam turbine. The exhaust from the high pressure steam turbine will be distributed to the pipes of the reheaters for the two waste heat boilers. Operation is more complicated than that in a single shaft arrangement, especially during start-up and shutdown and in matching the steam temperature with the metal temperature when the load changes. When a forced shutdown happens, the power system will be more affected. Once the steam turbine shuts down, the power output will be reduced by the amount of power output of 2 sets of generating units in a single shaft arrangement. Plan B presents less operational flexibility than Plan A.

Techno-economic Comparison:

The results of techno-economic comparison between the two plans are summarized in Table 5.2-1.

Table 5.2-1 Techno-economic Comparisons between Two Plans

Item	Plan A	Plan B
Operational Flexibility	Relatively higher.	Relatively lower.
Equipment Reliability	Relatively higher.	Relatively lower.
Mode of Unit Control	Simple.	Relatively more complicated.
Configuration of System and Equipment	Simple.	Relatively more complicated.
One-time Investment	Bigger.	Big.
Floor Area	Big.	Bigger.
Plant Layout Arrangement	Rather loose.	Relatively compact.
Construction Cycle	Relatively longer.	Relatively shorter.
Load Increasing/Reduction Capacity	Strong.	Bit weak.
Maintenance or Overhaul	Maintenance can be conducted to the gas turbines set by set, with the output of the plant reduced to 1/2.	Maintenance can be conducted to the gas turbines one by one, with the output of the plant reduced to 1/2; and the steam turbine gives out a low efficiency when it runs with half of the load.
Forced Shutdown	Relatively less effect to the system.	Relatively more effect to the system.

VI. Conclusion

The above analysis leads to a conclusion that the "one-plus-one" plan is characterized by the advantages of good flexibility and high reliability. Therefore, the "one-plus-one" plan with a multiple shaft arrangement is recommended for the project in question.

5.3 Technical Specifications of Major Equipment

5.3.1 Main Suppliers of Generating Units

(1) Main Suppliers of GT

Currently, there are several models of Grade F gas turbines available in the world market, i.e. 9F.05, 701F, 4000F GT26 and AE94.3A.

The 9F.05 (original model No. 9FA) gas turbine was developed by General Electric Company of USA at the end of 1980s, with its main production bases in Greenville, USA and Belfort, France. In 1987, GE designed the 7F gas turbine (with a generator frequency of 60Hz), on the basis of which the 9F gas turbine was developed under the guidance of modeling principle. The 9F gas turbine is driven from its cold end. With an axial exhaust and single shaft dual bearing support, it is equipped with a 18-level axial flow compressor, of which, Level 1 is arranged with variable entry guide vanes and Level 2 is arranged with exit guide vanes. The 18 combustion cylinders are arranged in a ring. With the DLN combustion technology, the 9F gas turbine takes the combustible natural gas or light oil as the fuel. Work is done by the 3-stage turbine marked with the advanced technology of cooling and coating. In China, the 9F gas turbine is manufactured by Harbin Power Equipment Group. As GE reveals in the latest data, currently, there are over 200 sets of 9F gas turbine generating units in operation worldwide, with a cumulative operation time of 7,900,000 hours and cumulative 84,000 start-ups.

The 701F gas turbine was jointly developed by Mitsubishi Heavy Industries Ltd. of Japan and Westinghouse Electric Corp of USA at the end of 1980s and manufactured by Mitsubishi Group of Japan. For the M701F gas turbine, power output is from its cold end. With an axial exhaust and single shaft dual bearing support， it is equipped with a 17-level axial flow compressor. The 20 burners are arranged in a ring. The DLN combustion technology is adopted and work is done by the 4-stage turbine. In China, the gas turbine in this model is manufactured by Dongfang Electric Corporation. With a high power output and efficiency, the M701F4 gas turbine was awarded with its first order for the project in Gaobeidian, Beijing, China.

The large-scale 4000F gas turbine was developed by Siemens of Germany in the early 1990s. The first Grade F SGT5-4000F (original model No. V94.3A) gas turbine manufactured by Siemens was put into operation in 1997. For the gas turbine in this model, power output is from its cold end. With an axial exhaust and single hollow shaft dual bearing support， it is equipped with a 15-level axial flow compressor with variable entry guide vanes. The 24 cell burners are arranged in a ring. With a low NOx technology, work is done by the 4-stage turbine marked with the technology of heat insulation coating and vane type film cooling. In China, the SGT5-4000F gas turbine is manufactured by Shanghai Electric Power Generation Group. About 20 SGT5-4000F gas turbines are in operation at the power plants in Xiaoshan, Shidongkou, Zhengzhou, Xiamen, Lingang, Chongming, Jingqiao and etc.

Initially, the GT26 gas turbine was manufactured by ABB of Switzerland, which was later acquired by ALSTOM of France. It was the ABB technology that was adopted by the GT26 gas turbine. In 2015, when ALSTOM was acquired by GE, GE transferred the technology of GT26 gas turbine to Ansaldo in order to evade the market monopoly regulation. As no order was awarded in the bidding of the national project package of gas turbines, no products of a localization model have ever been put into operation in the domestic market till date. In China, Shanghai Electric Group has established cooperation with Ansaldo by acquiring 40% of its stocks. Therefore, no comparison will be made in this report to the GT26 model. Instead, the AE94.3A Grade F gas turbine manufactured by Ansaldo & Shanghai Electric will be analyzed. Being the biggest manufacturer of power equipment and service provider in Italy, Ansaldo is also one of the top-class designers and manufacturers of gas turbine in the world. In 1991, Ansaldo acquired the gas turbine technology from Siemens. In 1995, it "jointly" developed the V94.2K (Grade E, IGCC) generating unit with Siemens. In 2005, cooperation in the term of authorization ended. In 2009, the model No. V94.3A was changed into AE94.3A. Till present, there have been no products of the localization model in operation in the domestic market. Yet, the Shanghai Shenneng Fengxian Fuel Gas Power Plant involving the turbine of the said model is being constructed.

The following characteristics are revealed in the technology introduced from abroad:

In 2001, introduction of the first project package of Grade F gas-steam combined cycle generating units and manufacturing technology was organized by the concerned government departments in an integration of technology acquisition with trade. Through bidding, it was decided that Harbin Power Equipment Group would manufacture the 9F.05 gas turbine generating units in cooperation with GE of USA, and Dongfang Electric Corporation would manufacture the 701F gas turbine generating units in cooperation with Mitsubishi Group of Japan. So far, the 9F.05 gas turbine generating units manufactured by Harbin Power Equipment Group in cooperation with GE of USA have been dispatched in succession from Qinhuangdao to the customers of power plants.

In 2004, it was decided, through bidding of the second project package of gas-steam combined cycle generating units, that Shanghai Electric Power Generation Group would manufacture the 4000F gas turbine generating units in cooperation with Siemens of Germany.

Through bidding of the first and second project packages, the three big domestic power groups established consortiums with GE of USA, Siemens of Germany and Mitsubishi Group of Japan respectively, laying a foundation for localization of the gas turbine generating units.

(2) Main Suppliers of Waste Heat Boilers

There are plenty of manufacturers of the waste heat boiler home and abroad, and all their products can match all models of the gas turbines. Some of the boiler manufacturers capable of providing the waste heat boilers with a bigger capacity are Hangzhou Boiler Group Co., Ltd., Wuhan Boiler Co., Ltd., Shanghai Boiler Co., Ltd., Harbin Boiler Company Limited, Dongfang Boiler Group Co., Ltd., CMI Group of Belgium, Mitsui Babcoc of Great Britain, NEA of Germany/Netherlands and etc. Currently, by acquisition of the manufacturing technology of waste heat boiler from foreign companies, several key domestic boiler manufacturers have made some achievements in the gas-steam combined cycle power plants, including Shanghai Boiler Co., Ltd. and ALSTOM (already acquired by GE)，Wuhan Boiler Co., Ltd. and Mitsubishi Group，Harbin Boiler Company Limited and Doosan Group，Hangzhou Boiler Group Co., Ltd. and NE of USA, and etc. As the waste heat boiler is a large-size heat exchanger in nature, there shall be no difficulty in the design and manufacturing of the waste heat boiler in support of the Grade F gas turbine, localization of such boiler can safely be realized.

It is noteworthy that, during bidding of the first project package of gas turbines, Hangzhou Boiler Group Co., Ltd. configured several waste heat boilers for the Grade F gas-steam combined cycle generating units of Jiangsu Zhangjiagang Gas Turbine Power Plant, Wangting Gas Turbine Power Plant and Zhejiang Banshan Gas Turbine Power Plant. The waste heat boiler used by Jiangsu Qiyeyan Gas Turbine Power Plant was produced by Foster Wheeler; the waste heat boiler used by Shanghai Chemical Industrial Park Combined Heat & Power Plant was produced by DELTAK of USA. For the second project package of gas turbine power plants, Hangzhou Boiler Group Co., Ltd. was also awarded several orders for the waste heat boiler. In addition, several other domestic manufacturers produce the waste heat boiler of the said grade in cooperation with well-known foreign companies. Currently, by acquisition of the manufacturing technology of waste heat boiler from foreign companies, several key domestic boiler manufacturers have made some achievements in the gas-steam combined cycle power plants, including Shanghai Boiler Co., Ltd. and ALSTOM，Wuhan Boiler Co., Ltd. and Mitsubishi Group，Harbin Boiler Company Limited and Doosan Group，Hangzhou Boiler Group Co., Ltd. and NE of USA, and etc.

In view of the above analysis, the waste heat boiler in support of the Grade F gas turbine can be localized, or, it can be manufactured by a domestic manufacturer by technology introduction.

For the project in question, it is recommended to purchase the waste heat boiler in support of the Grade F gas turbine from the domestic market.

(3) Main Suppliers of Steam Turbines

The steam turbine in a combined cycle is not the same as the one used in a conventional power plant. The gas turbine is an approved product, with relatively definite exhaust parameters. Yet, the design parameters and structure of a waste heat boiler must be in consistency with the steam turbine generating unit. At the same time, the waste heat boiler has to be restricted by the combination of design modules of the steam turbine manufacturer. This is why configuration of a gas turbine-steam combined cycle generating unit is so complicated. In addition, in a combined cycle power plant, the feed water heating system is cancelled from the thermal system. So the steam inlet parameters are different from what is given in the standard of the conventional steam turbine. The domestic manufacturers of large steam turbines have introduced the advanced technology from abroad and can conduct a design of module combination. Their ability in the design and manufacturing of the steam turbine has reached a certain level. Whether the module combination steam turbine applies to the project in question shall be identified during equipment bidding.

Normally, the steam turbine in a combined cycle shall be supplied in a package by the manufacturer of the gas turbine in order to ensure that its performance can meet the related standard. The steam turbine for the project in question can be purchased in this way.

5.3.2 Preliminary Model Selection of Major Equipment

(1) GE of USA

GE is successful in developing the 9F.05 gas turbine along with many advanced technologies, namely:

● The gas inlet temperature is increased to 1288℃. The material is changed. Blade cooling and combustion elements as well as the design of the mechanical part are improved, resulting in an improvement of the power output, efficiency and reliability. The reliability is 98.9% and availability is 96.3%. Before the Grade F generating unit was put into operation, its prototype was thoroughly and completely tested in the manufacturer's and the construction site of the power plant. The gas turbine will be dispatched after being assembled in a package.

● It is driven from the cold end, making it more suitable for the arrangement of combined cycle.

● The rotor is connected with dual bearing and multiple pull rods. The rotor bearing of the generating unit is supported by 2 end bearings, resulting in improved operating conditions for the bearing.

● The compression ratio of the air compressor is 15. The higher the compression ratio, the higher the efficiency of the gas turbine. GE improves the efficiency of the gas turbine by increasing the temperature of the combustion chamber instead of regulating the compression ratio, which is not a chief measure.

● The low NOX staged burner is adopted, with 5 jet nozzles in each of the combustion jet nozzles. Such a structure results in a homogeneous combustion, and the NOX discharge is just 25-9ppm.

● The combustion chamber is in a cannular structure with multiple cylinders and can take the combustible natural gas and light oil as the fuel. Each burner has one combustion chamber. It is high in reliability and easy for maintenance. There is no need to open the ring-shaped combustion chamber.

● The auxiliary turbine will be pre-assembled, and the compressor is equipped with a on-load washing device.

● The exhaust temperature is increased to over 600℃, making it possible for the waste heat boiler to reach the parameters of high temperature and high pressure.

(2) Siemens of Germany

The 4000F gas turbine developed and manufactured by Siemens of Germany is marked with the following technical characteristics:

● The rotor with the dual bearing instead of the medium span bearing is adopted.

● The rotor is in a structure of rotary plate, with just one center bolt. The rotary plate is calibrated with the radial tooth. Effective transfer of the torque is also completed by the radial tooth.

● NO_X is reduced by lowering the temperature of the combustion area, such as by spraying water. Yet, efficiency will be reduced at the same time. So the water sprayed will be changed into steam or inert gases.

● The guide vanes are arranged at the intake of the compressor so that surge of the rotor can be prevented and the flow rate can be regulated.

● The blades of the gas turbine are grouped into 4 levels. The enthalpy drop is big and efficiency is high. The blades are covered with a 0.2mm-thick heat insulation coating of ceramic membrane, which can reduce the temperature of the metal surface of the blades by 80℃.

● The dual fuel of the combustible natural gas and light oil can be used.

● The gas turbine is driven from its cold end. With an axial exhaust.

● The light rotor is used, with a small thermal stress, so that a quick start-up can be realized.

The following improvements have been made to the SGT5-4000F (4) gas turbine technology:

Redesign of Level 1 and Level 2 of the compressor to increase the mass flow rate and further increase the power output of the gas turbine;

Modification to the 4th stage movable vanes of the turbine to improve the turbine exhaust;

Control of the hydraulic gap to reduce the gap loss;

Reduction of the minimum continuous operating load to 42%~46%;

Replacement of the hollow shaft with three rotary plates to reduce the thermal inertia of the shaft and the purchase and supply time as well.

(3) Mitsubishi Group of Japan

In developing the large gas turbine technology, Mitsubishi Group of Japan aims at expanding the capacity of a single generating unit, raising up the inlet temperature of the gas turbine, increasing the efficiency and reducing the NOX discharge. Its new technology is marked with the following characteristics:

● Improvements to the cooling structure and cooling ways of the blades for an increase in the cooling effect.

● Adoption of twisted blades designed with the triaxiality flow theory for a reduction in the flow loss.

● Adoption of the high temperature resistant alloy material for the blades; application of a ceramic alloy insulation coating (TBC) on the blades.

● Adoption of the advanced compressor blades and a reasonable configuration to improve the efficiency and operating reliability of the compressor.

● Improvements of the manufacturing process of the blades; adoption of the oriented crystallization casting technique for an improvement of the mechanical performance of the material.

● Improvements of the burner structure; adoption of premixed combustion to reduce the temperature of the flames; cooling down the wall of the flame tube with steam for a reduction in the formation of NOX. The burners are arranged in a ring around the gas turbine.

● The rotor is in a structure of multiple pull rods connected with the rotary plate. The combined rotor for the compressor and gas turbine is supported by two bearings.

The following improvements have been made to the M701F4 gas turbine technology:

Adoption of the mature design of the G model gas turbine for the first six levels of the compressor to increase the inlet flow rate for the compressor and further increase the power output of the gas turbine;

Adoption of the acoustic lining for the G type gas turbine to restrain the noise of the burner;

Adoption of long blades at the 4th stage of the turbine to reduce the residual speed loss;

Outshape optimization to the exhaust divergent section.

The combined cycle efficiency can reach 59.5%.

(4) ALSTOM

Being in the standardized design of the traditional generating unit, the GT26 gas turbine developed and manufactured by ALSTOM is marked with the following technical characteristics:

● Welded rotor with the dual bearing.

● Two ring-shaped combustion chambers, one in the front and the other at the rear, for a twice combustion in succession. The dual fuel of the combustible natural gas and light oil can be used.

● A high compression ratio of 30 for the compressor, which requires the natural gas at a pressure of 45bar. The higher the compression ratio, the higher the efficiency for the gas turbine.

● Arrangement at the cold end of the generator, with no effect of the heat from the exhaust of the gas turbine.

Currently, GE has completed acquisitions of ALSTOM, yet, the gas turbine module is transferred to Ansaldo of Italy. In China, Shanghai Electric Group has established cooperation with Ansaldo by acquiring 40% of its stocks. Therefore, no comparison will be made in this report to the GT26 model. Instead, the AE94.3A Grade F gas turbine manufactured by Ansaldo & Shanghai Electric will be analyzed.

(5) Ansaldo

The AE94.3A large gas turbine manufactured by Ansaldo is marked with the following technical characteristics:

● Arrangement of variable entry guide vanes for the compressor in two levels to reduce discharge, regulate the flow rate and improve the efficiency under partial loads;

● Rotor displacement optimization system, to increase the power output by reducing the clearance at the tips of the blades of the turbine;

● Welded rotor with the dual bearing.

● Modified design of the intermediate shaft. Adoption of high-strength materials for the pull rods and rotary plate. Increase in the power limitation for the gas turbine at the low temperature.

● Ring-shaped combustion chamber, with ceramic insulation tiles. The dual fuel of the combustible natural gas and light oil can be used.

The combined cycle efficiency can reach 59%.

The technical performance of the gas turbine in the above models is summarized in Table 5.3-1.

Table 5.3-1 Performance Comparison of Gas Turbine Generating Unit under the rated conditions (15℃, 1.015bar, relative humidity of 60%)

Model No. / Item	9F.05	4000F	701F4	AE94.3A
Gas Turbine Rated Power (MW)	297.1	287.8	312	310
Rotating Speed (rpm)	3000	3000	3000	3000
Compressor Level	18	17	17	15
Compression Ratio	16.5:1	17:1	18:1	20:1
Gas Turbine Intake Pressure (bar)	30-34.4	26.5-34	28-46	33
Combustion Chamber Type	Multi-cylindering a cannular arrangement.	Mixed type in a ring arrangement.	Multi-cylindering a cannular arrangement.	Combustion chamber in a ring arrangement.
Fuel	Natural gas; light oil	Natural gas; light oil	Natural gas; light oil	Natural gas; light oil
Burner Qty	18	24	20	24
Thermal Loss (kJ/kw.h)	9680/9500	9075	9160	～9000
Burner Outlet Temp. ℃	1370	1310	1427	1260
Rotor Connection & Support	Multiple pull rods and dual bearing.	Single bolt in the center and dual bearing.	Multiple pull rods and dual bearing.	Center pull rod structure.
Gas Turbine Type	Impulse		Reaction	Reaction
Generator Arrangement	At the end of the shaft.	In the middle of the shaft.	At the end of the shaft.	In the middle of the shaft.

Item \ Model No.	9F.05	4000F	701F4	AE94.3A
Gas Turbine Stages	3	4	4	4
Exhaust Flow Rate (kg/s)	663	686.4	726	750
Exhaust Temp. (℃)	599.7	582.3	597	576
NOx Discharge Volume (mg/Nm^3)	50	50	50	50

5.3.3 Waste Heat Boiler

As the exhaust temperature of the gas turbine is relatively lower (than that of the coal fired boiler), it is not practical to recover heat by radiative transfer. Instead, heat is mainly transferred by convection.

Water circulation in the boiler is revealed in two forms, i.e. the natural circulation under the circulating force caused by the fluid density difference in the water circulation system and the forced circulation caused by the forced circulation pump of the boiler.

The boilers can be divided into the horizontal type and vertical type as per the flow direction of the exhaust. For the horizontal boiler, the heat transfer tube is arranged vertically and the air flows horizontally. For the vertical boiler, the heat transfer tube is arranged horizontally and the air flows vertically.

As per the water-steam system, the pressure of the steam produced by the waste heat boiler can be divided into five types, i.e. single pressure with no reheating circulation, dual pressure with no reheating circulation, dual pressure with reheating circulation, triple pressure with no reheating circulation, and triple pressure with reheating circulation.

For the Grade F gas turbine, both the exhaust temperature and flow rate are relatively high. In order to achieve a higher efficiency, the steam with a multiple pressure will be adopted in an optimized thermal system. In addition, with increase in the efficiency and capacity of the gas turbine, the waste heat boiler without an integral deaerator is gradually replaced by the one with an integral deaerator. The waste heat boiler with an integral deaerator can reduce the overall size of the body of the boiler in structure.

Table 5.3-2 Comparison of Horizontal & Vertical Waste Heat Boilers

	Horizontal Waste Heat Boiler	Vertical Waste Heat Boiler
1) Operational Flexibility & Reliability	In a suspension structure, the heating surface can expand freely. It is relatively slow to start up under natural circulation. Yet the system is simple with a high reliability. The exhaust of the gas turbine goes into the waste heat boiler directly through the diffusion tube. No flue tube elbow is needed.	The heating surface is in a suspension structure so that the heating elements can expand freely in all directions, and the thermal stress following quick changes of loads can be avoided. Both the heating water tube and steam drum are small in diameter, and the volume of the boiler water is small, thus reducing the thermal inertia of the boiler. The wall of the boiler is thin, and the thermal inertia of the boiler is small.
2) Inspection & Maintenance	The heat exchanger can be composed of modules. The heating water tube is arranged vertically, yet it is easier for the dust and dirt to be collected on the horizontally arranged fins.	The heat exchanger can be composed of modules. In between the modules there are manholes for an easy inspection. It is convenient to replace the tube on the heating surface.
3) Construction Cycle	The heating surface and boiler cradle form into a module. To make construction easier, the deaerator can be placed on top of the waste heat boiler as a LP steam drum.	Completion of the heat exchange module at the manufacturer's can guarantee its quality, make site construction easier and reduce the construction period as a result. The deaerator needs to be supported separately.
4) Floor Area	All the heating surfaces are arranged horizontally in parallel, covering a large floor area.	The heating surfaces are arranged vertically in stack, covering a small floor area.
5) Investment	Relatively cheaper.	Relatively more expensive.

In normal cases, the waste heat boiler shall be collocated by the manufacturer of the gas turbine or selected in a package as per the requirements of the specific project. The above analysis and the conditions of the project in question require a waste heat boiler with the steam at a triple pressure. Normally, a triple pressure boiler enjoys a better economy than a single pressure boiler. Therefore, the triple pressure reheating waste heat boiler with a natural circulation is recommended for the project in question. The steam turbine to be selected shall also be taken into consideration in the design and selection of the waste heat boiler.

Table 5.3-3 Comparison of Parameters of Waste Heat Boiler under the rated conditions (15℃, 1.015bar, relative humidity of 60%)

Associated Gas Turbine	4000F	9F.05	M701F4	AE94.3A
HP Steam Pressure, MPa	13.05	13	13.09	13.75
HP Steam Temp. ℃	566	565	566	555
HP Steam Flow Rate, t/h	282.5	342.89	290.8	297.6
Reheating Steam Pressure, MPa	3.3	3.3	3.72	3.21
Reheating Steam Temp. ℃	566	565	566	545
Reheating Steam Flow Rate, t/h	330.4	372.33	348	330
LP Steam Pressure, MPa	0.338	0.466	0.503	0.517
LP Steam Temp. ℃	292	319.45	238.6	235.4
LP Steam Flow Rate, t/h	50.2	38.37	51.7	51.6
Exhaust Temp. ℃	92	86	86.3	87.9

5.3.4 Steam Turbine

The steam turbine involved in combined cycle power generation is the same as the one used in a conventional power plant in its operating principle and similar in structure. Yet, it (i.e. the steam turbine in a combined cycle purely for power generation) differs from the normal steam turbine in the following aspects:

(1) Turbine Operating under Full Variable Pressure

In order to make a maximum use of the energy in the exhaust, the steam turbine involved in a combined cycle will operate under the full variable pressure, which will lead to a full-arc admission of steam. In normal operation, the steam regulating valve is at the Full Open state, and the load is controlled by the feeding quantity of fuel into the steam turbine.

(2) No Regenerative Steam Extraction

No feed water heater will be arranged for the steam turbine involved in a combined cycle, for a temperature rise of the feed water will result in an increase in the exhaust gas temperature, making the waste heat recovery efficiency reduced and thermal efficiency failed to be improved. Therefore, circulation of the steam turbine is normally one without regenerative steam extraction. The steam turbine discharges more exhaust gas than the one used in a conventional power plant

(3) There are three ways of exhaust for the steam turbine, i.e. axial exhaust, side exhaust and bottom exhaust.

(4) Under the premise that efficiency shall be affected as little as possible, try to increase the clearance between the static component and dynamic one so as to prevent the possible friction between the components caused by their unsynchronized expansion during a quick start-up.

(5)The requirement of a quick start-up can be satisfied.

5.3.5 DeNOX System & Equipment Selection

Reduction of NO_X in the exhaust shall be realized from two aspects. On one hand, the technology of low NO_X combustion, for example, a low NO_X burner, shall be adopted in order to reduce the quantity of NO_X formed in the process of combustion. On the other hand, treatment shall be conducted to the NO_X already formed so as to further lower its content to meet the emission standard. The content of NO_X can be kept at about 50 mg/m^3 or even lower. The planned area for the project in question is in Pakistan. According to the local environmental protection requirements, $DeNO_X$ treatment to the exhaust of the generating unit won‘t be included in the documents, and the $DeNO_X$ device won‘t be planned behind the high pressure evaporator of the waste heat boiler.

5.3.6 Main Technical Performance of Generating Unit

In order to ensure a safety reliability and flexible regulation for the project in question, a multi-shaft type of generating unit shall be configured for the combined cycle power generation. The performance parameters of the gas-steam combined cycle composed of the GE 9F.05 gas turbine are summarized in the following table.

Table 5.3-4 List of Performance Parameters

Model No. of Gas Turbine	9F.05
Total Power Output of the Combined Cycle Generating Unit, kW	458644
Hourly Natural Gas Consumption Nm^3 (with SSGC natural gas in its best quality)	73962
Hourly Natural Gas Consumption Nm^3 (with SSGC natural gas in its worst quality)	93697
Yearly Natural Gas Consumption MNm^3 (with SSGC natural gas in its best quality)	517.74
Yearly Natural Gas Consumption MNm^3 (with SSGC natural gas in its worst quality)	655.88
Hourly Natural Gas Consumption Nm^3 (with RLNG natural gas in its best quality)	64997
Hourly Natural Gas Consumption Nm^3 (with RLNG natural gas in its worst quality)	90295
Yearly Natural Gas Consumption MNm^3 (with RLNG natural gas in its best quality)	454.98
Yearly Natural Gas Consumption MNm^3 (with RLNG natural gas in its worst quality)	631.92
Yearly Power Generation Gwh	3214.18
Yearly Thermal Efficiency of Power Plant %	59.5
Yearly Avg. Natural Gas Consumption for Power Generation Nm^3/kWh (with SSGC natural gas in its best quality)	0. 162
Yearly Avg. Natural Gas Consumption for Power Generation Nm^3/kWh (with SSGC natural gas in its worst quality)	0. 204
Yearly Avg. Natural Gas Consumption for Power Generation Nm^3/kWh (with RLNG natural gas in its best quality)	0. 142
Yearly Avg. Natural Gas Consumption for Power Generation Nm^3/kWh (with RLNG natural gas in its worst quality)	0.197

Notes: (1) The yearly operation hours will be taken as 7000 hours.

(2) The efficiency of the waste heat boiler is considered as 90%.

(3) The data in the above table are the result of theoretical calculation and are provided simple for reference. The exact values shall be calculated as per the heat balance diagram later on.

5.4 Fuel Supply System

5.4.1 Fuel System

The fuel system extends from the natural gas intake at the battery limit of the power plant to the intake on the gas turbine, and the major equipment in the system includes the natural gas boost station, pressure regulating station, natural gas front module in front of the gas turbine and etc. SSGC pipeline connection location will be designed by calculation base on the pressure and diameter of existing pipeline of BQPS-I.

The function of the boost station and pressure regulating station is to regulate the pressure of the natural gas from the Natural Gas Pipeline Network and keep it in the range of the inlet pressure accepted by the gas turbine. It shall be kept stable as well, for it fluctuates with the natural gas consumption along the pipeline. Therefore, a pressure regulating station shall be arranged in the plant area so that the natural gas going into the gas turbine will be kept at a stable pressure.

The pressure at SSGC natural gas source for the project in question is rather low(about 1.8 bar to 4.5 bar), and the boost station is to increase the pressure of the natural gas from the Natural Gas Pipeline Network to the level accepted by the gas turbine. The pressure regulator is a major equipment at the boost station. In addition, there are many other auxiliary devices, such as the heater, filter, flow meter and etc. As there is moisture or impurities in the natural gas, the dewatering equipment and blowdown tank are required. The boost station shall be equipped with safety protection devices, such as the safety valve, natural gas shutoff valve, purging equipment and etc. At the outlet of the pressure regulator, a safety valve shall be arranged to prevent possible damages to the equipment and instruments in case the regulator fails or the pressure of the pipeline increases too high following sudden reduction of natural gas consumption by the gas turbine. The safety valve shall be installed on the emptying tube. It opens when the pressure of the gas in the tube exceeds the maximum allowable value, and the gas will be emptied into the atmosphere. When the pressure of the gas in the tube comes back to the allowable value, the safety valve will automatically reset. A continuous supply of the natural gas to the gas turbine will not be affected whether the safety valve is open or closed.

For the project in question, a set of boost station and a set of pressure regulating station will be arranged for two gas turbines. The pressure regulating station will be equipped with two main pressure regulating pipelines, on which the main and auxiliary pressure regulators, emergency shutoff valve and isolation valve will be installed. Accompanied by a bypass pressure regulating pipeline with the same capacity, each main pressure regulating pipeline will correspond to a gas turbine. The two main pipelines will not serve as a standby for each other. Each pressure regulating station will be equipped with two filters of 100% capacity and dewatering equipment, with one in operation and the other standby. And Flow meter, Gas Chromatograph and Gas Heater are in the gas treatment station.

All flow metering instruments are integrated into a module installed in the fuel system. When the flow rate is higher than 20%, the accuracy of the flowmeter can reach more than 99.5%. Flow signals will also be transmitted to the central control room.

The boost station and pressure regulating station can be arranged in three ways: outdoor arrangement; semi-outdoor arrangement with a rain hood; indoor arrangement. The valves at the pressure regulating station will be in frequent operation, resulting in a certain gas leakage. And reduction of pressure will give out a relatively low noise. So the indoor arrangement is not acceptable. Neither is the outdoor arrangement suitable for the equipment, such as the valve and instruments, will become corroded under the influence of the weather, thus it will not be recommended. In the semi-outdoor arrangement, a rain hood will be added against the rain. It also helps to prevent the spread of noise. Therefore, the semi-outdoor arrangement with a rain hood is recommended for the project in question.

5.5 Thermal System & Flue Gas Circulation System

The thermal system is composed of the waste heat boiler, deaerator, water feed pump, steam turbine, condenser, condensate pump and related pipelines. The steam circulates in the conventional water-steam circulation system. The waste heat boiler produces steam with the high temperature exhaust out of the gas turbine and then send it to the steam turbine. The steam will then, after expansion and work, be discharged into the condenser. The condensate will be sent by the condensate pump to the water feed pump through the shaft seal heater, and finally sent by the water feed pump to the coal economizer of the waste heat boiler.

(1) Main Steam System & Bypass System

The project in question decides on the Grade F gas-steam combined cycle generating unit, and a triple pressure reheating system will be selected for steam circulation.

The HP steam will be directed from the outlet header of the HP superheater in the waste heat boiler to the main inlet throttle-stop valve and main inlet control valve of the steam turbine, and finally goes into the steam turbine.

The MP steam will be directed from the outlet header of the MP superheater in the waste heat boiler to the reheat stop interceptor valve of the steam turbine.

The LP steam will be directed from the outlet header of the LP superheater in the waste heat boiler to the LP combined valve of the steam turbine.

For the HP/MP/LP steam, 100% HP/MP/LP bypass systems will be arranged. The HP bypass will be connected into the low-temperature reheating system through a temperature and pressure reducer, while the MP/LP bypass systems will be connected into the condenser through an energy dissipation device. The bypass systems help to match the steam parameters of the waste heat boiler to the metal temperature of the steam turbine, so that the start-up/shutdown requirements of the gas turbine power plant can be satisfied. Under the emergency conditions, they can also offer protection to the steam turbine.

(2) Condensate System

The condensate will come from the hot well of the condenser. It will go from the condensate pump to the condensate preheater of the waste heat boiler through the shaft seal condenser, and finally to the deaerator.

The shaft seal condenser will be kept in a state of micro-vacuum with the help of the shaft seal extraction fan so that no steam will leak into the atmosphere or the lubricating oil system of the steam engine. In order to maintain the state of micro-vacuum, there shall be sufficient condensate flowing through the shaft seal condenser. In this way, the possible steam leakage on the shaft can be condensed. The condensate system is arranged with the recycling tube with the minimum flow. The condensate pipe from the outlet of the shaft seal condenser will go back to the condenser through the minimum flow recycling valve. Such an arrangement can ensure the operation of the condensate pump with the minimum flow at start-up and with low load. Meanwhile, sufficient condensate flowing through the shaft seal condenser can also be ensured at start-up and with low load. Water makeup to the hot well of the condenser will come directly from the demineralized water tank. A regulating valve will be installed on the makeup pipe so that the rate of water makeup can be kept under control.

(3) Systems Related with Deaerator

The steam to heat the deaerator comes from the LP steam drum of the waste heat boiler. When the generating unit starts, in order to reduce the start-up time, the deaerator can be heated up with the auxiliary steam. The deaerator can operate with a sliding pressure. As the flow rate cannot be regulated at the source of the heating steam, when the ambient temperature is high and the load is low, there will be an excess of the heating steam for the deaerator, making the pressure on the deaerator increase. Therefore, an excess steam pipe will be directed from the deaerator to the condenser so that the quantity of the steam can be controlled as per the pressure on the deaerator increases.

The generating unit will be equipped with one waste heat boiler integrated with one deaerator. One waste heat boiler is integrated with one deaerator. The deaerated water tank shall be big enough to hold the quantity of feed water that is consumed by the waste heat boiler in 5 – 10 minutes continuously at the maximum evaporation rate.

The feed water system will be equipped with 2×100% HP feed water pump, MP feed water pump and LP feed water pump, sending the feed water tie the HP, MP and LP coal economizers of the waste heat boiler respectively. On the outlet pipe of each pump, the self-regulating recirculation valve will be installed to satisfy start-up or to send the redundant water back to the deaerator. Such an arrangement helps to keep the balance of steam production and water supply.

(4) Auxiliary Steam System

the two sets of generating units will serve as the standby for each other. The auxiliary steam will be used as the steam for start-up and for shaft seal of the steam turbine. It will be used for deoxygenation by the deaerator.

(5) Flue Gas System

In this project, the gas turbine inlet device is tentatively toward the East side.The flue gas system of the generating unit is composed of the gas turbine and waste heat boiler.

Air comes in from the inlet device of the gas turbine. According to the local climate and air quality, OME will choose the suitable equipment and filtration system, In general, it is use air filter screen and conical combined filter to clean the air. After being filtered and compressed, it gets mixed up with the fuel and then enters into the combustion chamber of the gas turbine, producing the high temperature flue gas. The flue gas works and is then sent to the waste heat boiler, where it exchanges heat with the working medium before finally being discharged into the atmosphere through the main chimney.

The gas circulation system is mainly composed of the gas turbine and auxiliary equipment. It has two parts, i.e. the air part and flue gas part. The major equipment in the system includes the air strainer, silencer, air intake, body of the turbine and high temperature flue gas discharge passageway.

The thermal process is indicated in the below: air strainer → silencer → air intake → compressor → burner → high temperature flue gas passage → power turbine → diffusion section of the waste heat boiler → water-steam heating surfaces → silencer at the rear → chimney → atmosphere.

As per the requirements of the project in question, operation of one gas turbine must be ensured. So a flue gas bypass system needs to be arranged. Before construction of the waste heat boiler and steam turbine, the flue gas can be discharged into the atmosphere through the bypass. In this way, simple circulation can be implemented successfully.

5.6 Electrical

5.6.1 Generator transformer unit

In this stage, two fuel-steam combined cycle units are constructed and commencement of production is considered in different stages. Two gas turbine generators and two condensing engine generators are connected to the low voltage side of unit step-up transformer(UT) via continuous isolated phase bus. Generator circuit breaker(GCB) will be equipped at outgoing of the gas turbine generator(GTG).

The gas turbine generator adopts full-hydrogen or water-hydrogen-hydrogen cooling. The rated power is temporarily determined as 300MW and the rated power factor is 0.85. The static excitation is adopted.

The steam turbine generator(STG) adopts air cooling. The rated power is temporarily determined as 150MW and the rated power factor is 0.85, self powered and static excitation.

Generator parameters shall be defined after bid for main equipment is invited.

5.6.2 220kV system in plant

A new 220kV GIS substation will be built. 4 generators will be connected to the new 220kV substation via four unit step-up transformers. The new GIS bus bar is consider being double bus with two bus section CBs and two bus coupler CBs. The original 4 outgoing overhead lines in BQPS-1 GIS will be used as the outgoing lines of the new GIS. For incoming lines, there will be 2(two) 9F gas turbine unit step-up transformers、2(two) 9F steam turbine unit step-up transformers、1(one) new middle-voltage standby transformer、 G1、G2、G5、G6 unit step-up transformers and startup transformers. 2 short link lines of BQPS-1 GIS，connected to BQPS-2 GIS, will be transferred to the new GIS, and two series reactors will be set between new GIS switchyard and BQPS-2 GIS switchyard.

U1, U2, U5 and U6 control and protection scheme with shifting of relay/control room will be retained. It is not contain in this project scope. But the whole new 220kV substation will be monitor in the new Network control building.

According to the power system interconnection scheme, in the first half year of 2018, two short link lines (with series reactors) and one outgoing line to ICI in BQPS-1 GIS will be transferred to the new GIS, meanwhile there will be another short line between the new GIS and BQPS-1 GIS. Then the first 9F generator (300MW) with open cycle operation will be connected to the new GIS. Unit-3 and unit -4 will remain in operation.

In the last half year of 2018, the first 9F generators (300+150MW) with combined cycle will be connected to the new GIS and unit-4 will be considered to decommission.

In 2019, the remaining generators and outgoing lines in BQPS-1 GIS will be transferred to the new GIS one by one. And after unit-3 decommission, the second 9F generators (300+150MW) with combined cycle will be connected to the new GIS.

All incoming lines of the new GIS will use 220kV cable. 4 outgoing lines will be connected to the overhead lines in BQPS-1 GIS using 220kV cable.

New power cables for U1, U2, U5 & U6 of the existing BQPS-1 when shifting from the old GIS to new GIS will be considered. New 220 kV substation tunnels from old GIS gantry to new GIS substation will be considered.

The 220kV new GIS bus bar rated current is considered to be 4000A. The 220kV new GIS outgoing lines CBs rated current is considered to be 2500A, bus section CBs and bus coupler CBs rated current is considered to be 4000A. The 220kV new GIS CBs rated short circuit current is considered to be 50kA. The series reactors impedance is considered to be 10Ω, the rated current is considered to be 2500A.

Indoor GIS equipment should be installed on both sides of the installation、maintenance and inspection channel. The main channel should be 2~3m wide and close to the side of the circuit breaker. The inspection channel should not be less than 1m. Panel for local control can be either by the wall or in GIS, determined by GIS provider. 2 bays space for future use will be considered, one on either side.

5.6.3 Start/standby power supply

GCBs are equipped at outgoing of two gas turbine generators. During unit start, the plant supply can be reversibly sent via 220kV substation and unit step-up transformers. A middle-voltage standby transformer with 25MVA capacity temporarily determined is equipped and taken as the standby middle-voltage power supply in this stage. The power supply at the high-voltage side of the middle-voltage standby transformer is introduced from 220kV system of this stage. The specific plan shall be determined in next design.

According to the requirements of KE company, the project should be considered black start mode, it will be in studied in the next stage.

5.6.4 Station auxiliary power system

(1) Middle-voltage auxiliary power system

The middle-voltage plant service power supply of the unit is introduced from generator outgoing of gas turbine generator. For unit auxiliary transformers(UAT), adopt duplex winding on-load tap-changing and step-down transformer. The capacity is temporarily determined as 25MVA and two 6kV middle-voltage buses are set for each unit.

(2) Low-voltage auxiliary power system

Two 400V PC will be set for each unit, backup to each other. For two units, two common 380V PC will be set, backup to each other. They are all directly earthed with 400V neutral points;

In the auxiliary plant, original chemical water system will be used for the new 9F units and it will be powered by existing units.

Original circulating water system will be used for 9F. It will be powered by existing units temporary and after G3 and G4 shut down, its power source will be transferred to 9F.

Two 400V PC will be set in firefighting pump house to power the rest auxiliary load.

400V MCC quantities will be set as required.

(3) 400V emergency power supply

For AC emergency busbar section, adopt single busbar modular system tie lines to respectively supply AC emergency load of the unit. Diesel generator capacity is temporarily determined as 1000kW.

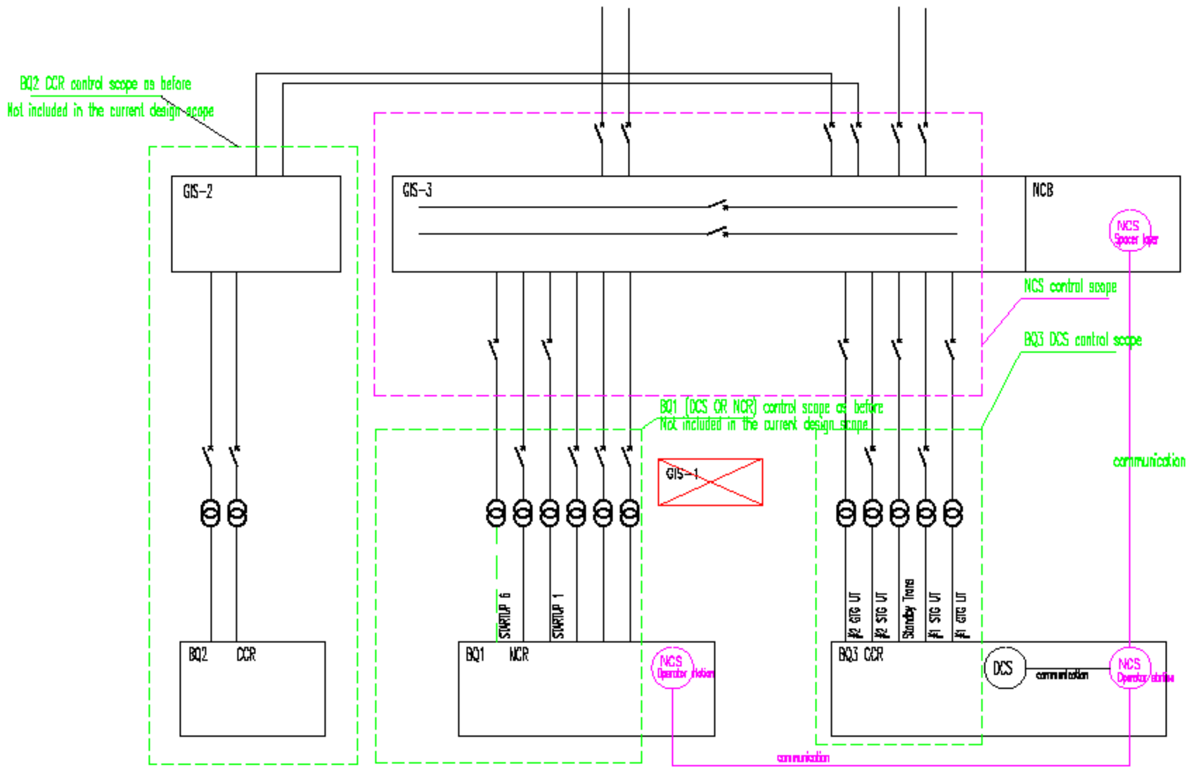
5.6.5 Control and protection

The project adopts the two-unit-control modular control room. Power generation and transformation unit, motor control signal of high/low voltage plant power source and major auxiliary engine will be monitored by DCS. Protection relays will be time synchronized with GPS.

The main control room will not equiped with a mosaic mimic panel.

220kV substation will be monitored by Network Computer Control System (NCS) at one time and then connected based on different stages. NCS bay layer and line protection, busbar protection and other equipment are arranged in 220kV Network control building constructed in this stage. The station monitor and control layer of NCS are arranged in the electric control buildings of this stage or previous plants as required.

Generator transformer units, high-voltage plant transformers and high-voltage standby transformers in this stage adopt two sets microcomputer comprehensive protection devices. For electric quantity protection, adopt doubling configuration. Non electricity protection using a single set of protection. 6.6kV switchgears adopt one set microcomputer comprehensive protection devices.



The control range of detailed drawing

5.6.6 DC and UPS

Each set of unit is equipped with one set 220V valve regulated lead acid sealing battery bank and one section of 220V DC as the power supply for emergency oil pump and sealing oil pump, UPS, emergency lighting, etc.

Each set of unit is equipped with two set 110V Valve regulated lead acid sealing battery banks and two sections of 110V DC as the control power supply for unit control equipment, protection and signaling device, etc.

Each unit is equipped with a set of UPS mainly for computer supervisory control system of the unit. The normal power supply is from 380V emergency MCC.

220kV substation will be equipped with two set 110V Valve regulated lead acid sealing battery banks and two sections of 110V DC as the control power supply and one set of UPS.

Though BQ-1 unit control voltage is 220V，there will be no problem with 110V control voltage of the 220kV substation on wiring。

5.6.7 Over-voltage protection and earthing

(1) Over-voltage protection

Equip lightning rod or lightning conductor to protect direct lightning over voltage. Equip arrester to protect lightning invasion wave, lightning counterattack and induction lightning overvoltage.

(2) Earthing

The earthing system is composed of horizontal earthing body and vertical earthing body.

5.6.8 Cable and cable appliance

(1) Cable

Power, control, computer, communication and other cables are all made of copper wire cable. XLPE is selected as power cable insulation and PVC is selected as insulation of control cable.

For 220kV voltages, TR-XLPE cables will be considered.

(2) Cable facility

For cable laying mode, mainly adopt hot-dip galvanizing cable bridges to arrange pipes. For cable bridge laying in the plant, use synthetical pipe support as far as possible.

Aluminium alloy or fiber glass Cable trays and pipes are recommended for outdoor applications.

5.7 Chemistry

5.7.1 Overview of Existing Power Station

Situated at the port of Bin Qasim of Karachi, Pakistan, the BQPS1 Power Station of Pakistan has 6 sets of the 210MW oil fuel/gas EHV generating units, which were put into commercial operation in the 1980s and 1990s. The project in question is an expansion of the existing BQPS1 Power Station and plans to construct two sets of Grade F gas-steam combined cycle straight condensing units with natural gas as the fuel. The project area is planned on the south of the existing 6 generating units, right on the sea front. The generating units, once completed, will replace the #3 and #4 generating units of the existing power station.

There are 3 water treatment plants and demineralized water can be transferred to Unit 1~2,Unit 3~5 and Unit 6 separately. The treatment technology of primary demineralization and the mixed bed is adopted in the system of each water treatment plant. The system capacity used to Unit1~2 is 2×40m^3/h. Another capacity is 3×40m^3/h for Unit 3~5. The last capacity is 1×40m^3/h for Unit 6. Currently, in the existing power station, the water used in the demineralized water treatment system comes from the city tap water. A new UF and RO plant has been built in 2015. The capacity is 120 m^3/h and the product water can be transfer to every unit. But the capacity just can meet the quantity demands of 3 units. And the city tap water will be used directly for the rest units. The product water quality of demineralized water treatment system is shown in Table 5.7.1-1, 5.7.1-2.

Table 5.7.1-1 Information of demineralized water Quality of Unit 1~2

BIN QASIM THERMAL POWER STATION I

Stream # 1 Analysis & Performance Record W/T # 1,2

Date	Test in Graval Filter Ferric Chloride in ppm		Test in Anion		Test in Mix Bed		Running Hours	Reason of Exhaust	Remarks
	Inlet (3.0 ppm)	Outlet (Nil)	Silica 50 ppb	Cond. 5 to 10 µs/cm	Silica 20 ppb	Cond. 0.2 µs/sec			
1/1/2017	2.9	Nil	94	4.8	28	0.18	13.5	High Silica	R.W
1/2/2017	-	-	16	6.4	32	0.12	12	-	R.O
1/3/2017	-	-	18	8.0	26	0.16	24	-	R.O
1/4/2017	-	-	16	9.2	32	0.24	24	-	R.O
1/5/2017	-	-	86	4.6	49	0.12	20.5	High Silica	R.O
1/6/2017	2.8	Nil	16	4.8	22	0.18	24	-	R.W
1/7/2017	2.8	Traces	16	5.8	22	0.22	11.5	-	R.W
1/8/2017	-	-	18	6.6	19	0.28	24	-	R.O
1/9/2017	-	-	92	5.2	20	0.20	21	High Silica	R.O
1/10/2017	-	-	16	>12	18	0.40	1.75	High Conductivity	R.O
1/11/2017	Stand by		Stand by		Stand by		Stand by	Stand by	Stand by
1/12/2017	-	-	16	9.0	15	0.24	5.5	-	R.O
1/13/2017	-	-	16	5.4	24	0.20	24	-	R.O
1/14/2017	-	-	16	5.0	24	0.18	24	-	R.O
1/15/2017	-	-	80	4.6	35	0.16	21	High Silica	R.O
1/16/2017	-	-	18	5.2	30	0.18	24	-	R.O
1/17/2017	-	-	18	6.6	26	0.12	24	-	R.O
1/18/2017	-	-	16	6.2	26	0.14	24	-	R.O
1/19/2017	-	-	18	3.2	20	0.08	24	-	R.O
1/20/2017	-	-	16	2.8	18	0.06	24	-	R.O
1/21/2017	-	-	18	3.0	20	0.08	24	-	R.O
1/22/2017	-	-	18	4.4	17	0.16	24	-	R.O
1/23/2017	-	-	16	4.8	20	0.18	24	-	R.O
1/24/2017	-	-	16	4.8	25	0.20	24	-	R.O
1/25/2017	-	-	17	4.6	25	0.16	24	-	R.O
1/26/2017	-	-	28	3.2	25	0.08	24	-	R.O
1/27/2017	-	-	110	2.6	28	0.06	5.0	High Silica	R.O
1/28/2017	-	-	18	6.8	22	0.12	23.5	-	R.O
1/29/2017	-	-	18	4.6	25	0.18	24	-	R.O
1/30/2017	-	-	18	5.2	25	0.18	16.5	-	R.O
1/31/2017	Stand by		Stand by		Stand by		Stand by	Stand by	Stand by

Note:The RO product water is the makeup water of demineralized water treatment system.

Table 5.7.1-2 Information of demineralized water Quality of Unit 3~4

BIN QASIM THERMAL POWER STATION I

Stream # 4 Analysis & Performance Record W/T # 3,4

Location: WT - 3,4

Date	Test in Graval Filter		Test in Anion		Test in Mix Bed		Running Hours	Reason of Exhaust	Remarks
	Ferric Chloride in ppm		Silica	Cond.	Silica	Cond.			
	Inlet (3.0 ppm)	Outlet (Nil)	50 ppb	5 to 10 µs/sec	20 ppb	0.2 µs/sec			
1/1/2017	2.9	Nil	80	5.6	25	0.28	20.5	High Silica	R.W
1/2/2017	2.8	Nil	16	>10	22	0.48	21	High Conducitivity	R.W
1/3/2017	2.8	Nil	96	6.8	28	0.22	19	High Silica	R.W
1/4/2017	2.9	Nil	22	>10	28	0.46	18	High Conducitivity	R.W
1/5/2017	2.9	Nil	18	>10	16	0.50	19	High Conducitivity	R.W
1/6/2017	3.0	Traces	17	>10	16	0.56	14	High Conducitivity	R.W
1/7/2017	2.8	Nil	15	>10	14	0.28	18	High Conducitivity	R.W
1/8/2017	2.8	Nil	19	>10	17	0.44	18.5	High Conducitivity	R.W
1/9/2017	2.9	Nil	18	5.4	20	0.18	8	-	R.W
1/10/2017	2.9	Nil	65	6.2	25	0.24	17.75	High Silica	R.W
1/11/2017	3.2	<0.05	25	>10	20	0.46	18	High Conducitivity	R.W
1/12/2017	2.8	Nil	110	6.8	16	0.22	18.5	High Silica	R.W
1/13/2017	2.8	Nil	101	6.6	20	0.18	15.5	High Silica	R.W
1/14/2017	2.8	Nil	16	>10	18	0.48	17	High Conducitivity	R.W
1/15/2017	2.8	Nil	20	>10	16	0.52	15	High Conducitivity	R.W
1/16/2017	2.8	Nil	18	>10	24	0.56	18	High Conducitivity	R.W
1/17/2017	2.8	Traces	17	>10	16	0.44	5	High Conducitivity	R.W
1/18/2017	2.8	<0.05	14	5.6	15	0.20	6	-	R.W
1/19/2017	2.9	Nil	28	>10	17	0.44	13	High Conducitivity	R.W
1/20/2017	3	Nil	18	4.6	16	0.18	3	-	R.W
1/21/2017	3	Nil	30	>10	18	0.38	15	High Conductivity	R.W
1/22/2017	2.8	Traces	56	6.4	28	0.22	18	High Silica	R.W
1/23/2017	2.8	Nil	18	>10	16	0.36	19	High Conductivity	R.W
1/24/2017	2.9	Traces	17	>10	16	0.42	18	High Conductivity	R.W
1/25/2017	2.9	Nil	15	>10	20	0.48	7	High Conductivity	R.W
1/26/2017	2.8	Nil	78	6.8	16	0.28	17	High Silica	R.W

Note: The city tap water is the makeup water of demineralized water treatment system.

Conventional industrial effluents will be neutralized and discharged into the sea. Non-conventional industrial effluents will be treated up to the standard by sub-contractor and discharged to sea. There are 2 hydrogen generation plants in the existing power station. The design capacity of each plant is 6Nm^3/h. Due to age, hydrogen generation plant is operating at 50% capacity. Manual dosing method is adopted in Circulating cooling water chlorination system.

5.7.2 Source & Quality of Water

The water source for demineralized water treatment system of the project in question will be city tap water, the quality of which is shown in Table 5.7.2-1.

Table 5.7.2-1 Information of city tap water Quality

Specification	**Quality at time of Commissioning**	**Present Water Quality**
Chloride	25-45 ppm	116 ppm
Mg	20-30 ppm	131 ppm
Ca	60-100 ppm	114 ppm
T.Hardness	90-130 ppm	245 ppm
Silica	2-4.5 ppm	7.8 ppm
PH	7.9-8.3	7.9-8.0 ppm
Conductivity	Upto 400 μs/cm	873 μs/cm
TDS	200	472

5.7.3 Water-Steam Quality Standard

For the project in question, the steam will be kept at the pressure of ~13.05MPa. As required by the applicable regulations such as GB/T 12145-2016 *Quality criterion of water and steam for power plant and steam-generating equipment*, the water-steam quality shall be controlled in consistence with the requirements indicated in the following tables.

(1) In order to prevent salt collection inside the steam turbine of the generating unit, the steam shall be maintained in a quality as indicated in Table 5.7.3-1.

Table 5.7.3-1 Quality Standard of Steam

Item	Degassed cation Conductivity (25℃,μS/cm)	SiO_2 (μg/kg)	Fe (μg/kg)	Cu (μg/kg)	Na (μg/kg)
Standard Value	≤0.15	≤15	≤15	≤3	≤5
Expected Value	—	≤10	≤10	≤2	≤2

(2) In order to reduce corrosion and scale formation at the evaporation section of the generating unit and ensure the steam quality, the feed water of the boiler shall be maintained in a quality as indicated in Table 5.7.3-2.

Table 5.7.3-2 Quality Standard of Boiler Feed Water

Item	Cation Conductivity (25℃,μS/cm)	SiO_2 (μg/L)	Fe (μg/L)	Cu (μg/L)	DO (μg/L)		TOCi (μg/L)
					AVT(R)	AVT(O)	
Standard Value	≤0.30	The SiO_2 of steam shall meet the related standard.	≤20	≤5	≤7	≤10	≤500
Expected Value	—		—	—			

Note: Due to feed water system of the project in question without copper alloys, AVT(O) will be adopted.

(3) In order to prevent corrosion in the water-steam system, regulation shall be conducted to the feed water, and the data controlled by regulation shall be in consistence with those indicated in Table 5.7.3-3.

Table 5.7.3-3 N_2H_4 Concentration & pH Value of Boiler Feed Water

pH Value (25℃)		N_2H_4(μg/L)	
Feed water system with Copper	Feed water system without Copper	AVT(R)	AVT(O)
8.8～9.3	9.2～9.6	≤30	—

Note: Due to feed water system of the project in question without copper alloys, AVT(O) will be adopted.

(4) The condensate shall be maintained in a quality as indicated in Table 5.7.3-4.

Table 5.7.3-4 Quality Standard of Condensate

Item	Cation Conductivity (25℃,μS/cm)	Na (μg/L)	DO (μg/L)	Hardness (μmol/L)
Control Value	≤0.30	—	≤40	≈0

(5) The boiler water shall be maintained in a quality as indicated in Table 5.7.3-5.

Table 5.7.3-5 Quality Standard of Boiler Water

Item	Conductivity (25℃,μS/cm)	SiO_2 (mg/L)	Phosphate Radical (mg/L)	Chloridion (mg/L)	pH (25℃)
Standard Value	<20	≤0.45[a]	≤3[b]	≤1.5	9.0-9.7
Expected Value					9.3-9.7
a The control value will be relaxed properly if there is a set of cleaning device in the steam drum. The SiO_2 of boiler water shall be controlled in order to guarantee the SiO_2 of steam shall meet the related standard. b The control value of boiler water hardness is 0μmol/L.					

(6) The quality of the makeup water shall ensure that of the feed water and can be controlled in consistence with the requirements indicated in Table 5.7.3-6.

Table 5.7.3-6 Quality Standard of Makeup Water

Item	Conductivity of Water Coming into Demineralized Water Tank (25℃,μS/cm)	Conductivity of Water Outgoing from Demineralized Water Tank (25℃,μS/cm)	SiO_2(μg/L)	TOCi[a] (μg/L)
Standard Value	≤0.20	≤0.40	≤20	≤400
Expected Value	≤0.10			
a If makeup water is treated by RO, monitoring will be not necessary.				

5.7.4 Demineralized water treatment Systems

5.7.4.1 System Selection

For the project in question, the 2×450MW gas-steam turbine combined cycle straight condensing units will be constructed, with city tap water as natural gas as the fuel. The demineralized water will be supplied by the existing power station. Due to the demineralized water not treated by UF and RO, the demineralized water quality can not meet the demands of water quality for the project in question. Therefore, the treatment technology of UF,RO,primary demineralization and the mixed bed is requested to be adopted for the project in question.

Having been treated through the existing process, the demineralized water can be expected to be qualified in accordance with the following standard:

SiO_2: ≤10μg/L

Conductivity (25℃): ≤0.10 μs/cm

5.7.4.2 Power Output Calculation

For the 2×400MW gas-steam turbine combined cycle straight condensing units to be constructed for the project in question, the quantity of makeup water for the generating units will be calculated as per the GB 50660-2011 *Code for design of fossil fired power plant*. Details of the loss of water-steam over the power plant are shown in Table 5.7.4-1.

Table 5.7.4-1 Loss of Water-Steam over Power Plant

Sr. No.	Item	2×450MW
1	Loss from normal water-steam circulation (t/h) (at a rate of about 2%)	16.2
2	Loss from blowdowns (t/h) (at a rate of about 1%)	8.1
3	Normal makeup water quantity (t/h)	24.3
Note: the total amount of evaporation of the triple pressure boiler is 405 t/h.		

Taking into consideration the water demand revealed from the above table as well as such factors as maintenance and repair of the related equipment, the power output of the demineralization unit for the project in question is designed as 25 m^3/h. The generating units will replace the #3 and #4 generating units of the existing power station. The makeup water quantity of each existing unit is about 40t/h. The capacity of existing demineralized water treatment system can meet the demand of the project in question.

5.7.5 Condensate Treatment System

The content of iron is over 3000μg/L when the generating unit initially starts up, and is about 200～300 μg/L at normal start-up. It takes quite a long time to get the related requirements satisfied even after changes of the condensate and large quantity of discharge, causing a great waste of heat, demineralized water and power in the due course. What's more, the feed water with a high content of iron presents potential risks to the safe operation of the generating units. Therefore, for the project in question, in addition to strengthened protection during shutdown of the generating unit, the special equipment will be arranged to remove iron from the condensate so that the issues of excessive iron content during start-up and large quantity of discharge can be settled. Preliminarily, one iron removing filter that can cope with the maximum quantity of condensate is considered for each set of the generating units.

Please refer to F007101K-A-07 *Condensate water treatment system flow diagram* for details of the iron removing system.

5.7.5.1 Selection of Iron Removing Filter

The iron removing filter to be selected shall be equipped with the folding type mass flow filtering elements, which are characterized by a very good capacity in catching the dirt, a long operation cycle and a small differential pressure in operation.

5.7.5.2 Capacity of Iron Removing Filter

In order to meet the maximum demand of condensate treatment, each set of the generating unit will be equipped with a full capacity iron removing filter with a bypass device.

5.7.5.3 Arrangement of Iron Removing Filter

The iron removing filter will be placed near the condensate pump.

5.7.6 Chemical Dosing System & Water-Steam Sampling System

5.7.6.1 Chemical Dosing System

For the waste heat boiler-steam turbine generating unit, calibration shall be conducted to the feed water and boiler water so that the water chemistry conditions of the steam and water recycling systems can be maintained under control and the possibilities of scale formation and corrosion can be reduced to a minimum. For the project in question, a set of chemical dosing device will be arranged and shared by the two sets of generating units. The device will be placed on the zero meter floor in the plant building.

The chemical dosing system includes ammonification into the feed water and addition of phosphate into the closed circulation of cooling water and boiler water. In addition, one tank and one pump will be arranged to meet the requirement of shutdown protection to the boiler. The chemical dosing system can satisfy the dosing requirements of the gas turbine and waste heat boiler in operation, standby maintenance during shutdown of the boiler, start-up as well as those under all kinds of normal and abnormal circumstances.

5.7.6.2 Water-Steam Sampling System

In order to improve water-steam sampling and accuracy of analysis and make it convenient for centralized sampling and analysis, a unit-wise centralized water-steam sampling and analytical device will be arranged.

The centralized water-steam sampling system covers the cooling equipment, temperature and pressure reducing equipment, on-line analyzers, microprocessor-based monitoring device and manual sampling panel so that a continuous sampling and analysis of the water and steam of the thermal system can be conducted, and the water-steam system of the generating unit can be monitored as well. For the project in question, a water-steam sampling system will be arranged for each set of the generating units. The water-steam sampling systems for both generating units will be placed on the zero meter floor in the plant building.

5.7.7 Cooling Water Dosing System

The cooling water system for the project in question will be once-through type, with the seawater. In order to keep the growth and reproduction of microorganism in the circulating cooling water inside the condenser under effective control, prevent possible clog and corrosion to the cooling equipment, and ensure a certain specific heat transfer efficiency and vacuum degree of the condenser, the circulating water shall be added with bactericide. In consideration of the limited plant area and a low dosage, manual dosing method will still be adopted which is the same as the existing power station. The bactericide considered in the project in question is sodium hypochlorite, the already-made product of the same will be purchased from the market.

5.7.8 Industrial Effluent Treatment System

In consideration of demineralized water supplied by the existing power station,and non-conventional industrial effluents which is treated up to the standard by sub-contractor and discharged to sea, industrial effluent treatment system will not be new-built.

5.7.9 Generating Unit Drainage System

For the project in question, a generating unit drainage pit will be arranged at the back of the boiler between the two generating units to collect the effluents from the boiler as well as the waste water from the plant building.

5.7.10 Hydrogen Generation System

Due to age, the poor safety and reliability, and hydrogen source is unavailable near the power station, for the project in question, hydrogen supply required by the hydrogen cooling system of the generator will come from the new-built hydrogen generation system. The capacity is 2×5 Nm^3/h. The hydrogen generation and storage pressure is medium-pressure. Hydrogen which is regulated by flow and pressure devices will be sent to main building by two stainless steel pipes.

The quality of product hydrogen is as follow:

Purity： ≥99.8 %

Temperature： ≤40℃

Humidity： atmospheric pressure dewpoint≤-50℃

5.7.11 Oil Purification Treatment

For the project in question, no oil purification workshop or oil tank will be arranged. Purification of the insulating oil for the transformer will be conducted locally through filtration, and suitable oil filtration device shall be provided.

If the oil filtration device is available at the existing power station, then no such preparations will be necessary.

5.7.12 Material Selection for Condenser

For the project in question, the cooling water for the condenser will be the seawater, and the condenser shall be manufactured with seamless titanium tubes.

5.8 Instrumentation and Control

5.8.1 Modes of Unit Control

(1) At the current phase of the project, the 2 sets of gas-steam combined cycle generating units will be constructed and then put into operation in steps. Thermal automation is engineered for the 2 sets of Grade F gas-steam combined cycle generating units and will be achieved by a centralized control of the boiler, generator and power. The gas-steam combined cycle generating units are controlled with a distributed control system (DCS) at the core and the LCD and keyboard monitoring as the major control measures. The centralized control room will be equipped with a small quantity of buttons for emergency, start and shutdown so that a safe

shutdown of the generating units can be ensured in case a failure occurs in the DCS system.

(2) Based on the principles of applicability, reliability and advancement, a sequential control program will be designed for the project, with different control levels of the generating unit (automatic start-up/shutdown), function group and subgroup, and execution for a sequential control of the major auxiliary equipment and equipment in the related systems. The control system of the automatic start-up/shutdown program and sound interlock protection system will be established, so that the requirements of the fast one-click start-up/shutdown of the peaking unit (with several breakpoints) can be satisfied.

(3) Each set of the gas turbine-steam combined cycle generating units is equipped with a DCS system for a centralized control of the boiler, generator and power in the set. The gas-steam turbine control system (TCS) packaged for the turbine island is part of the control system of the combined cycle generating unit, and the DCS system shall be in consistence with the TCS of the generating unit in terms of hardware selection as much as possible.

(4) For the utility system over the whole power plant, a common DCS network will be designed and connected with the control system of each set of the gas turbine-steam combined cycle generating unit via the network bridge, so that relative independent ability can be ensured between the concerned generating unit and the common DCS network. Monitoring to the common DCS network can be conducted with both the control systems of the generating units, which are interlocking to each other so that the DCS system of just one generating unit can release effective operating instructions at any time. The utility system over the whole power plant includes the auxiliary utility system and service power system of the whole power plant, pump house of the circulating water, air compressor station, and etc.

(5) The monitoring system of the generator-transformer unit in the generating unit and that of the high/low-voltage service power supply shall be included into the DCS system.

(6) The newly designed and constructed control systems based on PLC will be provided for the natural gas pressure regulating station,hydrogen generation station , circulating water dosing systems, water-steam sampling systems..And the above-mentioned control systems will be connected to the common DCS through Ethernet communication..

5.8.2 Automation Level

(1) Each set of the gas turbine-steam combined cycle generating units is controlled by a distributed control system (DCS) based on a set of advanced microprocessors. Such a DCS system makes it possible for a centralized control of the gas-steam combined cycle generating units, and the functions of testing and inspection, control, alarming, interlocking protection, diagnosis, start-up/shutdown of the generating units, normal operation, accident management and operating instructions of the combined cycle generating units as well as the main and auxiliary equipment can be realized. With LCD and the keyboard as the major monitoring and control measures of the generating units, a small quantity of necessary buttons for emergency shutdown and start-up is arranged so that a safe shutdown of the generating units can be ensured in case a failure occurs in the DCS system. The signals are transferred between the TCS and DCS systems via hard wiring.

(2) The gas-steam turbine control system (TCS), gas-steam turbine surveillance instrument (TSI) will be supplied in a package with the steam turbine. Each set of the generating unit will be arranged with a vibration data and fault diagnosing system (TDM) for the gas-steam turbine and auxiliary equipment. Monitoring will be conducted at the DCS operator station of the generating unit.

(3) The natural gas pressure regulating station will be individually and separately controlled, with important signals sent to DCS for monitoring and control instructions from DCS received.

(4) The air compressor station will be controlled in common DCS

(5) Control of the auxiliary systems: the circulating water dosing system and water-steam sampling system are scheduled to be monitored and controlled in the control room of the demineralization system. No regular control panel will be arranged. The control system is composed of the programmable logic controller (PLC) and upper computer with such functions as data collection, treatment, display alarming, tabulation and performance calculation, and the automatic sequential control, interlocking protection and regulation of the system can be realized as well.

(6) A continuous emission monitoring system (CEMS) will be arranged for each set of the generating unit. In the data collecting device, interfaces will be left for communication with the DCS of the generating unit and environmental protection system so that remote monitoring and analysis to the total emission can be conducted.

5.8.3 Layout Arrangements of Control Building & Centralized Control Room

At the current phase of the project, the 2 sets of combined cycle generating units will be monitored and controlled in the centralized control room, and control will be conducted in a unit-wise centralized manner. The centralized control room will be situated in one side of the unit with a floor area of about $130m^2$, and the operator station of the boiler, generator and power for each set of the generating units will be placed here. In addition, the centralized control room will also be equipped with the closed-circuit TV monitoring system for the generating units and the plant area, making it convenient for the operators to learn about the operating status of the whole plant.

5.8.4 Selection of Major Control Equipment

- The gas turbine-steam combined cycle generating units, the control and monitoring of which will be conducted with the DCS control system;
- The control system of the gas turbine will be supplied in a package with the gas turbine;
- The control system, emergency tripping system, turbine surveillance instrument, vibration data and fault diagnosing system of the steam turbine will be supplied in a package with the steam turbine;
- The control systems of the hydrogen, oil and water for the generator will be supplied in a package by the manufacturer of the generator;
- Control of the bypass system will be included into the DCS system;

- Type and model selection of the major instrument and control equipment, such as the transmitter, shall be in consistence with the bidding documents.

5.8.5 Coding Principle

The KKS coding identification system will be adopted for the project.

5.8.6 Communication and security system

5.8.6.1 Private Automatic Branch Exchange

There will be one(1) set of digital program controlled exchange system with 800 lines, including power cabinets, interchangers, distribution frames, etc.

5.8.6.2 Administration LAN

A Plant Information System (PIS) will be provided. The application functions of PIS are based on real-time database, servers and a LAN over the whole plant. The LAN will communicate with DCS, so that users can monitor the real-time process data and search the history process data through each terminal PC of the LAN. Terminal PCs will be provided in offices and control rooms according to the application requirements. The LAN will be connected with Internet through a firewall.

Please refer to F007101K-A-14, Plant Information System Configuration Diagram for details.

5.8.6.3 Broadcast call system

There will be one(1) set of broadcast call sysem with 128 lines.

5.8.6.4 Closed-circuit TV security system

At the current phase of the project, a closed-circuit TV security system will be arranged. The video signals collected from each of the monitoring points will be processed, distributed and transferred to the corresponding monitor via the image broadband network. All these constitute the closed-circuit TV monitoring system for the generating unit, which will be controlled in the centralized control room.

5.9 Layout Arrangement of Power Plant Building

(1) Layout Arrangement of Gas Turbine & Waste Heat Boiler

The gas turbine can be arranged indoors or outdoors. For the project in question, in consideration of the operation and maintenance of the equipment, noise reduction and environmental protection, the gas turbine will be arranged indoors.

As the gas turbine has an axial exhaust, the waste heat boiler can be placed directly at the exhaust end of the gas turbine. The two sets of gas turbine-waste heat boilers can be arranged in parallel.

In the layout arrangements recommended by the manufacturers of the gas turbines in the models of SGT5-4000F, GE 9F.05, M701F4 and AE94.3A, the positions of the intakes are quite different. The intakes in these four models can all be arranged on the top of the generating unit, which will be placed in a lower-position arrangement; while the intake of the M701F gas turbine can also be arranged underneath the generating unit, which can be placed in an upper-position arrangement. In consideration of saving construction costs for the gas turbine building, the gas turbines selected for the project in question will all be placed in a lower-position arrangement and the air inlet will come from the top.

As recommended by the manufacturers of the gas turbines in these four models, the exhaust port will be in parallel with the axis of the gas turbine, and the bypass chimney and waste heat boiler will be placed behind the gas turbine building. There are two options for the height of the roof truss lower chord for the gas turbine building. One is in a compact arrangement. With such an arrangement, when maintenance is to be conducted after installation of the gas turbine, there is no need to lift up the roof of the gas turbine building by a travelling crane. Instead, the steel roof will be dismantled and the components of the gas turbine will be lifted up by the mobile crane for maintenance. The other option is to conduct maintenance as per the domestic practice, i.e. arranging a travelling crane inside the gas turbine building for lifting up the rotor and combustion cylinders of the gas turbine for maintenance. In the second option, the roof truss lower chord of the gas turbine building is higher than the one in the first option.

The gas turbine will be placed in a lower-position arrangement. Meanwhile, such auxiliary facilities as the electrical control center and CO_2 protection module of the gas turbine and excitation chamber of the generator will also be arranged inside the gas turbine building.

With improvements of the efficiency and capacity of the gas turbine, the waste heat boiler without an integral deaerator is gradually replaced by the one with an integral deaerator. The waste heat boiler with an integral deaerator can reduce the overall size of the body of the boiler in structure. Apart from the boiler and chimney package, some additional equipment, such as the HP/LP feed water pumps, condensate circulation pump, deaerator, intermission blowdown and continuous blowdown devices, needs to be arranged. Normally, such equipment will be supplied by the manufacturer of the boiler. Instructions can be given to the manufacturer of the boiler that the deaerator can either be placed on top of the boiler or on the top of the framework of the water pump. The HP/LP feed water pumps will be arranged on the floor beside the boiler. In order to reduce noise, the pumps will be placed indoors.

(2) Layout Arrangement of Steam Turbine Building

Among three major modules of main power houses, gas turbine exhaust shall be directly connected to the waste heat boiler. Therefore, position of heat recovery boiler room with respect to the gas turbine room is determined based on the exhaust mode of the gas turbine and fixed basically. With respect to the gas turbine plant, steam turbine room position is relatively free and it can be arranged beside the gas turbine plant or independently. In the project, there are two units. The two gas turbine workshop modules can be arranged in parallel or coaxially. The distance therebetween can be adjusted based on repair space requirements of different gas turbines.

All three types of turbines adopt axial exhaust. Gas turbine room and boiler room are in long strip distance. It is proper to arrange two units in parallel. The matched gas turbine room can be arranged transversally between two boilers to form a combined plant with the gas turbine plant. It can also be arranged longitudinally behind the boiler as an independent plant.

Layout plan I of main power house **(combined plant plan):**

In the plan, steam turbine room and gas turbine room adopt combined arrangement mode. The mainly plant 184m in length contains No.1 gas turbine room, No.1 steam turbine room, No.2 steam turbine room and No.2 gas turbine room. Generator outlets of gas turbine and steam turbine are in same direction. Waste heat boilers and chimneys are arranged behind the gas turbine room in turn.

Gas turbine plant is 52.5m*39m. Gas turbine is arranged indoors in low position. Except that the gas turbine inlet is arranged beyond the generator, all other devices are arranged over 0m ground. Lower chord elevation of plant roof truss at gas turbine is 23.5m. Plant roof elevation at the generator is about 12m. At one side of the gas turbine, there are lubrication oil module, fire supply module, hydraulic module, preposition module and gas turbine washing module. Maintenance field is left at one side of the gas turbine for local maintenance.

One crane arranged in each gas turbine room covers the area between C and D of the gas turbine room to facilitate maintenance lifting. Above the gas turbine generator, a monorail crane is arranged.

The boil room is temporarily arranged for a horizontal boiler. The boiler top elevation is about 30m and the chimney outlet elevation is 60m. In the boiler room, high and low pressure water supply pumps and condensed water recycle pump along with intermission and continuous blowdown are arranged at the boiler side. The deaerator is arranged at boiler roof based on the manufacturer's data.

The steam turbine room is arranged along transversal direction in sequence. With 100m length and 51.5m width, the gas turbine is arranged in high position. With 12m operation layer, two turbines are arranged in a large platform. On the 0m ground, there are condensate pump, vacuum pump, rubber ball recirculating pump, lubricating oil system filter, closed pump, water-water heat exchanger, etc.

Layout plan II of main power **house (independent plant plan):**

In the arrangement of an independent building, both the steam turbine building and gas turbine building will be arranged independently. The two gas turbine buildings will be placed on one side of the power plant building, and the gas turbines will be placed in a lower-position arrangement. An area for maintenance will be left between the two gas turbines. The bypass chimney and waste heat boiler will be arranged outdoors in between the steam turbine building and gas turbine building, on the axis of the gas turbine. Both steam turbine generating units will be arranged in the longitudinal direction in the steam turbine building. The center line of the steam turbine shall be perpendicular to that of the gas turbine.

The gas turbine building will be 90m long and 52.5m wide. The gas turbines will be placed in a lower-position arrangement, with the intakes on the roof above the generator. In between the two gas turbines will be the centralized control room and electrical control room.

The boiler building will temporarily arranged for the horizontal boiler. The elevation of the crown of the boiler is about 30m, and the elevation of the outlet of the chimney is 60m. In the boiler room, the HP/LP feed water pumps, condensate circulation pump, intermission blowdown and continuous blowdown devices will be arranged on one side of the boiler. All the water pumps will be arranged indoors.

The steam turbine building will be arranged separately, with the two steam turbines in the longitudinal direction and their center line perpendicular to that of the gas turbine. From east to west will be #1 Steam Turbine and #2 Steam Turbine. The steam turbine building will be 100m long and 32.5m wide, in a large platform arrangement. The operation floor has an elevation of 12m, and the elevation of the intermediate floor is 6m. The bottom floor of the steam turbine building mainly hosts the condensate pump, vacuum pump, water filter, closed water pump, closed water cooler, oil cooler, sponge ball cleaning device, hydrophobic expanding vessel and etc. The intermediate floor hosts the steam seal heater, excitation equipment, 6kV power distribution equipment and etc. One travelling crane will be arranged in the building and it will be shared by the two steam turbines. An area for maintenance will be left between the two steam turbines.

In plan I, combined building, the unit has the highest economical efficiency, the main building requires less land and volume, with a high space utilization ratio, clear functional zoning, good conditions for maintenance, and less consumption of materials. Therefore, plan I is recommended for land and investment.

5.10 Civil engineering structure

5.10.1 Major building and structure

Gas turbine house: 42.5x39x23.5 (height)m; steel-frame structures are adopted at top and independent reinforced concrete foundations or raft foundations are adopted as the foundations.

Gas turbine pedestal: reinforced concrete raft foundation.

Steam turbine house: 100x51.5x27.9 (height)m, with intensive control building included; steel-frame structures are adopted at top and independent reinforced concrete foundations or raft foundations are adopted as the foundations.

Steam turbine pedestal: reinforced concrete-frame structures are adopted at top and raft foundations are adopted as the foundations.

Waste heat boiler: process facilities are supplied by related manufacturers. Based on top process facilities, adopt reinforced concrete raft foundations or independent foundations.

For other general buildings and structures (except that steel structure is adopted for comprehensive pipe support), adopt reinforced concrete structure, reinforced concrete independent foundation or raft foundation.

Based on plant owners' requirements, concrete class of superstructures will be C40.

5.10.2 Earthquake resistant design principle

According to the seismic zoning map of Pakistan, the proposed site is located in 2B area. For 50 years beyond probability under the condition of 10%, the peak ground acceleration is 0.18 ~ 0.24 g, and 0.24g is recommended, which is corresponding Chinese seismic fortification intensity of 8 degrees（based on Chinese standards）..

Seismic fortification measures: based on building structure damage, foundation damage and earthquake damage may be serious. Based on building classification, respectively adopt different security level and earthquake fortification principle.

Structural calculation: for structural calculation, adopt mature calculation software and methods. In order to guarantee more accurate and reasonable calculation, adopt structural space for analysis and calculation based on processing arrangement.

5.10.3 Foundation treatment

For main buildings and structures of this project (GT house, GT pedestal, ST house, ST pedestal, waste heat boiler, GIS building and relay building, etc), to meet the foundation bearing capacity and subsidence control requirements, cast in situ pile whose diameter is 800mm will be used for foundation treatment. For general buildings and structures, pile or natural foundation will be used.

5.10.4 Main Hydraulic buildings

The hydraulic buildings will include the follows, but not be limited. In general, Contractor will execute all hydraulic buildings that will be necessary to build the plant according to applicable standards, job specifications, codes and rules. In the following sections some of the main items will be described, all of these use pile foundation.

(1) 800m^3 Reinforced Concrete Water Basin

There are 2 800m^3 reinforced concrete water basins for industry and fire.These two water basins are located on the east side of Hygiene generation station.

Each basin’s size is 14.8mx14.8mx4m (length×width×depth). The structure will be a reinforced concrete structure and be constructed by excavation method.

(2) Multi-function Water Pump House

The substructure size is 9×9m, 2m depth. The underground structure will be a reinforced concrete structure and be constructed by excavation method.

The superstructure size is 15x9m, height is about 7m. The superstructure will be a reinforced concrete frame structures, brick wall enclosure.

(3) Fire Pump House

The substructure size is 18×9m, 2m depth. The underground structure will be a reinforced concrete structure and be constructed by excavation method.

The superstructure size is 24x9m, height is about 7m. The superstructure will be a reinforced concrete frame structures, brick wall enclosure.

(4) Unit Drain Basin

The basin size is 10.6×10.6m, 5.8m depth. The underground structure will be a reinforced concrete structure with anti-corrosion paste with side wall of granite, and be constructed by excavation method.

(5) Circulating Water Pump House

The circulating water pump house to use the existing circulating pump house, but due to the aging pump house and the updating circulating pump, there is a need to overall detect and assess the old pump house. According to the assessment, the old pump house need to be local transformation.

5.11 Architecture

5.11.1 Individual building design

5.11.1.1 Gas turbine room and steam turbine room

Regarding fire hazard, gas turbine house and steam turbine house are classified to grade D. About the fire resistance rating, they are classified to grade II. Both are steel structures. The enclosures adopt double-layer light steel purlin system with heat preservation profiled steel sheet. The roof adopts cast-in-situ reinforced concrete roof with thermal insulation and grade II waterproof. The floor level adopts wear-resisting terrace paint or rubber flooring. Different workshops of gas turbine house and steam turbine house have no less than two emergency exits with escape stairs, touring inspection ladder, travelling work ladder and roof maintenance ladder equipped to facilitate equipment maintenance.

5.11.1.2 HRSG

Most gas turbine facilities are arranged outdoors. HRSG is the large-scale equipment. Colors of waste heat boiler, other facilities (including stack) are designed uniformly in combination with color of surrounding workshops. Platforms, access stairs, etc. therein are arranged in accordance with operation requirement on the precondition that fire fighting, safety, etc. are met.

5.11.1.3 Other production building

Different auxiliary production buildings newly constructed shall be confirmed based on data of different technology specialties. Generally speaking, reinforced concrete frame structure and cast-in-place reinforced concrete roof with insulation are adopted. Masonry enclosure, external wall surface paint, external aluminum alloy window and painted internal wall surface are adopted. The floor ground is wear-resisting terrace paint or floor tile. The doors are made of finished steel.

5.12 Water supply and drainage system

5.12.1 Overview

Existing No.1 and 2 units of original plant share a water intake pumping house and open channel. No.3~6 units share another water intake open channel and a water intake pump house. Water-supply source is the sea water nearby. This project adopts sea water once-through cooling water supply system. It is planned to take use of the facility of existing No.3 and 4 units, which include water intake open channel and pump house. Production and domestic water required in the plant shall be prepared through sea water desalination technology. The drained industrial water in the plant can be directly connected to wastewater treatment workshop of the previous plant and then drained after being processed based on the standard. The domestic wastewater shall be discharged to a septic pit and then to the sewage pipe network of previous plant and then discharged or recycled for greening after being processed based on discharge standards.

5.12.2 Quantity of circulating water

2×450MW gas turbine is expanded in the project and the circulated water quantity is as follows:

Table 5.12.2-1 Demands of recycled water

<table>
<tr><td rowspan="2">No.</td><td colspan="2" rowspan="2">Unit / Water volume m^3/h / Item</td><td colspan="2">Combined circulation of 2×450MW gas turbine</td><td rowspan="2">Remark</td></tr>
<tr><td>No.1 Gas turbine</td><td>No.1 Gas turbine</td></tr>
<tr><td>1</td><td colspan="2">Water consumption of condenser</td><td>26195</td><td>26195</td><td rowspan="4">1. Water consumption of condenser in the table is the maximal water consumption. The condensing quantity of the unit is calculated based on 403t/h temporarily.
2. Cooling rate is temporarily considered as 65 times.</td></tr>
<tr><td>2</td><td colspan="2">Consumption of open cooling water</td><td>2500</td><td>2500</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">In total</td><td>m^3/h</td><td>28695</td><td>28695</td></tr>
<tr><td>m^3/s</td><td>7.97</td><td>7.97</td></tr>
</table>

5.12.3 Chemical, industrial, domestic and other fresh water consumption

Chemical, industrial, domestic and other water consumption of circulating water system are shown in table 5.12.3-1.

Table 5.12.3-1 Consumption of chemical, industrial, domestic and other fresh water

Water Consuming Point	Quantity of Fresh Water Consumed m^3/h	Water Quality
Make-up water for steam-water system	25	Demineralized water
Industrial maintenance water	50	raw water from old plant
Domestic water	2	raw water from old plant
Miscellaneous water	3	raw water from old plant
In total	80	

It can be learned from the table above that the intake quantity of consumed fresh water in the project is $80m^3/h$ and designed fresh water consumption index is $0.03m^3/s/GW$.

5.12.4 Water supply and drainage system of circulating water

In this project, seawater is used as the water supply source. One-through cooling system will be adopted. The circulating cooling system is unit system with two circulating cooling water pumps (2×50%, Q=14347.5 m^3/h, H=16m, N=800kW, V=6000V), which is set for each unit. Based on circulating water temperature digital-analog report data of power plant established nearby, the design water temperature of cooling water is temporarily determined as 28℃ and maximal water temperature is determined as 34℃.

Circulating cooling water of the project is temporarily taken from water intake open channel, pump house and other facilities of No.3 and 4 units of the old plant. The old circulating water pump has operated for many years and the capacity is different. A new circulating water pump is considered in the project. Each unit is equipped with two circulating water pumps. Capacity of each circulating pump is considered based on maximally designed water quantity of 50% single unit.

In the project, open cycle and combined cycle shall be put operation in different stages. While operating under open cycle condition, the cooling water for gas turbine and other users shall be supplied from auxiliary cooling water pumps of No.5 and 6 of old plant. The outlet pipe of auxiliary cooling water pumps will be connected to the main CW pipe in the new plant. The auxiliary cooling water will go through the main CW pipe, and then will be connected with the pipe in the gas turbine house and other users. During the open cycle condition, the auxiliary cooling water is discharged to the water intake open channel. During the combined cycle condition, the auxiliary cooling water for the new plant will be provided by the main cooling water pumps and the auxiliary cooling water pumps of old plant will be standby.

Main and auxiliary cooling water drainage system of grade F combined cycle plant is preliminarily considered as: when the units of No.3 and 4 are shut down, cooling water of the new plant is discharged into seal pits of original No.3 and 4 units by the existing CW pipe in the main power houses. After U4 Decommission, the condenser of U4 and the butterfly valve in the inlet and outlet pipes of the condenser will be dismantled. The rest of the existing CW pipes in the turbine house will be connected by the welded steel pipe. Bypass the condenser of U4, the cooling water of the new plant will be connected to existing seal pit, and then to the drainage system. There will be a drainage pit in the turbine house. In the pit, two submerged pumps (one on duty and one standby) will be set for the drainage of the leakage of the CW pipes in the turbine house, and there will be a level gauge in the drainage pit to monitor the water level. When reaching the warning level, alarm will be issued to remind the operator to check the dangers.

5.12.5 Service & potable water system

The water quantity of service & potable water in the project is about 55m^3/h. the flow diagram for water supply is as follows:

Pipe networks of old plant →2×800 m^3 combined service and fire-fighting water basin →industrial water pump → industrial water pipe network in plant area

The structures and major equipment in raw water plant mainly contain: one composite pump house (industrial water pump, electric control room, etc.) one fire-pump room, two 800m^3 fire-fighting and industrial water basins. , which is located in the south of the plant.

5.12.6 Strom water & domestic water

Strom water will be drained to the discharge channel by the discharge ditch. Refer to the old plant treatment process, the domestic water will be drained to the septic pit and then drained to the sea.

5.13 Fire-fighting system

Considering the differences in design standards and the longer service life of the old fire-fighting system, new fire-fighting system will be built for the new plant..

(1) Design of the fire protection system is based on the codes of NFPA in combination with the actual situation of the project. The system will send out alarm signal in the early stage and can realize the concentrated, regional and local monitoring of the fire and also the remote and local control of the firefighting device, what's more, enough equipment capacity to put out the fire once a fire occurs is also equipped.

(2) Independent water supply system for firefighting is adopted. Two 800 m^3 combined service water and fire-fighting basins are considered to be designed to meet the firefighting water consumption. According to NFPA, capacity of the water tank is based on running pumps at rated capacity with all fire reals / hoses in service and deluge system for continuous 2 hours at the required operating pressure. High pressure regulation system is also equipped.

(3) An electric fire pump($Q=565m^3/h$，$H=105m$), a diesel standby fire pump ($Q=565m^3/h$，$H=105m$)and a set of fire protection equipment are set in the firefighting pump house.. According to related specifications, diesel driven fire pump and electric fire pump are set separately by the firewall.

(4) Fire pipes are annularly arranged in the plant, and indoor hydrants are equipped in the buildings. Automatic sprinkler system, water spray system and gaseous extinguishing system will be adopted for the important equipment in turbine house and so on. Gaseous extinguishing system, water spray system or Nitrogen Suppression System will be adopted in central control building. Water spray system will be adopted in transformers. Potable extinguishers or indoor hydrants will be set in the GIS buildings.

(5) According to related code, automatic fire alarm system will be set in steam turbine house, gas turbine house, central control building, transformer, oil tank and auxiliary buildings which have a fire risk. Automatic fire alarm system is composed of main monitoring panel, regional monitoring panel, local monitoring panel and remote diplopia panel, various detectors, manual alarm, alarm, cable and other equipment. When a fire occurs, fire signal is sent to the local monitoring panel, regional monitoring panel and the main monitoring panel by the detector, fire occurrence time and place can be displayed at all of the control panels, sound and light alarm signals are sent out and operation command is sent to the firefighting systems.

5.14 Heating, Ventilation and Air Conditioning

(1) As the power plant is situated in an area without central heating, no central heating system will be arranged over the plant.

(2) A central cooling station is set up in the main plant area, using water-cooled screw unit and cooling tower for cooling. Chiller, cooling tower, circulating water pump in accordance with the 3×50% configuration, the refrigeration station provides 7℃~12℃ water to the cooling air conditioning system and cooling ventilation system in the main plant area etc..

(3) The gas turbine will be arranged indoors and the waste heat boiler will be arranged in the open air. The gas turbine building is to be equipped with a ventilation system of natural air inlet

through the electric-drive blinds and mechanical exhaust by the explosion-proof roof fan, the ventilation system also is used for emergency ventilation. Exhaust from the exhaust housing, gas turbine casing and HP/MP casing will be directed outdoors. A standby exhaust fan shall be considered. The ventilation systems of the exhaust housing, gas turbine casing and HP/MP casing will be designed and supplied by the manufacturer of the related equipment. In order to prevent accumulation of hydrogen and natural gas, the natural vent cap shall be arranged at the highest point on the roof of the gas turbine building. The roof fan shall be of an explosion-proof type. Local jet fans shall be arranged at the points with possible process leakage and the dead corners of ventilation so that local accumulation of explosive gas and heat can be avoided. All the HVAC equipment placed in hazardous areas shall be of an explosion-proof type.

(4) The centralized control room and electronic equipment room shall be equipped with the centralized air conditioning system, Air conditioning equipment in accordance with the configuration of 2x100%, air-conditioning system heating source is using electric heating. The switchgear rooms and MCC rooms in the main plant building shall be equipped with the cooling and ventilation system.

(5) The other control rooms , duty rooms, laboratories, testing rooms and instrument maintenance rooms shall be equipped with the air cooled heat pump split air conditioner in accordance with the process requirements.

(6) 220kV GIS and each of the pump room and dosing room inside the power plant shall be equipped with a ventilation system.

(7) The centralized control room shall be equipped with a mechanical smoke exhaust system. Electronic equipment room and each of the electrical rooms and process rooms with hazard shall be equipped with an post-accident exhaust system.

(8) The central cooling station, and the cooling and ventilation system at the switchgear room of the main plant building and that as well as the air conditioning system at the centralized control building will be equipped with a two-level automatic monitoring system controlled by the microprocessor controller.

(9) As per the fire protection grade of the building, the fire resisting shield shall be arranged at the place where the air ducts of the ventilation and air conditioning system go through the partition wall and floor slab in the fire protection area. In the room with a fire detection system, the air conditioning unit and ventilator of the related ventilation and air conditioning system shall be under a linkage control by the fire protection control center as per the fire detection signals.

(10) The air ducts of the cooling, ventilation and air conditioning system shall be designed into the non-combustible materials. If a corrosive gas is to be transferred, the air ducts of the ventilation system shall be of an anti-corrosion material. Insulation of the air ducts will be achieved by the non-combustible insulation materials, while insulation of the water pipes will be achieved by the non-combustible or fire retardant insulation materials.

6 Relocation of Existing Facilities/Decommissioning Strategy for Unit 3 & Unit 4 of BQ1

For original buildings and structures in the engineering construction land, most buildings in the area shall be removed. The workshop and circulating water dosing room of No.6 unit with a total construction area of about 1700m^2 will be removed. Other buildings on the construction land covers about 2000 m^2 area. The fence is about 700m in length. According to the general layout plan, there are some buildings and structures needed to be removed, including a warehouse about 3500m^2 areas, a abandoned construction distribution room about 150m^2 areas, three lighthouse and a fire hydrant demolition and so on.

According the business plan of KE, all existing units of BQPS-1 will still in operation during the summer peak of 2018. After that unit 4 will be decommissioned. The circulating water system of unit 4 will be modified for the use of combined cycle part of UNIT 7. In 2019, unit 3 will be decommissioned. The circulating water system of unit 3 will be modified for the use of combined cycle part of UNIT 8.

Removed or relocated facilities

Description	**Relocated / Removed**
Ware House at North Side of Unit 6	Relocate
Ware House at East Side of Unit 6	Relocate
Chlorine Generating Plant	Removed
Abandoned Construction Distribution Room	Removed
Three Lighthouses	Relocate
Fire Hydrant	Modify
Air Element Washing Area, Soakage Pit, Scrap Yard	Relocate

7 Necessary modification of existing GIS/TLN schemes of BQPS-1/2

A new 220kV GIS substation will be built. 4 generators will be connected to the new 220kV substation via four unit step-up transformers. The new GIS bus bar is consider being double bus with two bus section CBs and two bus coupler CBs. The original 4 outgoing overhead lines in BQPS-1 GIS will be used as the outgoing lines of the new GIS. For incoming lines, there will be 2(two) 9F gas turbine unit step-up transformers、2(two) 9F steam turbine unit step-up transformers、1(one) new middle-voltage standby transformer、 G1、G2、G5、G6 unit step-up transformers and startup transformers. 2 short link lines of BQPS-1 GIS，connected to BQPS-2 GIS, will be transferred to the new GIS, and two series reactors will be set between new GIS switchyard and BQPS-2 GIS switchyard.

According to the power system interconnection scheme, in the first half year of 2018, two short link lines (with series reactors) and one outgoing line to ICI in BQPS-1 GIS will be transferred to the new GIS, meanwhile there will be another short line between the new GIS and BQPS-1 GIS. Then the first 9F generator (300MW) with open cycle operation will be connected to the new GIS. Unit-3 and unit -4 will remain in operation.

In the last half year of 2018, the first 9F generators (300+150MW) with combined cycle will be connected to the new GIS and unit-3 will be considered to decommission.

In 2019, the remaining generators and outgoing lines in BQPS-1 GIS will be transferred to the new GIS one by one. And after unit-4 decommission, the second 9F generators (300+150MW) with combined cycle will be connected to the new GIS.

All incoming lines of the new GIS will use 220kV cable. 4 outgoing lines will be connected to the overhead lines in BQPS-1 GIS using 220kV cable.

The 220kV new GIS bus bar rated current is considered to be 4000A. The 220kV new GIS outgoing lines CBs rated current is considered to be 2500A, bus section CBs and bus coupler CBs rated current is considered to be 4000A. The 220kV new GIS CBs rated short circuit current is considered to be 50kA. The series reactors impedance is considered to be 10Ω, the rated current is considered to be 2500A.

New tunnels will be considered to connect the existing Units (1,2,5,6) with the new GIS. The detail layout of the tunnel was provided in the general layout, which is 30-F007101K-A-08.

All 220kV power cables for U1, U2, U5 & U6 will be changed to new cables and 220kV cable connectors will also be changed.

8 Environmental Protection

For environmental protection design in the project, the EIA report and approved files shall be taken as the basis in the end.

8.1 Standard to be adopted for environmental protection and environmentally sensitive protection objective

Within the engineering evaluation range of this stage, related environmentally sensitive protection objective is not found.

For environmental protection design in this stage of project, refer to pollution discharge standard of Pakistan (SEQS 2016). The EIA report shall prevail.

1.1.1 8.1.1 Air pollutant release standard

For air pollutant release standard of Pakistani industrial enterprise, see table 8.1-1:

Table 8.1-1 Air pollutant release standard of Pakistan (unit: mg/m^3)

No.	Pollutant	Pakistan (SEQS 2016)
1	SO_2	1700
2	NOx	400

8.1.2 Water pollutant release standard

For waste water discharge standard of Pakistan, see table 8.1-2.

Table 8.1-2 Water pollutant discharge standard

No.	Pollutant	Parkistan (SEQS 2016) (Discharged to sea)
1	Temperature rise	≤3℃
2	pH	6-9
3	BOD_5	200
4	COD	400
5	TSS	200
6	TDS	3500
7	Oil	10
8	Phenolic compound (such as phenol)	0.3
9	Chloride (such as Cl-)	Discharge concentration at or below sea concentration
10	Fluoride (such as F-)	10
11	Total cyanide (such as CN-)	1
12	Anionic detergent (such as methylene blue active substance)	20
13	SO_4^{2-}	Discharge concentration at or below sea concentration
14	S^{2-}	1.0
15	NH_3	40
16	Pesticide	0.15
17	Cadmium	0.1
18	Chromium (trivalent and hexavalent)	1.0
19	Copper	1.0
20	Lead	0.5
21	Mercury	0.01

No.	Pollutant	Parkistan (SEQS 2016) (Discharged to sea)
22	Selenium	0.5
23	Nickel	1.0
24	Silver	1.0
25	Total poisonous metal	2.0
26	Zinc	5.0
27	Arsenic	1.0
28	Barium	1.5
29	Iron	8.0
30	Manganese	1.5
31	Boron	6.0
32	Chlorine	1.0

8.1.3 Environmental quality standards for noise

table 8.1-3 For noise quality standard of Pakistan, see.

Area	Daytime (6.00a.m.~10.00p.m.)	Night (10.00p.m.~6.00a.m.)
Industrial area	75	65

8.2 Emission amount and controlling measure of main pollutant

8.2.1 Power plant scale

Two 9F class combined cycle units shall be constructed in three phase of this project.

8.2.2 Fuel source and consumption quantity

(1) Fuel source and feature

The project adopts natural gas as the fuel. For natural gas ingredient, see chapter “fuel supply”.

(2) Consumption of natural gas

Consumption of natural gas of each unit is as follows:

Hourly consumption of natural gas: 70477~88989Nm^3/h

Natural gas consumption of each kilowatt-hour power: 0.154~0.194Nm^3/kWh

In consideration of 5% allowance:

Optimum gas quality: 0.162Nm^3/kWh

The poorest gas quality: 0.204Nm^3/kWh

8.2.3 Water source

The project adopts once-through seawater supply system.

8.2.4 Pollutants emission in smoke and control measure

In this project, two 9F combined cycle units are constructed and natural gas is used as the fuel. Under normal condition, concentration of NOx in smoke can be controlled within 100mg/Nm3 to meet NOx concentration discharge limit (400mg/Nm3) specified in Pakistan pollutant discharge standard (SEQS 2016). Regarding natural gas used at this time, no sulphur is detected. Referring to similar gas turbine in China, SO_2 discharge concentration of Huaneng Shanghai gas turbine power plant, namely 2~8mg/Nm3,SO2 discharge concentration in this project is chose to be 10mg/Nm3 which is slightly higher than the analogy data. Smoke discharge in this project meets SO2 concentration discharge limit (1700mg/Nm3) specified in pollutant discharge standard of Pakistan, and it is dust free. For this project, hourly emission of NOx is about 0.39t and hourly emission of SO2 is about 0.039t.

8.2.5 Waste water discharge and control measure

This project only produce a small amount of non-recurring industrial wastewater, and use the equipment and solutions in old plant to treat waste water, specific please refer to "Chemical part" section. The domestic sewage is about $4m^3/h$. After be treated, the waste water is discharged to sea after meeting standards. This project adopts once-through seawater circulation system with waste water discharged to the sea. After complete mixing, the cooling water drained from this project has little effect on quality of sea water.

8.2.6 Noise and control measures

Devices in gas turbine mainly generate noise comprise gas turbine, steam turbine generator unit, water supply pump, waste heat boiler, circulating water pump, cooling water tower, etc. For noise level of major noise, see table 8.2-1.

Table 8.2-1 Noise Level of Major Devices in Plant (unit: dB(A))

Name of device	Sound level range
Gas turbine	91～96
Steam turbine	95
Turbo generator unit	90～95
Waste heat boiler	85～90
Circulating water pump	86～93
Main transformer	68～70
Water supply pump	86～93
Cooling tower (about 1m)	85
Gas Booster Station	80~85
Boiler Feed Pump	85~90

Noise of power plant can be controlled respectively from noise source, transmission route and personal protection of sound receivers.

(1) During equipment ordering, put forward noise limiting requirement on major and auxiliary manufacturers. Furthermore, it is also required to supply matched acoustic shield, silencer and other devices to control equipment noise within the allowable range.

(2) Air flue and steam and water pipelines are designed to guarantee reasonable arrangement and smooth flow pass and further decrease air power noise. Reasonably select supports and hangers and distribute them reasonably to reduce air flow and vibration noise.

(3) Main power plant, other workshops with high noise and walls thereof adopt sound absorption materials and sound absorption devices with good sound absorption effects; decrease window opening percentage of main power plant; adopt double-layer sound insulation doors and windows. Around plant area, plant trees for greening. Strengthen power plant operation and management to decrease effect from sudden and abnormal noise on surrounding environments.

(4) In workshop work areas with great noise effects, consider sound absorption materials and arrange sound absorption work places and duty rooms to meet noise requirements of different work areas.

8.3 Environment effect analysis

8.3.1 Analysis of flue gas emission effect on environment

Two 9F combined cycle units of this project shall take natural gas as the fuel. Natural gas as the clean fuel is free of dust. After operation, gas turbine only emits NOx to the atmosphere. Under normal operation condition, concentration of NOx emitted from flue gas can be controlled within 100mg/Nm3 so as to meet NOx concentration discharge limit (400mg/Nm3) specified in Pakistan pollutant discharge standard (SEQS 2016).

8.3.2 Analysis of waste water discharge effect on environment

In project of this stage, recycled cooling water is directly discharged to the sea. The added chemical waste water and domestic wastewater shall be treated based on wastewater discharge standard of Pakistan and then discharged to the sea, which have no effect on quality of sea water.

8.3.3 Analysis of noise effect on environment

Gas turbine adopted in this stage of project is the major noise source for environmental noise of the power plant. In order to effectively reduce and control power plant noise effect on the environment, the strong noise source shall be distributed intensively and concealed in low position. Furthermore, adopt sound absorption building materials to put forward noise control requirements on equipment manufacturer. At the side with effect on environment, arrange greening belt and adopt other measures to reduce noise effect on environment.

8.4 Water and soil conservation

8.4.1 Analysis of noise effect on environment

During the power plant construction period, water and soil loss factors are analyzed based on plant areas and construction areas.

(1) Plant area

During construction preparation period, carry out excavation, filling and other works for field leveling. Therefore, large area of soil shall be completely exposed because original landform soil is disturbed and the covering on the ground is cleared, which shall easily result in water and soil loss.

During civil construction, carry out foundation pit excavation, pile foundation engineering and building and structure construction. Therefore, a large area of original landform is damaged, which shall result in water and soil loss.

During unit installation and test period, all surface excavation and filling disturbance shall be fully finished. Temporary soil, stone, residue, device materials, etc. stockpiled during civilwork construction period are completely cleared away and the field has been leveled. This is the preparation stage for unit commissioning and operation. During this period, water and soil conservation facilities has exert the functions preliminarily. Therefore, there are still some water and soil losses. However, the loss strength has been greatly reduced.

(2) Construction area

Field leveling during construction preparation period shall disturb the earth surface and destroy original vegetation, which then generate ground exposure along with water and soil loss.

Stockpiling of machineries, building materials, prefabricated members for production, etc. during construction period shall strongly compact and disturb the surface soil, damage ground vegetation and cause water and soil loss. During unit installation period and test period, great decrease of civil work activities shall decrease earth surface disturbance and then water and soil loss.

8.4.2 Water and soil conservation and control measures

Effects from engineering construction in this stage on local water and soil loss mainly comprise ground disturbance during construction process, change and destroy of original landform and vegetation in certain degree, damage of original water and soil conservation facilities in different degrees. Therefore, during engineering construction period and operation period, following water and soil conservation work shall be done in different areas:

(1) It is required to complete ground hardening, blocking, slope protection, temporary soil stockpiling ground and temporary protection measures for foundation trench, perfect water interception and drainage system of the plant area. After construction is completed, perform site clearing on time. Regarding plant measures, greening and beautifying must be considered at the same time.

(2) For pipeline, prevention and control area out of the plant, complete highway subgrade drainage, blocking and protection, greening and beautifying measures along the line and strengthen temporary protection measures during construction period. Pipeline construction must be performed in different sections, excavation must be performed in different layers and then filling and leveling must be performed in time and strengthen temporary protection measures during construction. The vegetation must be recovered in time after construction is completed.

(3) Different kinds of construction activities must be strictly controlled within the land range to protect the ground surface from random occupation, disturbance and destroy. The spoil (residue) generated during construction process must be cleared to the designated place for stockpiling and

protection. No random pouring is permitted. After construction is finished, the construction site must be cleared and leveled and the vegetation must be recovered.

9 Labor safety

Based on investigation and survey, there is no related requirement on labor safety in the feasibility report of Pakistan. Therefore, the labor safety section here is designed first based on Chinese standard.

Labor safety hazard sources of thermal power plant comprise two aspects, namely external environment and production projects. External environment factors include meteorology, geology, thunder, rainstorm, flood, earthquake, etc. Hazard factors related to safety and health during production process are mainly from following aspects: fire and explosion, electrical injury and mechanical injury, poison and corrosion prevention, noise protection, heatstroke prevention and dust prevention. With respect to power plant design and production operation, it is required to establish and implement strict safe operation rules and management rules to completely eradicate fire, explosion and other accident from the root.

9.1 Power plant effect on neighboring enterprise or residential area

The major principle for general site planning of the plant area is to take full advantage of available site for construction on the site, optimize general layout of power plant to realize no land acquisition, no demolition, no resident disturbance and decrease tenancy of the power plant area. For the engineering construction, no residential demolition is involved. Based on preliminary estimation, after the project is constructed, the noise in the plant boundary can meet relevant standard requirements.

For chemical processing devices used in the project, acid and base storage tanks are arranged in a way not affecting resident's production.

9.2 Engineering geological condition

9.2.1 Weather

Project of this stage is located 80km away from east of Karachi, Pakistan and close to Arab Sea in the south with long and zigzag coastline. Karachi city is located at the South Asian Sub-Contient, northwest of Indus River delta and close to Arab Sea at the south. With even terrain, high temperature and little rain in most time of a year, the city is so hot and the average minimal air temperature in winter is 13℃. The average maximal air temperature in summer is 34℃. Owing to few rain, mean annual precipitation is only 200mm.

On the plant site, the natural elevation is about 0.0m~6.0m with even terrain. The sea area is the shallow sea with intertidal zone, large area of mangrove forest and good natural condition which is good for wave and flood resistance of the plant site.

9.2.2 Earthquake

Based on earthquake block plan of Pakistan, the proposed project site is located in "2B" earthquake area. The earthquake acceleration exceeding 10% probability in 50 years is 0.20g.

The main strata of the proposed plant site downwards are: sludge clay, silty clay, silt and fine sand. The underground water burial depth is generally 2.4~5.0m. The underground water and foundation soil have strong corrosivity to buildings and reinforcing steel bars in buildings. For most buildings, raft foundations can be adopted. So as to boiler and other important buildings, when the bearing capacities meet requirements, pile foundation can be adopted. Sand layer exists within 20m range, it is required to consider the earthquake-induced liquefaction effect.

9.3 Fire and explosion prevention

The major potential hazard for fire in power plant is the facilities or places where combustible media is stored or pass through, such as transformer area, unit oil and natural gas system area. The cable interlay and cable dense region may get fire owing to poor cable heat dissipation or insulation and then burn cables. There are also combustion caused by electrical equipment short circuit or other reasons. Furthermore, the high-temperature pipeline may get fire owing to oil leaked from oil and natural gas system.

Potential explosion hazard in thermal power plant may cause fire or instrument and equipment damage. Therefore, anti-explosion is very important. Major explosion hazard is the natural gas system, regulator station, different pressure vessels, accumulator room, etc.

For this purpose, it is required to fully consider fire prevention and spreading in design. In addition, it is required to adopt feasible and effective fire prevention and extinguishing measures. At the same time, corresponding measures must also be adopted for above areas with explosion hazard.

For fire and explosion prevention in power plant, besides mature deliberation and adoption of effective measures under existing technical conditions, during power plant design and production operation, it is required to establish and implement strict safe operation regulations and management measures so as to completely eradicate explosion accident from the root.

9.4 Prevention of mechanical and other injuries

Most portion of human injuries in power plant belong to mechanical injuries. Moreover, most of them occur during overhauling operation. Therefore, during operation and overhauling process, it is required to strengthen security concept and strictly observe safe operation rules. Protection measures set in design mainly contain:

Exposed parts of all revolution machinery are designed with protection hood and guard bars.

For work high above the ground, it is required to prepare reliably safe fence and guardrails, safety belt and helmets.

For valves, pore plates, explosion doors, arrange maintenance platforms at maintenance, operation regions and high-temperature pipeline creep expansion supervision points, etc.

In order to prevent high-altitude falling, platforms and ladders must be equipped with reliable handrails based on national standards.

Main power houses, production building, plant roads, etc. must be designed with necessary and sufficient illumination.

Blind pits, channels, etc. in the plant must be designed with safe cover boards.

9.5 Poison and corrosion prevention

Toxic and harmful substances generated during production process of thermal power plant mainly comprise acid, base, chlorine, ammonia and other substances in chemical water and waste water system. In order to protect operators and devices, ventilation measures are mainly adopted for protection.

Acid and base storage tanks of chemical process equipment must be painted with anticorrosive materials or lined with anticorrosive materials. For other related pipelines and accessories, it is also required to adopt anti-corrosion measures.

Control room, equipment room, etc. must possess certain anti-static and shielding requirements. For terrace, wall surface, ceilings, etc. with acid proofing requirements, adopt acid-resisting floor tiles, ceramic tiles and ceiling materials. Furthermore, the acid resistance must conform to operation requirements.

Devices required rubber liner in equipment corrosion resistance comprise different kinds of ion exchangers, active filters, cleaning tanks, decarburization device, high (low) level acid base) storage tank, metering tank, etc.; hot water tanks, base injectors, etc. must be made of stainless steel; backwashing water tanks, sweet-water tanks, condensed water feeding tanks, etc. must be coated with antiseptic paints. Low-level acid-base loading and unloading pits, etc. must be lined with fiber glass epoxy plastic devices.

For pipeline anticorrosion, most pipelines in make-up water treatment and waste water treatment system along with base and acid pipelines, etc. must be lined with plastic. Resin delivery pipelines, water vapor sampling pipeline, etc. must be made of stainless steel. For waste acid-base drain trench and acid-base discharge terrace along with high and low level acid and base terrace in the chemical water workshop, it is required to adopt granite floor for anti-corrosion. With respect to acid-base pipe trench, waste water pond and related device foundation, it is required to adopt epoxy glass fiber reinforced plastics as the antiseptic means. Platforms, ladders, supports, etc. with intensive distribution of acid-base devices outdoors, it is required to adopt glass fiber reinforced plastics products for corrosion prevention.

9.6 Labor safety in construction process

Labor safety rules in construction process are based on the standards and norms made by construction units.

Education and propaganda measures about safety in the process of construction should be taken to improve safety awareness. The major labor safety measures on construction site are as follows:

Safety helmet should be put on after entering the site, and safety materials should be correctly used.

Materials and equipment on the construction site should be neatly stacked, and shall not be stored in the main channel.

When work in more than 2 meters high level without safety facilities, people should fasten the safety belt and safety draw hook.

When work in the high level, materials and tools are prohibited to be thrown carelessly.

Keep maintenance of construction equipment, which are prohibited of malfunctioning and overload operation.

Those stuff who are not specialized in electrical and mechanical work are strictly prohibited to use mechanical and electrical equipment.

All the electrical wiring, mechanical equipment must be installed by professional according to regulations and conform to the standards.

People except for operation personnel should keep out of lifting area, and the hoisting machinery must be in good condition, all the people are prohibited to stand under the barre.

Fire production work must be executed on construction site.

10 Occupational health

Based on the investigation and survey, there is no related requirement in the feasible report on occupational health description of Pakistan. Therefore, in the project, the occupational health is simply described as below by referring to related national standards.

The power plant has features such as many large scale devices, operation devices, electrically charged devices, pressure vessels, high-temperature and high-pressure pipelines and high-rise buildings along with high degree of automation.

10.1 Noise and vibration prevention

10.1.1 Noise prevention

Noise prevention and treatment are important constituent parts for environmental protection, employee labor protection and industrial health. In the project, comprehensive treatment modes can be adopted for noise prevention and treatment: noise source is controlled at first. For example, put forward noise limiting requirements on manufacturers producing noise source equipment. Regarding the noise that cannot be eliminated from the sound source, adopt effective sound insulation, elimination, absorption, vibration prevention and other measures.

10.1.2 Vibration prevention

With respect to machine equipment generating strong vibration and impact and then inducing solid vibration radiation noise, it is required to adopt vibration isolation measures.

10.2 Sunstroke, Thermal and moisture prevention

10.2.1 Sunstroke prevention

Production operators are generally on duty in the intensive control room to keep away from heat source and achieve the sunstroke prevention purposes. For operators carrying out patrol inspection or local operation in workshop, owing to severe work condition in local high temperature area, besides heat insulation measures adopted in design, it is also required to consider ventilation methods to reduce the temperature of the work area. For valves that are operated frequently in these areas, select electric valves to improve operators' work condition and alleviate work strength.

10.2.2 Thermal insulation

In design, pipelines with hot source shall be isolated with surrounding area by insulation materials to prevent heat loss and improve heat efficiency besides sunstroke prevention, cooling and safe production. Production operators generally work in the intensive control room away from the heat source. During patrol inspection in workshop or local operation, for valves that are arranged in high temperature area with severe work condition and operated more frequently, adopt electric valves to improve operators' work condition and alleviate work strength.

10.2.3 Damp proof

Underground buildings are generally gloomy, cold and moist. In design, besides ventilation facilities, trench wall and baseboards of underground parts of buildings must be placed with waterproof concrete. The contact areas between external wall and soil, apply pitch.

10.2.4 Radiation protection

Project radiation hazards are mainly from power distribution units, transformer, high-voltage devices, lines and microwave communication which can generate power frequency electromagnetic radiation. Operators and related personnel often working within the 6m distance away from the device (vertical distance) may be injured by electromagnetic radiation. Exposed to electromagnetic radiation for long time, human body may subject to insomnia, headache, palpitation, weakness, alopecia, hypomnesis and other symptoms. The power frequency electromagnetic field radiation strength shall conform to related sanitation standards.

10.2.5 Antitoxin

The power plant shall pay special attention to poison from different chemicals to human bodies and complete emergency plans. Companies storing, transporting and using dangerous chemicals along with companies disposing waste and dangerous chemicals, it is required to be engaged to activities related to dangerous chemical products based on related laws, regulations, rules and technical standard requirements.

10.3 Safe training and establishment of regulations

Before pilot run of the unit, it is required to determine the formal training plan so as to guarantee that operators can safely and effectively operate equipment normally.

The enterprise shall train a personnel team can safely and accurately recondition equipment and establish maintenance regulations containing routine technologies and special technologies to include different potential safe factors, such as temperature, pollution or oxygen deficit, internal pressure, access restriction or confined space, etc.

Regulations must conform to safety requirements and manufacturer's recommendations.

10.4 Sanitation and others

In power plant design, it is required to pay attention to domestic and sanitary fixtures. The main power house must be equipped with rest rooms, rubbish silos and cesspits. Different production and control rooms are equipped with rest rooms and changing rooms.

11 Resource utilization

11.1 Principles and requirements

The project aims at combined cycled power generating units, and the main the resources needed are land, natural gas, water, raw materials and other resources. Upon engineering construction, saving land resources, saving energy, saving water, saving investment, and reducing cost will be organically combined together.

11.2 Energy utilization

BQPS phase I and II have been built gas pipeline SSGC. Currently SSGC pipe has been laid to the northwest of the project. Pipeline design parameters are 6bar, DN750. Due to lack of gas, SSGC pipeline can only meet the gas consumption of one F-class gas turbine. Natural gas is connected to pressurized equipment from SSGC pipeline in this project. Pressure to about 40bar and then sent to #1 and #2 gas turbine. #1 gas turbine use SSGC gas first. After the completion of the #2 gas turbine, #1 gas turbine stop using SSGC gas. #1 and #2 gas turbine will use RLNG as gas source. RLNG shall be delivered to the plant gate by pipeline, then send to the pressure regulating station, and transported to the two F class gas turbine. At the same time, SSGC switch to the standby gas source.

11.3 Land utilization

This project is the expansion and reconstruction project of the old factory, the main construction site is located in the southeast space of BQPS-I factory which is the power plant’s self-use land. This project does not need new requisition of land. Present situation of the land is yard, there are a few structures which need to be demolished / relocated.

During the planning and design of this project , we have given full consideration to the measures of economical use of land. Efforts to implement the "build a resource-conserving and environment-friendly society" principle, on the premise of reasonable and short of process flow, as far as possible to save land and investment. On the original site, we considered both the layout of venues of the generating units of current facility, at the same time, and the possibility of layout of the forward units power generation equipment, make full use of available land resources, layout compactly, reduce the land area of the buildings/structures, to achieve the requirement of the economical use of land.

11.4 Utilization of water

11.4.1 Water resource

In this project, seawater is used as the water supply source. One-through cooling system will be adopted. Pump house and other facilities of No.3 and 4 units of the old plant. The water quantity of circulating water for new plant is less than the quantity of No.3 and 4 units of the old plant. The water intake facilities of No.3 and 4 units can make sure of the demand of the new plant.

The fresh water for the new plant comes from the pipe network of the old plant. There are four 3000m^3 water basins to supply the fresh water for the old plant. The flow of fresh water is 40m^3/h for each unit and the flow of fresh water is 55m^3/h for new plant. When no 3 and 4 units retired, the fresh water for the two units is 80m^3/h, which is larger than the water demand of new plant. Fresh water for the new plant is guaranteed.

11.4.2 Water Conservation Measures

To rationally utilize water resources, minimize the environmental pollution, control wastewater discharge, and effectively reduce the water consumption indicators, this project puts forward the following water-saving measures:

As the freshwater resource of power plants is in shortage and the fresh water supply cost is high, from the perspective of implementing related water saving policies and economic reliability of power plants operation, this project will take concrete and effective measures, carry out the study of multi-purpose use of water, wastewater reuse and other water conservation engineering facilities to save water and protect the environment. The main water conservation measures are as follows:

(1) The industrial service water in the main plant mainly adopts demineralized water closed cycle (the heat passes through the plate heat exchanger and carried off by the circulating water).

(2) Water tanks are provided with water level gauges and water level alarms to prevent overflow.

(3) Discharge pipes of water supply pump are furnished with metering devices, controlling water supply of all water supply systems, which is in the favor of water management.

11.5 Utilization of building materials

Due to the rapid economic growth, Pakistan's arable land which is not rich originally has decreased dramatically in recent years, along with the extensive use of clay bricks in the construction industry, and the arable land has been further nibbled. The severity of this problem has aroused people's wide attention, and the state and local government has issued relevant policies to limit the use of traditional clay bricks, encourage producing and using various lightweight walls. In addition, as the insulation performance is poor, from the energy saving point of view, solid clay bricks are obviously not the ideal wall materials.

In the short run, building facades can be made from lightweight composite materials with low cost depending on actual circumstances, with the outer surfaces being waterproof, thermal insulative, and anticorrosive, with the inner surfaces being heat preservative, sound insulative, and easy to clean, with the middle using hollow porous fire-preventive non-toxic materials.

To meet the needs of roof energy saving design, it's proposed to strengthen the insulating layer and add an aerial ventilation layer, with the air inter-layer pasted with heat reflective materials or set up inversion type roof which is conducive to protect the waterproof layer to make it durable. Meanwhile, high efficient thermal insulative materials have come into use in roofing, such as expansive polystyrene boards. The waterproof layer is laid on the top for most cases, while the inverted laying method may also be adopted, which prevents the waterproof layer not directly affected by sunlight exposure and hence delays aging.

Varieties of window glass include heat-absorbing glass, heat reflective glass, low emissivity glass and hollow glass. Appropriate glass varieties can be determined according to the comparison of prices of air conditioning and cost of refrigeration and heating, and the energy saving effects are compared from the solar energy barrier properties and thermal conductivity of all kinds of glass so as to improve the airtight level.

12 Energy saving analysis

12.1 Energy saving standards and specifications

During the implementation of this project, the main energy-saving standard standards and specifications to be observed are as follows:

- Design rule for combined-cycle power plants DL 5174-2003-2000
- Design Specification for Design of Large- and Medium-sized Thermal power plants GB 50660-2011
- Technical Regulations on Hydraulic Design of Thermal power plants DL/T 5339-2006
- Technical Regulations on General Layout and Transportation

Design for Thermal power plants DL/T 5032-2005

- Norm of Water Intake Part 1 Thermal Power Generation GB/T 18916 1-2002
- Guidelines for Water Saving of Thermal power plants DL/T 783-2001
- Technical Regulations on Chemical Design of Thermal power plants DL/T 5068-2006
- Technical Regulations on Design of Thermal Control System of Thermal power plants DL/T 5175-2003
- Technical Regulations on Power Utilization Design of Thermal power plants DL 5153-2002
- Technical Regulations on Design of Heating Ventilation and Air Conditioning of Thermal power plants DL/T 5035-2004
- Standard for Energy Conservation Design of Public Buildings GB 50189-2005

12.2 Energy consumption indicators of this project

This project is the combined cycle power generation project, with the energy consumption mainly being primary natural gas and electricity, while the needed electricity is completely generated by the power produced by the period of project itself.

The main energy consumption indexes of this project are shown in Table 12.2-1:

Table 12.2-1 Main energy consumption indexes of this project

S.N.	Content	Unit	Expected value
1	Total-plant power generation efficiency (ISO)	%	59.5
2	Yearly Avg. Natural Gas Consumption for Power Generation Nm^3/kWh	Nm^3/kWh	0.154(SSGC best quality)/ 0.194(SSGC worst quality) / 0.176(RLNG)
3	Station service power consumption rate	%	~2(Exclude compressor)/2.95(Include compressor)

12.3 Energy saving measures and effect analysis of this project

In the construction of the project, it is important to combined save investment, reduce costs and conservation, rational use of energy together. The major energy conservation measures adopted by the design of the project are as follows:

(1) In the selection of units, try to choose a mature, efficient, reliable, advanced gas turbine.

(2) The general layout of the plant is optimized to save land.

(3) The selection of HRSG should not be confined to the type of turbine and strive to make the design optimization of the boiler.

(4) The main auxiliary equipment adopts the energy saving products with excellent performance, good reliability and high efficiency, and put an end to the use of the products which have been outdate.

13 Staffs

As this project is built inside the boundary of BQPS-I power plant, the number of staff who operate and maintain the BQPS-3 shall be decided by KE.

According to the experience of F class combined cycle power plant in China, average number of staff is 120.

14 Project implementation condition, construction schedule and duration

14.1 Project implementation condition

14.1.1 Transportation plan for heavy equipment

14.1.1.1 Traffic condition

In this stage, main equipment suppliers are undecided. Referring to experience of old plant, the plant has good external land and water traffic condition. There are no transportation problems.

(1) Railway

The power plant is 6km to national railway trunk of Pakistan. The railway network is connected with Qasim Port in the west of the power plant.

(2) Highway

Pakistan highway is located about 8km from north of power plant. It is connected to north of the power plant from Qasim port highway. There are several accesses in existing plant of the power plant, which are all connected to Qasim port highway. During construction of the project, general middle and small equipment and construction buildings can be transported to power plant via highways. Roads in power plant have formed a network.

(3) Water route

The power plant is in east of Qasim port is the second busiest port of Pakistan, which handles about 35% Pakistan goods (about 17 million tons annually). The port is not only a good connection with the sea, but also good connection with inland area via good railway and highway transportation network. It is only 15km to Pakistan via expressway and 14km to state railway trunk. Furthermore, there are 6 railway networks connected with port wharf. It is 22km to Ginna International Airport. It is also convenient to use waterway transport.

14.1.1.2 Transportation size and weight of heavy equipment

For transportation of heavy equipment in the project, mainly consider transportation plan of equipment to the construction site. Wherein, major heavy equipment contains gas turbine module, power generator module and waste heat boiler.

Company	Equipment	Dimension (L×W×H)	Weight (t)
GE	1. Turbine module of gas turbine	10.53m×4.95m×4.99m	310
	2. Stator module of generator	12.51m×4.78m×4.25m	278
	3. Waster heat boiler module	20.51m×3.82m×2.38m	230
SIEMENS	1. Turbine module of gas turbine	10.8 m×5.3m×5m	308
	2. Stator module of generator	10.244m×4.564m×4.855m	296
	3. Waster heat boiler module	20.51m×3.82m×2.38	230
ANSALDO	1. Turbine module of gas turbine	14 m×6m×6m	390
	2. Stator module of generator	10.6m×4.81m×4.63m	291
	3. HRSG module	20.51m×3.82m×2.38m	230

In feasibility study stage, major equipment supplier has not been determined, so the size and weight of the above equipment is refer to the same type of major equipment engineering data. Detailed data will be clear when the equipment purchase contract is signed at the next stage.

14.1.1.3 Transportation plan of heavy equipment

In this stage, heavy equipment has great transportation size and heavy transportation weight. Furthermore, railway has restriction for transportation size and weight of transported equipment. Therefore, equipment shall be limited during railway transportation. Owing to high bearing capacity, height and width limitation in highway transportation, it is required to strengthen and transform bridge, culvert, road, etc. on the way. Therefore, it is difficult to directly transport the heavy equipment via road.

In this stage of project, water-land transshipment plans are considered as the transportation plan for heavy equipment.

14.1.2 Planning of construction site

14.1.2.1 Construction site planning

In the project, construct two grade 450MW combined cycle gas turbine unit. For construction land, refer to relevant regulations of DG[1997] No.274 file "Notification about Printing and Issuing Design Regulation for Construction Organization Outline of Thermal Power Plant (trial implementation)" and GDDY [2002] No.849 file "Notification about Issuing Guide Rule for Construction Organization of Thermal Power Generation Project". Construction production site covers 4hm^2 area and construction living site covers 1hm^2 area. Specific planning area shall be further defined.

14.1.2.2 Flood protection and drainage plan of construction area

In the construction area, consider natural drainage through flat slope. Establish temporary water drainage system to prevent waterlogging. Sewage in the living quarter shall be drained to the drainage point appointed by the owner via the cement pipeline. Rain water is drained to the closed conduit via open channel. At both sides of all roads, brick-laid open drains are uniformly arranged. With respect to the open channel crossing road and vehicle passing channels, it is required to embed steel pipe or cement pipe.

Site in the construction area shall form a natural drainage slope to prevent waterlogging after rainstorm. At the same time, arrange grid pebble blind drain which is connected with open drain along road. Rainwater in the foundation pit of main plant is drained to the rainwater collection deposition well arranged outside the foundation trench via the submerged pump. After settlement, the rain water is drained to the rain water system in the plant. Sewages from toilet on site and in living quarter, including sewage from High altitude toilet and living quarter are drained after processed in the septic-tank.

14.1.2.3 Planning of construction road

Transportation items during power plant construction period mainly include power plant equipment, cement, gravel, reinforcing steel bar and other large amount of materials. Power plant equipment (including heavy equipment) is transported to the power plant via highway. Other materials transported via highway include cement, gravel, reinforcing steel bar and other large number of materials taken locally.

Based on "permanent and temporary combination" principle, construction road and plant road shall be combined. Adopt two-lane clay bound macadam pavement or concrete pavement in 6m width. Considering road damage condition during the construction period, place a layer of concrete pavement at first. At later stage of the project, place the second layer of concrete based on the design elevation of the pavement. About design of the permanent and temporary combined road subgrade, except for construction requirement, it is also required to meet design requirement of permanent road.

14.1.3 Supply of construction force energy

14.1.3.1 Construction power

Construction power capacity is determined based on calculated load of construction appliance equipment, construction living facilities, on-site office facility during the peak time of power consumption. Therefore, after referring to the construction experience of domestic fuel turbine unit with similar scale, it is determined that maximal load of temporary power utilization at initial period is 1,500kW and capacity of installed transformer is 2,400kVA.

Based on construction power supply capacity of this project, the construction power is introduced from auxiliary power of the plant or connected to the site after an application is given to the power supply department from the power plant. After the construction companies enter into the site, a power consumption application is put forward to the power plant. After being approved, the construction companies shall introduce power from pile heads under 400V shunt switch of the power distribution station. The total capacity of power supplies to be arranged on the construction site is 2,400kVA (three 800kVA box-type transformer).

During the construction stage of major project, it is required to be fully prepared for taking the peak elimination and avoidance measures for power consumption in construction so as to give full play to the power supply capacity and guarantee normal implementation of different construction operations. For construction projects to be performed continuously, several diesel generators must be equipped on construction site as the emergency power supply to guarantee continuous construction of this kind of project after accidental power failure.

14.1.3.2 Construction water

Water supply quantities on the construction site shall meet the maximal requisite amount for direct production water, construction machinery water, domestic water and fire-fighting water. Portable water shall meet GB5749 *Hygienic Standard for Drinking Water* and regulations of local health authorities; water for mixing of concrete and mortar shall meet regulations of JGJ63 *Standard for Concrete Mixing Water*; quality of construction machinery water shall conform to regulations for water supply quality in GB1576 *Standard for Low-Pressure Boiler Water Quality*.

Based on regulations of *Guide for Construction Organization Design of Thermal Power Engineering* along with practical condition of this phase of project, it is preliminarily determined that maximal water consumption (including fire-fighting water) for production is 130t/h. Maximal domestic water quantities in construction is about 20t/h. In total, peak water consumption in the project is 150t/h. Average water consumption in this project is 84 t/h. In old power plant, construction and production water along with domestic water required in the construction field can be taken from water main of the power plant. Water supply pipelines are mainly arranged along arterial traffic or fences. Fire-fighting water and construction water are from a pipe network. Furthermore, along the water supply pipeline, arrange certain quantities of above hydrants as required. The construction companies shall put forward water consumption application to the power plant. After being approved, the construction companies shall connect a water branch from an appointed primary valve. The construction water outlet meets pressure requirements; pressure of the construction water is ≥0.2Mpa and pressure of construction and living water is ≥0.4Mpa.

14.1.3.3 Construction communication

Temporary communication for construction of the project is under combined construction by several units. Totally 5 pairs of telephone trunks are required. As the major means for external contact in the construction, the trunks are supplied by the preparation company. The bus in different construction companies shall be solved by different companies.

14.1.3.4 Gas consumed in construction

Oxygen, acetylene, argon and compressed air required for the construction shall be purchased by the construction contractor as required. However, it is required to consider safety of gas cylinder pipeline and different gases. Relevant units shall prepare and record specific management measures.

During civil work construction process, oxygen and acetylene are required. In principle, it is required to adopt the cylinder package. It is prohibited to use acetylene generator on site. During installation and construction process, owing to great oxygen and acetylene demands and complicated operation condition, central gas supply way can also be adopted. Arrange central oxygen and acetylene supply station to supply the gases to the construction site via underground pipe network.

Oxygen pipe and acetylene pipe shall be made of seamless carbon steel pipe. Gas supply pipes along with gas supply pipes and gas supply valves are all connected through welding. The fire return device is arranged before outlet of each newly cut gas supply valve. After gas supply pipeline is installed, it is required to perform air-tight test.

Compressed air for construction is supplied by mobile air compressor.

14.1.3.5 Local building materials

Cement, yellow sand, pebble and other building materials can be directly purchased locally and then supplied to the construction site. Material supply is quick and convenient.

Owing to short duration of the project, the owner should obtain related power supply, water supply and communication protocol for the construction, arrange construction access to the site and create condition for early commencement of the project.

14.1.4 Construction schedule and duration for project implementation

The primarily tentative construction major milestone of this project is:

No.	Milestone	Schedule	Remarks
1	Issue the PO of Feasibility study	2017.01.30	
2	Complete the Feasibility Study	2017.2.6- 2017.2.24	
3	Complete the review Feasibility Study	2017.2.28	
4	Issue the PO for Detail Geological Investigation and measurement	2017.3.1	
5	Determined the manufacturer and the type of the Gas Turbine, HRSG, Turbine, Generator.	2017.3.1-2017.3.15	
6	Complete the Basic Design and Basic Design Review	2017.3.16-4.30	
7	Complete the EIA Report compilation & approval	2017.1.25-4.20	
8	Complete the Bid Invitation and selection of the EPC Contractor	2017.4.15	
9	Complete the Detail Geological Survey & Information Providing	2017.3.15-5.10	
10	Complete the soil treatment Scheme and Review	2017-6-30	
11	Close the Financing of this project	2017.9.30	
CIVIL WORK			
1	Complete the pilling work of Gas Turbine house and part of Steam Turbine house and other buildings of Unit #7	2017.7.1-9.1	

No.	Milestone	Schedule	Remarks
2	FCD Gas Turbine house and part of Steam Turbine house of Unit #7	2017.9.1	
3	Complete the Civil and Steel Structure Work of Gas Turbine house and part of Steam Turbine house and other buildings of Unit #7	2017.12.30	Civil work of Open Cycle part of Unit #7 finish.
4	Complete the pilling work of Steam Turbine house, HRSG and other buildings of Unit #7	2017.9.1-12.1	
5	Complete the Civil and Steel Structure Work of Steam Turbine house, HRSG and other buildings of Unit #7	2017.12.30	Civil work of Combined Cycle part of Unit #7 finish.
6	Complete the pilling work of Gas Turbine house, HRSG and other buildings of Unit #8	2017.12.1-2018.2.1	
7	Complete the Civil and Steel Structure Work of Steam Turbine house, HRSG and other buildings of Unit #7	2018.6.1-2018.8.1	Civil work of Combined Cycle part of Unit #8 finish.
Work of New GIS of BQPS-III			
1	Prepare the document of technical requirements of new GIS equipments and reactors.	2017.3.15-4.15	
2	Complete the relay protection, remote control, telecommunication, and NCS requirements with KE and prepare the specification	2017.3.15-4.30	
3	Bidding processes of GIS equipments and reactors.	2017.4.15-5.15	
4	Manufacture of GIS equipments and reactors.	2017.5.15-8.15	For 2018, only partial GIS Equipment for new 900MW, short connections with BQPS II GIS, and two outgoing transmission lines and the other necessary equipment required for 2018. The rest of equipment can be supplied during the

No.	Milestone	Schedule	Remarks
			2019 and so on.
5	Complete the Civil and Steel Structure Work of GIS，reactors，NCS Control Building and cable trench		For 2018, only partial GIS Equipment for new 900MW, short connections with BQPS II GIS, and two outgoing transmission lines and the other necessary equipment required for 2018. The rest of equipment can be supplied during the 2019 and so on.
6	Transportation of GIS equipments and reactors to BQPS	2017.8.15-9.30	
7	Complete GIS equipment，reactors and NCS building equipment installation and test	2017.9.30-11.30	For 2018, only partial GIS Equipment for new 900MW, short connections with BQPS II GIS, and two outgoing transmission lines and the other necessary equipment required for 2018. The rest of equipment can be supplied during the 2019 and so on.
8	Complete two transmission lines transfer from the BQPS I to the new GIS, and energized the new GIS	2017.11.30-2017.12.30	
9	Complete two short-connections between BQRS II GIS and new GIS	2017.12.30-2018.1.30	
10	Complete the electric supply for the single cycle part of first 9F unit.	2018.1.30	
Work of Open Cycle part of Unit #7			
1	Gas Turbine Module in Place	2018.1.20	
2	Generator Module in Place	2018.1.20	
3	Electric Feedback	2018.1.30	
4	Gas Turbine Ignition	2018.3.10	

No.	Milestone	Schedule	Remarks
5	First Synchronization	2018.4.26	
6	**Open Cycle part of Unit #7 into operation**	**2018.5.26**	
Work of Open Cycle part of Unit #7（Schedule can be adjust according to decommission time of unit #4 of BQPS-I）			
1	HRSG Steel Structure Installation	2017.11.1	
2	Turbine in Place	2018.3.5	
3	Generator in Place	2018.3.5	
4	HRSG Steam Drum in Place	2018.3.5	
5	Turbine Cylinder Buckle	2018.7.5	
6	HRSG Steam Water Pressure Test	2018.9.10	
7	HRSG Acid Wash	2018.10.1	
8	**Decommissioning of unit 4 of BQPS-I**	Start from 2018.11.1	
9	HRSG and Pipes Blow	2018.11.1	
10	**Commission and Put into Operation of Unit #7 in Combined cycle mode**	2019.2.15	
Work of Open Cycle part of Unit #8			
1	Gas Turbine Module in Place	2019.1.20	
2	Generator Module in Place	2019.1.20	
3	Electric Feedback	2019.1.30	
4	Gas Turbine Ignition	2019.3.10	
5	First Synchronization	2019.4.26	
6	**Open Cycle part of Unit #8 into operation**	**2019.5.26**	
Work of Open Cycle part of Unit #8（Schedule can be adjust according to decommission time of unit #3 of BQPS-I）			
1	HRSG Steel Structure Installation	2018.11.1	
2	Turbine in Place	2019.3.5	
3	Generator in Place	2019.3.5	
4	HRSG Steam Drum in Place	2019.3.5	
5	Turbine Cylinder Buckle	2019.7.5	
6	HRSG Steam Water Pressure Test	2019.9.10	

No.	Milestone	Schedule	Remarks
7	HRSG Acid Wash	2019.10.1	
8	**Decommissioning of unit 4 of BQPS-I**	Start from 2019.11.1	
9	HRSG and Pipes Blow	2019.11.1	
10	**Commission and Put into Operation of Unit #8 in Combined cycle mode**	2020.2.15	

15 Risk analysis

15.1 Market risk analysis and countermeasures

As Pakistan had shortage of electric power up to 4000 MW in 2013, market demand was far from satiable. According to the business plan of KE, two new units of BQPS-3 is still needed to be put into operation to meet the peak demand up to 2019. Therefore, market for electric power from the project is guaranteed.

15.2 Policy risk analysis and countermeasures

As there are many ways to learn adjustment of national and industrial policies, policy-related risk is low. However in a foreign country, due to great difference in language, habits and investment environment and our unfamiliarity with local market as well as in standpoint of local government, there is higher unpredictability of policy and risks.

Investor of the project shall try to know more about and analyze industrial policy of Pakistan for natural gas and electric power industries, to learn trend of development of the region and the country and to learn the consistency between operation of the project and industrial planning and energy resources planning of local government and the compatibility between urban planning, environmental protection planning and resources utilization planning. For issues involving with many local factors, policy of risk passage can be adopted.

15.3 Technical risk analysis and countermeasures

Development of the project in question is in consistency with the local structure adjustment of energy and peak valley requirements of the local Power Grid. Karachi is an economically developed city and one of the centers of power consumption in Pakistan. The social demand for electricity keeps on increasing. The gas-steam combined cycle generating unit is characterized by a quick start-up/shutdown, wide range of peak load regulation and relatively higher efficiency of partial loads. It is more suitable for peak load regulation of the Power Grid than the coal fired generating unit.

In addition, the project in question is in favor of environmental protection. With the natural gas as the fuel, the combined cycle generating unit with a high efficiency will be constructed under the project. It involves no emission of dust or sulfur dioxide, and discharges much less NO_X than a coal fired power plant.

In consideration of the site conditions for the project in question, the internationally advanced Grade F gas-steam combined cycle generating unit is recommended. The technology adopted by the generating unit at this grade is advanced, reliable and suitable. No brand-new technology is involved. Neither will there be any technical risks that are in contradiction with the locally available conditions. Judging from the desirable performance of the Grade F gas-steam combined cycle generating units that have been in the commercial operation, the Grade F gas-steam combined cycle generating unit to be constructed under the project in question will entail no technical risks in terms of the design, manufacturing, installation and construction as well as safety and reliability after it is put into the commercial operation.

15.4 Engineering risk analysis and countermeasures

15.4.1 Flood and water-logging disaster effect and preventive measures

On the basis of the currently available data of the tides, the high tide level near the project area in a 100-year return period is estimated to be 3.0m. The area planned for the project was converted into a relatively flat land through sea reclamation. The natural elevation of the land is about 4.0m. At the site of rainwater drainage condition is good, does not produce water-logging. The power plant can reach 100 years flood and water-logging control standard，also can achieve the requirements of *Technical code for designing fossil fuel power plants*.

15.4.2 Geologic conditions risk analysis

According to the seismic zoning map of Pakistan, the proposed site is located in Zone 2B. The Peak Ground Acceleration with 10% probability of exceeding in 50 years (475 years return period) is 0.18 ~ 0.24 g, and 0.20g is recommended, which is corresponding intensity of Ⅷ degrees.

The possible geological disasters of this project are: earthquake liquefied sand, land subsidence and flow.

Earthquake liquefaction protective measures should be taken after the possible liquefaction depth found out. The most effective method for soil improvement in this type of soil is vibroflotation and/or installation of Stone Columns.

During the period of project construction, especially in the process of excavation of pile foundation, Monitoring special settlement, displacement, piling vibration and pore water pressure are recommended at the space of gas turbine, turbine main workshop, gas turbine main transformer, turbine main transformer and other important buildings, which can monitor the construction process and completion settlement dynamic at any time.

Prevention of sand flow should be controlled in engineering before construction. After finding out the distribution features of the shallow silty sand ground, corresponding drop and drainage measures should be taken at the time of excavation, with corresponding containment measures according to the circumstance when necessary.

15.5 External collaboration risk analysis and countermeasures

15.5.1 Resources supply risk

The fuels of this project are supplied by SSGC and RLNG supplier. To avoid the risk of insufficient gas supply, KE should sign long term gas supply agreement with SSGC and RLNG supplier as soon as possible.

In this project, seawater is used as the water supply source. One-through cooling system will be adopted. Pump house and other facilities of No.3 and 4 units of the old plant. The water quantity of circulating water for new plant is less than the quantity of No.3 and 4 units of the old plant. The water intake facilities of No.3 and 4 units can make sure of the demand of the new plant.

The fresh water for the new plant comes from the pipe network of the old plant. There are four 3000m^3 water basins to supply the fresh water for the old plant. The flow of fresh water is 40m^3/h for each unit and the flow of fresh water is 55m^3/h for new plant. When no 3 and 4 units retired, the fresh water for the two units is 80m^3/h, which is larger than the water demand of new plant. Fresh water for this project is guaranteed.

15.5.2 Analysis of risk in large cargoes shipment

15.5.2.1 Risk recognition

Risks in various operations involved with in the project are given below. Items with "√" indicate potential risk and those with "×" indicate that there is almost no risk.

Schedule of Risks in Various Operations

Risk \ Operation		Sea transportation	Water carriage	Land carriage		Storage	Handling	Packaging	Loading and unloading
				Rail transport	Highway transport				
Natural risks	Rainstorm	√	√	√	√	√	√	√	√
	Hail	√	√	√	√	√	√	√	√
	Fog	√	√	√	×	√	×	×	×
	Sandstorm	√	√	√	√	√	√	√	√
	Freezing	√	√	√	√	√	√	√	√
	Earthquake	×	×	√	√	√	√	√	√
	Volcanic eruption	×	×	√	√	√	√	√	√
	Seaquake	√	×	×	×	×	×	×	×
	Windstorm	√	√	√	√	√	√	√	√
	flood	×	√	√	√	√	√	√	√
	Tunnel collapse	×	×	√	√	×	×	×	×
	Cliff fall	×	√	√	×	√	×	×	×
	Landslide	×	√	√	×	√	×	×	×
Accident hazard	Willful	√	√	√	√	√	√	√	√
	Fault	√	√	√	√	√	√	√	√
	Negligence	√	√	√	√	√	√	√	√
Economic risk	Market price falling	√	√	√	√	√	√	√	√
	Exchange rate fluctuation	√	√	√	√	√	√	√	√
	Default	√	√	√	√	√	√	√	√
Technical risks	Tools	√	√	√	√	√	√	√	√
	Cargoes	√	√	√	√	√	√	√	√
Political risk	War	√	√	√	√	√	√	√	√
	Nationwide Riot	√	√	√	√	√	√	√	√
	Demonstration	√	√	√	√	√	√	√	√

Risk \ ✦ Operation		Sea transportation	Water carriage	Land carriage		Storage	Handling	Packaging	Loading and unloading
				Rail transport	Highway transport				
✦	Strike	√	√	√	√	√	√	√	√
Social risk	Duty adjustment	√	√	√	√	√	√	√	√
	Quarantine restrictions	√	√	√	√	√	√	√	√
	Security of society	√	√	√	√	√	√	√	√

Shipment of large equipment for the project is subject to natural risk, fortuitous accident and technical risk. As the result of analysis of transportation route determined show, ascertainable natural risks are as a result of:

- Rainstorm: all operations in the plan are subject to impact of rainstorm. During rainstorm, all operations in the large equipment transport plan must be stopped, and rainstorm may result in delay of performance of the plan.
- Windstorm: in this plan, waterway transport is subject to the most serious impact from windstorm, and windstorm has minor impact on other operations. During windstorm, all operations in the large equipment transport plan must be stopped, and windstorm may result in delay of performance of the plan.
- Flood: all operations in the plan are subject to impact of flood. During flood, all operations in the large equipment transport plan must be stopped, and flood may result in delay of performance of the plan.
- Tunnel collapse: tunnel collapse has impact on highway and railway transportation, there is no report of probability of occurrence.
- Landslide: landslide has impact on highway and railway transportation, there is no report of probability of occurrence.

Risks arising out of accident are common to all plans. Execution organization is critical for aversion of the risks. In bidding for transport operations in the future, project executor shall be subject to higher requirement so as to avoid risk due to accident in so far as possible.

15.5.2.2 Measures for risk control

Control of risk in large equipment transportation is by two means, i.e., management control and financial handling.

(1) Management control

By this method, administrative measures are taken to prevent, eliminate or reduce risks. For performance of the project, it includes risk aversion, risk prevention and risk separation.

1) Risk aversion

Risk aversion means giving up or abstaining from activities or job which may result in loss. In respect of the project, as the activities compose a complicated system and are subject to various risks, it is impossible to avoid all risks. Therefore, risk aversion applies to certain cases only.

2) Risk prevention

Risk prevention means reduction of risks or mitigating loss resulting from the risks by means of prevention and control. This is an active way as compared with risk aversion. Although risks exist in the whole project, loss of the Owner and loss in operation can be reduced by active preventive measures. There are three major measures for risk prevention: 1) preventive measures, e.g., design of plan for large equipment transport, and the carrier is required to prepare more rational transport organization plan for prevention to the largest extent; 2) protection measures, e.g., packing and colligation of conveying articles, handling in strict accordance with specifications; 3) loss reduction measures for minimizing loss by minimizing range of loss after occurrence of a loss, e.g., reinforcement and reconstruction of bridges and roads.

3) Risk isolation

Risk isolation means isolation of unit of exposure confronted with by enterprises, e.g., separate transportation of individual large objects and ensuring certain distance among the objects during transportation so as to separate hazards and isolate risks. According to statistical data, when risks are equally distributed to n independent spaces, total risk after isolation is $1/\sqrt{n}$ of the original risk. When n＝100, total risk after isolation is 1/10 of the original risk. Risk isolation has significant effect on risk reduction. As there are restrictions by objective conditions, the executor shall present feasible measures.

(2) Accounting approach

This approach means risk handling by accounting techniques. For execution of the plan, there are two approaches, i.e., risk self-retention and risk passage.

1) Risk self-retention

Risk self-retention is a way of risk handling by which the Owner bears partial or all risks. Factors determining risk self-retention include: 1) necessity, when other ways are infeasible, risk self-retention is the only way; 2) controllability, risk self-retention is usually easy to operate and control; 3) economical efficiency.

In respect of the project, risk self-retention is advantageous than risk passage in the cases listed below: ① cost of risk self-retention is lower than additional premium for the insurer (e.g., loss by theft during large equipment transport); ② the carrier has many units Of exposure and is capable of isolation (e.g., in the case of separate transport of large equipment and spare parts, some insurances for spare parts is not required), ③ excellence of internal services or services of the carrier (selecting carrier of higher qualification can significantly reduce insurance expense.

2) Passage of risk

Passage of risk is a way of transferring risks to others by an enterprise. The two methods listed below are suggested:

① Passing of title

Passing of title means passage of titled-related risk to the supplier instead of passage of risk from the supplier to oneself before arriving at work site. By this method, "CIF" commercial clause is entered into with the supplier and the supplier takes charge of transportation.

② Insurance

Passage of risk by insurance means passage of risks to the insurer by means of insurance. By this method, the Owner pays certain amount of insurance premium to the insurer periodically and it will be compensated in the case of accident occurring within insurance coverage. Steps of risk handling by means of insurance are given below:

A、Determining optimal types of risks to be covered for execution of the plan according to the final transportation scheme;

B、Selecting insurer;

C、Consulting with the insurer on object of insurance and insurable interest;

D、Analyzing and selecting way of reducing insurance cost;

E、Verifying that clauses of insurance contract are as required for risk handling;

F、Enter into insurance contract when the conditions are met, otherwise adjustment is required till the conditions are met.

15.5.2.3 Energetic guarantee risk analysis

Based on experiences in construction of similar projects in the country and abroad and the practical situations, risk in energy guarantee during construction period exists in sudden interruption of power supply and water supply which will result in interruption of operations such as concrete placement which requires continuous work.

To avoid risk in power supply for construction and ensure power supply for construction, it is advised that measures for avoiding peak hours of power utilization be taken during main works construction so as to make full use of power supply capability and ensure normal proceed of the operations. For construction works requiring continuous operation, the construction site shall be provided with diesel generators as emergency standby power to ensure continuous construction in the case of power failure.

To avoid risk in water supply during construction, adequate water source for construction shall be ensured. Source of water for construction of the project is groundwater near the plant area. Capacity and quality of water source for construction are reliable, and permit for freshwater supply from related authority has been obtained. Furthermore, water stored for firefighting shall be not for other purposes and technical measures shall be taken to prevent water quality deterioration.

16 Economic and social impact analysis

16.1 Economic impact analysis

The installed capacity of this project is 900MW, which is beneficial to remit the economic restriction of Karachi due to power shortage.

The project will supply stable, clean and cheap electrical source to the area and promote further development of upstream and downstream industrial chains (e.g., textile industry, transport service and building materials industry) and promote healthy development local economy.

To ensure normal operation of the project after completion, service staff will be provided for the power plant for transport, inspection, processing and logistics in addition to the plant management and production personnel. This will promote development third industry and provide employment opportunities from industries in relation to the power plant.

16.2 Social impact analysis

16.2.1 Alleviate tension in supply of electric power in Pakistan

Pakistan has low degree of self-sufficiency of energy resources. Today, 40% of its primary energy source supply is imported. In recent years, Pakistan is confronted with tension in supply of electric power. Development of this project will alleviate the tension in electric power supply in Karachi.

16.2.2 Provide employment opportunities

Construction of the project will provide employment opportunities for hundreds of persons and result in tangible and intangible industrial chains such as machine maintenance, automobile maintenance, business, service industry and food and beverage industry which allow considerable number of persons to obtain employment and not only alleviate tension in employment confronted with by the government and burden of social and labor security sectors but also increase income of local labors.

16.2.3 Uplift living standard and quality of life of the employed

Those newly employed will experience change of life after execution of the project, and with increase in revenue, their inhabited environment, traffic, living standard and life style will experience change.

16.2.4 Promote social stability

Economic development will certainly result in social stability, and harmonious society is a foundation for social stability.

16.2.5 Uplift technological level and increase income

Development of the project and establishment of industrial chain will attract many design and scientific research institutions to study, development construction which in providing technical support for the project will have its technological level and professional work uplifted and acquire economic benefit.

16.2.6 Positive social effect and social benefit

Development of the project will make contribution to the society, promote national economy development and economic prosperity, increase economic benefits of the enterprises and enhance social stability. Therefore, execution of the project will create positive social influence and social benefit.

16.2.7 Conclusion of social assessment

As analysis of the social impact and adaptability of the project to local conditions show, the project will result in positive effect and satisfactory social benefit, and the project is of social feasibility. With support of the organizations and active participation of the society, execution of the project will go smoothly and make expected social and economic benefits.

17 Conclusion and suggestion

17.1 Necessity of the project

Karachi is presently faced with severe power shortage especially in summer peak. This project is base on business plan of KE. The power generating capacity of this project is necessary for meet the power peak demand both in 2018 and 2019. Hence, this project construction is in favor of raising power supply installed capacity of KE company and satisfying load development demands.

17.2 Feasibility of the project

(1) Power output. Two sets 9F generators in BQPS-3 will connect to the new 220kV GIS, and evacuate power to KE system through the existed transmission lines.

(2) The land for this project is inside the boundary of BQPS-1 power plant. The land has open and flat terrain, and the plant site satisfy the demand for use of land for the project.

(3) In this project, seawater is used as the source of cooling water. One-through cooling system will be adopted. After the decommission of No.3 and 4 units of BQPS-I, Two new units of this project will utilize the circulating pump house and other facilities of those units. The water quantity of circulating water for this project is less than the quantity of No.3 and 4 units of BQPS-I. So the water intake facilities of No.3 and 4 units can make sure of the demand of this project.

The demi water and service water are supplied by BQPS-I. The quantity and quality of water production of water treatment facility in BQPS-I can meet the requirement of this project.

Retrieval No.
100-XA04421K-A01

2×450MW BQPS-III Power Plant Project　Feasibility Study

Grid Interconnection Study

国核电力规划设计研究院有限公司
STATE NUCLEAR ELECTRIC POWER PLANNING DESIGN&RESEARCH INSTITUTE CO.,LTD.

Engineering Design Comprehensive Class A
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Pakistan BQPS-III 2×450MW Combined Cycle Power Plant and Supporting Renovation Project

Feasibility Study

Major Content

No	Name	Volume Retrieval No
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	Section I: Grid Interconnection Study for 2×450MW BQPS-III Power Plant Project	**100-XA04431K-A01**
	Section II: Grid Interconnection Study for Alteration of KPC-I Evacuation System	100-XA04421K-A01
Volume II	Pakistan Karachi KE KPC-I 248MW Power Evacuation System Alteration Feasibility Study Report and Drawings	100-FA05671E01-A-01
Volume III	Pakistan BQPS-III 2×450MW Combined Cycle Power Plant Feasibility Study Report and Drawings	30-F007101K-A

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1.2 Study Scope

Based on the interconnection scheme of BQPS-3 power plant and related electrical calculation, the report discusses the impact on power system after the power plant interconnecting to the grid, proposes feasible solutions to potential grid problems and raises suggestions on grid reinforcement.

1.3 Commissioning Schedule and Study Level Year

Considering the decommissioning plan of BQPS-1 power plant, the commission schedule of BQPS-3 2×450MW combined cycle power plant is listed as follow:

(1) May 2018, the 1st open cycle unit (280MW) in commission;

(2) November 2018, #4 unit(210MW) of BQPS-1 decommissioned;

(3) January 2019, the 1st combined cycle unit (170MW) in commission;

(4) May 2019, the 2nd open cycle unit (280MW) in commission ;

(5) November 2019, #3 unit (210MW) of BQPS-1 decommissioned;

(6) January 2020, the 2nd combined cycle unit(170MW) in commission

Thus, the study level years are selected as 2018, 2019 and 2020.

1.4 Approach and Key Content

Approach: Aiming at optimizing the overall scheme, during the study, TP-1000 transmission project will be taken into account and long-term perspectives and scientific verification will also be adopted to ensure the power grid operated safely and reliably. Capability of transmission lines will be fully utilized in order to save transmission line corridor resources.

Key Content: The impact on power grid after interconnection of 2×450MW BQPS-3 power plant will be analyzed via power balance analysis, load flow calculation and short circuit current calculation. Furthermore, feasible solutions to potential grid problems and suggestions on grid reinforcement will be proposed.

2 Overview of Karachi Power Grid

At present, the highest voltage level in Karachi power grid is 220kV. Karachi power grid has formed the 220kV double-circuit looped network and connected with NTDC grid by four 220kV circuits (220kV BALDIA—NKI transmission line, 220kV KDA—NKI transmission line and double circuit 220kV KDA—JAMSHORO transmission line). According to the location of 220kV substations and load distribution, Karachi power grid could be divided into 5 supply divisions, which are PIPRI WEST, KCR-LALAZAR, KDA, BALDIA and MAURIPUR. The peak load of Karachi power grid in 2016 was 3195MW.

In 2016, the total installation capacity of Karachi power grid was 3340MW (2973MW available), including KE installation capacity 2268MW (1966MW available), IPP installation capacity 422MW (357MW available) and 650MW imported from NTDC, as attached in table 2.1-1.

In Karachi power grid, there are six 220kV substations, twelve main transformers with total capacity of 3000MVA. There are twenty 220kV transmission lines in the grid with total length of 338.02km, including

323.3km overhead line and 14.71km underground cable. There are sixty 132kV substations, one hundred and thirty main transformers with total capacity of 4809.5MVA. There are ninety-eight 132kV transmission lines in the grid with total length of 761.9km, including 611.203km overhead line and 150.697km underground cable.

The network diagram for Karachi 132kV and above grid in 2016 is shown in Fig.2.1-1.

Existing Problems of Karachi Grid:

(1) Lack of Generation

The total installation capacity of Karachi power grid is 3340MW. Most power plants in Karachi are oil or gas generator units, which have been running for a long time and some of these units have even past their original retirement age. Due to the shortage of fuel supply and the aging of equipments, the available installation capacity of gird is about 2323MW at present. Taking 650MW power imported from NTDC into account, the maximum power supply capability is only about 2973MW. During peak load period, Karachi grid has to shed around 200MW load.

(2) Insufficient power supply capability due to weakness and high losses of grid

Currently, the main transformers load ratio in most 220kV and 132kV substations in Karachi power grid is usually over 70%. And some substations have been even close to limitation. Evacuation capability of some 220kV and 132kV transmission lines is restricted by small cross-section conductors, leading to bottleneck problems.

As a result of aging equipments and widespread electricity stealing, Karachi power grid has very high line losses. According to the statistics, line losses of Karachi power grid was 35.9% in 2009. By optimizing management of power distribution grid and implementing technical measures, line losses have reduced to 22% currently.

(3) System short circuit current level is generally high

Auto-transformers with direct grounding system are widely used in substations of Karachi grid. Therefore, the single phase short circuit current of power system is usually high. Moreover, most 132kV power supply divisions are not available for opening loop. Short circuit currents of some substations or switchgears have been approaching the limit of rated breaking capacity. As the development of generation and power grid, the power system capacity will keep increasing, and the system short circuit current will also become higher and higher. So, implementing technical measures to reduce short circuit current is very necessary.

(4) Preliminary work will be more and more difficult due to the resource shortage of the transmission right-of-way.

Table 2.1-1 Installation details of Karachi Grid, 2016

Classification	No.	Power Plants	Installation Capacity (MW)	Available Capacity (MW)
KE	1	BQPS-1	1260	985
	2	BQPS-2	560	557
	3	KPC-I	248	239
	4	SGTPS	100	88
	5	KGTPS	100	97
In Total			**2268**	**1966**

IPP	6	APGL	12	12
	7	Gul Ahmad	127.5	127.5
	8	KANUP	137	75
	9	Tapal	123.5	123.5
	10	IIL-1&2	22	19
In Total			**422**	**357**
Imported	11	NTDC	**650**	**650**
In Total			**3340**	**2973**

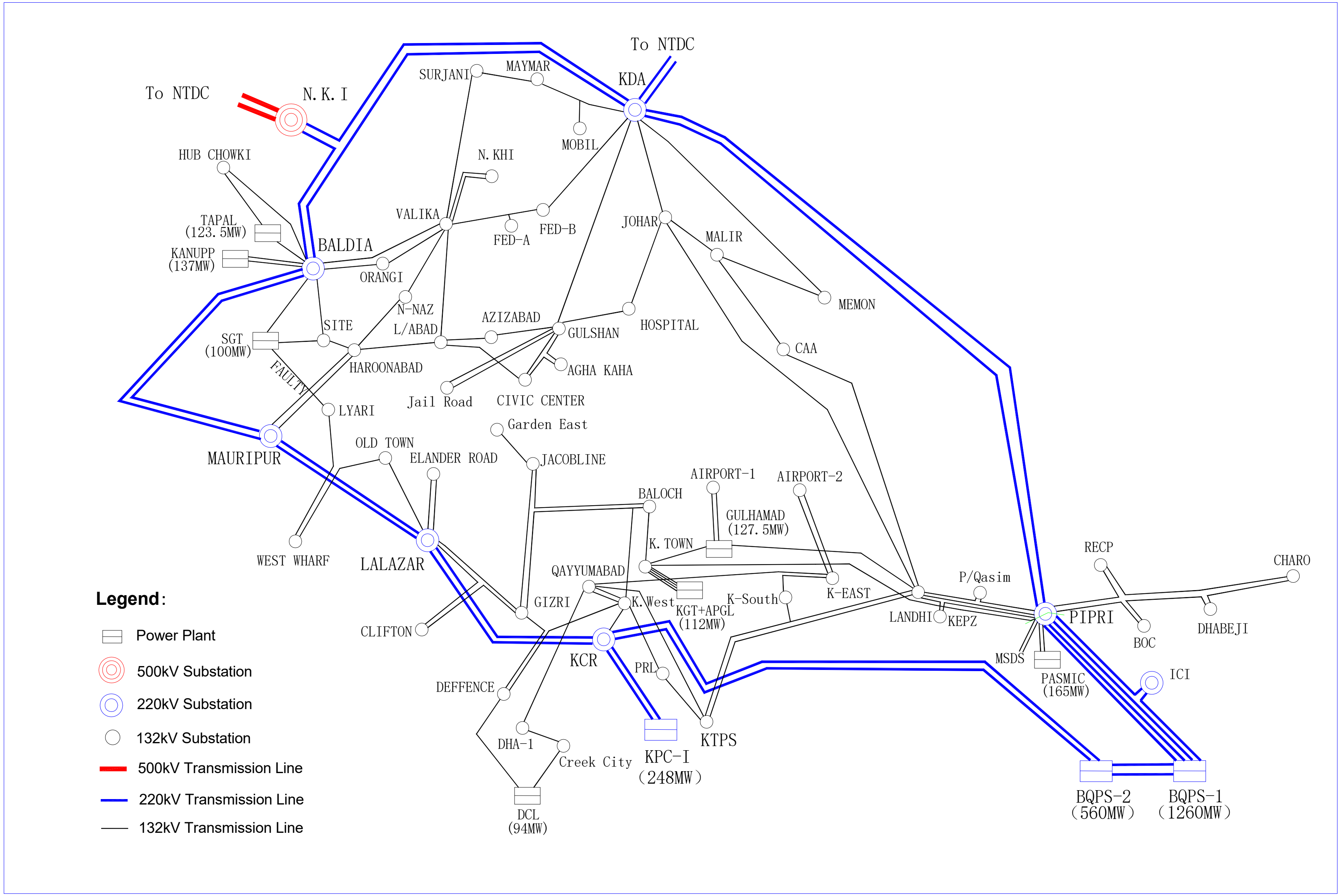

Fig .2.1-1 Network Diagram for Karachi 132kV and above Grid in 2016

3 Peak Load Forecast and Power Balance

3.1 Peak Load Forecast

Karachi is located on the south coast of Pakistan and northwest of delta of the Indus, bordered by the Arabian Sea on the south. The population of Karachi is about 20 million and the area is about 3527 km2. As the largest city in Pakistan, Karachi has almost 30% manufacturing industry and 95% overseas trade of the country. According to the load forecast by KE, the peak load of Karachi power grid will reach 4709MW up to 2023. The annual growth rate from 2017 to 2023 is about 5.7%. Load forecast details are shown in table 3.1-1.

Table 3.1-1 Load Forecast of Karachi Power Grid from 2017 to 2023

Year	2016	2017	2018	2019	2020	2021	2022	2023	Annual Growth
Peak Load (MW)	3195	3377	3569	3773	3988	4215	4455	4709	5.7%

3.2 Generation Initiatives

KE planned to add about 2747MW generation projects by 2020 to solve the power shortage in Karachi. 697MW of these generations will be interconnected to 132kV grid and principally consumed locally to relieve the power supply pressure of 220kV grid. The other 2050MW generation (BQPS-3, DATANG and ENGRO) will be interconnected to 220kV grid. Construction plan of main power plants in Karachi from 2017 to 2020 is shown in table 3.2-1. With the construction of BQPS-3 power plant, 2 units of BQPS-1 power plant will decommission between 2018 and 2020, which are unit 3 and unit 4. Besides, KE planned to stop importing power from NTDC by 2020. Decommissioning plan of power plants in Karachi from 2017 to 2020 is shown in table 3.2-2.

Table 3.2-1 Construction plan of main power plants in Karachi

Project	Owner	Installation (MW)	Fuel	Voltage (kV)	Expected COD
FPCL	FFBL	52	Coal	132	Mar.2017
SNPC	GOS/TK	100	Gas	132	Mar.2017
Oursun	MG/NB/AA	50	Solar	132	Mar.2018
BQPS-3	KE	280	Gas	220	May 2018
		170			Jan. 2019
		280			May 2019
		170			Jan. 2020
Western Electric	Tapal	295	HFO+GAS	132	Feb. 2019
Orient Kolachi	Orient/KE	200	RFO+RLNG	132	Feb. 2020
ENGRO	ENGRO/KE	450	RLNG	220	Dec. 2019
Datang	CDTO/CMEC/KE	700	Coal	220	Oct. 2020
In Total		2747			

Table 3.2-2 Decommissioning plan of power plants in Karachi

Unit	Owner	Installation (MW)	Fuel	Voltage (kV)	Planed Date
BQPS-1 #4 Unit	KE	210	HFO	220	Nov. 2018
BQPS-1 #3 Unit	KE	210	HFO	220	Nov. 2019
Imported	NTDC	650		220	2020
In Total		1070			

3.3 Power Balance Analysis

By the end of 2016, the total effective installation capacity of Karachi is about 2973MW (including imported from NTDC).

Power Balance Conditions:

- As the peak load of Karachi power grid normally occurs in summer, from May to June. In the power balance study, the capacity of units, which are expected in commission in the first half year, are taken into account in current year and capacity of units, which are expected in commission in the second half year, are put into the next year.

- Wind power and solar power are not taken into account.
- In the power balance study, the reserve capacity is set at 15%, including 5% load reserve and 10% emergency reserve. During peak load period, emergency reserve is not considered.

Based on the load forecast results, construction plan of main power plants and decommissioning plan, the power balance analysis of Karachi power grid is conducted for 2018, 2019 and 2020. The results are shown in table 3.2-1.

Table 3.2-1 Results of Power Balance Analysis

Year	**2018**	**2019**	**2020**
1. Required Installation(MW)	4104	4339	4586
1) Peak Load(MW)	3569	3773	3988
2) 15% Reserve(MW)	535	566	598
2. Available Installation(MW)	3632	4176	4714
1) KE(MW)	2283	2543	2523
2) IPP(MW)	699	983	2191
3) Imported(MW)	650	650	0
3. Installation Surplus/Deficit(MW)			
1) Full Load	63	403	726
2) 15% Reserve	-472	-163	128
3) Without BQPS-3 (Full Output)	-217	-117	246
4) Without Datang & Engro (Full Output)			-424

As shown in the results of the power balance analysis:

(1) If without BQPS-3, there will be at least 217MW power shortage in summer of 2018.

(2) If BQPS-3 and all other planned projects could be in commission in time,

Karachi power grid would meet the load demand under full output mode in summer of 2018. And up to 2020, as the commissioning of planned generation step by step, Karachi power grid may have a surplus of 128MW~726MW.

According to current status of projects progress, there is still some uncertainty for Datang and Engro generation projects.

(3) If Datang and Engro power plants cannot be in commission in time, there will be at least 424MW deficit in Karachi power grid.

Hence, in order to guarantee sufficient power supply, it is necessary to speed up the construction of planned generation projects.

3.4 Project Necessity

(1) To fulfill Load Demand

According to the results of load forecast, the peak load of Karachi power grid will reach 3569MW in 2018 and 4709MW in 2023, with the annual growth rate of 5.7%. Karachi power grid cannot meet the load demand with current capability. Based on the power balance study, Karachi power grid will have a power gap of 217MW at least in 2018. Constructing one open cycle unit of BQPS-3 before the peak load period in 2018 could mostly fill the gap and almost meet the load demand.

(2) To Solve Short Circuit Current Problems of BQPS Power Plant, Improving the Operation Reliability

At present, the single phase short circuit current of both BQPS-1 and BQPS-2 have overreach the rated breaking capacity 40kA. According to the result of short circuit study, if there was no limitation measurement, the bus short circuit current of both BQPS-1 and BQPS-2 will have a further increase after the commissioning of BQPS-3.

A new constructed 220kV GIS (50kA) in BQPS-3 project, instead of existing BQPS-1 GIS (40kA), and installation of current limiters in short links between BQPS-3 and BQPS-2 could effectively solve the short circuit current problem of BQPS power plant, improving operation reliability.

In conclusion, in order to meet the load demand in 2018, improving operating safety of BQPS power plant, the project is very necessary.

4 Interconnection Scheme

4.1 Overview of BQPS Power Plant

BQPS power plant is located at southeast of Karachi, nearby port Qasim. The existing total installation capacity of BQPS is 1820MW, including 1260MW BQPS-1 and 560MW BQPS-2.

Units of BQPS-1 are connected to 220kV BQPS-1 switchgear (40kA GIS) via 6 two-winding transformers, while units of BQPS-2 are connected to 220kV BQPS-2 switchgear (40kA GIS) via 4 two-winding transformers.

The 220kV switchgears of both BQPS-1 and BQPS-2 are all located at BQPS-1 power plant, and are interconnected with each other by two short links. One of the short links is 1600mm^2 XLPE with rated capacity of 1800A and the other is GIL with rated capacity of 3150A.

The electrical arrangement of BQPS-1 GIS is double-bus, which has 6 outgoing lines: 3 to Pipri West, 1 to ICI and 2 to BQPS-2. The electrical arrangement of BQPS-2 is also double-bus, which has 4 outgoing lines: 2 to KCR and 2 to BQPS-1. The electrical single line diagram (SLD) of BQPS power plant before BQPS-3 is shown in Fig. 4.1-1.

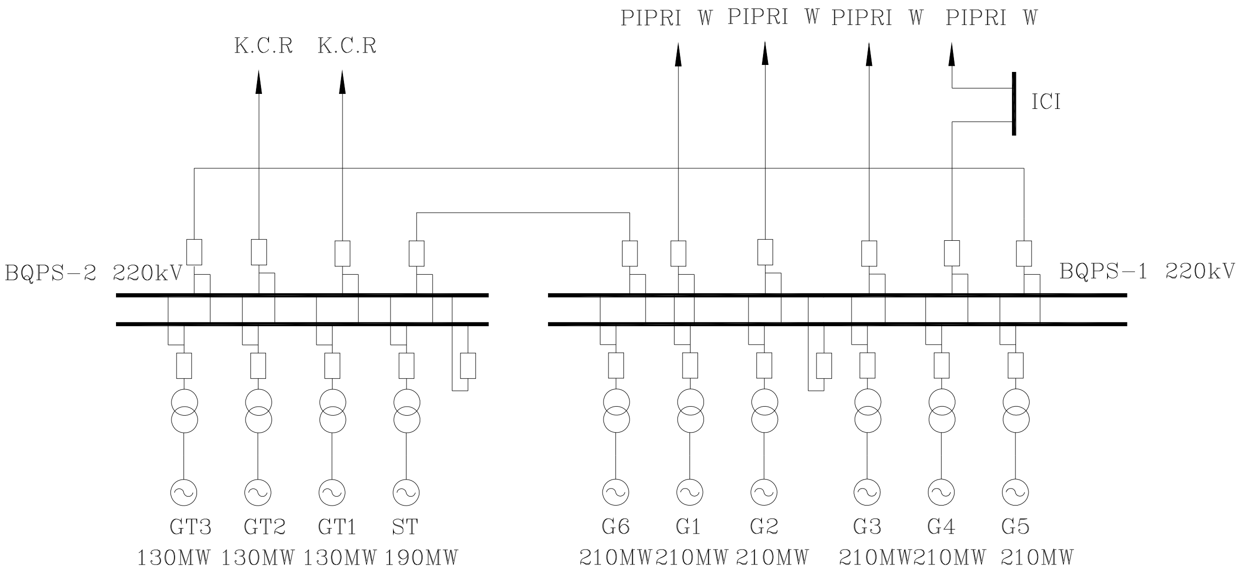

Fig. 4.1-1 Existing Electrical Single Line Diagram of BQPS Power Plant

In this project, it is planned to construct 2×450MW 9F class gas-steam combined cycle units (BQPS-3) within BQPS-1 power plant. Units of BQPS-3 will be in commission step by step from May 2018 to January 2020. In coordination with decommissioning plan of BQPS-1, the commissioning sequence of units of BQPS-3 is shown as following:

(1) May 2018, the 1st open cycle unit (280MW) in commission;

(2) November 2018, #4 unit(210MW) of BQPS-1 decommissioned;

(3) January 2019, the 1st combined cycle unit (170MW) in commission;

(4) May 2019, the 2nd open cycle unit (280MW) in commission ;

(5) November 2019, #3 unit (210MW) of BQPS-1 decommissioned;

(6) January 2020, the 2nd combined cycle unit(170MW) in commission

4.2 Evacuation Conditions of BQPS and Grid Adaptability Analysis

4.2.1 Evacuation Conditions of BQPS

At present, BQPS power plant has six 220kV evacuation lines, which are connected to the 220kV Karachi power grid. Among these lines, 4 of them are connected to the PIPRI WEST substation and 2 of them are connected to the KCR substation. All these lines are using 2×400mm^2 conductors and the designed rated capacity is 1780A.

However, from the information offered by KE, the actual rated capacity is only about 1000A as a result of equipments aging, the total evacuation capability of all 6 transmission lines is about 2280MW. In this project, 2× 450MW units will be commissioned. Considering the decommissioning of #3 and #4 units of BQPS-1, the total effective generation capacity of BQPS will be about 2120MW.

4.2.2 KPC-I Power Plant

KPC-I power plant is located at Korangi Creek, south of Karachi, which has a total installation capacity of 248MW and available capacity of 239MW. The electrical arrangement of 220kV switchgear is double-bus. KPC-I power plant is currently connected to KCR substation via two 220kV transmission lines. The conductors of these transmission lines are both 800MCM. The rated transmission capacity of double circuit is 600MW.

There is KTPS 132kV switching station (31.5kA AIS) in the plant with double bus configuration. The switching station has 4 outgoing lines: 2 to Landhi, 1 to PRL and 1 to QAYYUMABAD.

In order to relieve supply pressure of 220kV KCR substation, it is planned to alter the evacuation system from 220kV to 132kV before summer peak load period of 2018. The alteration scheme is described as follow:

(1) Constructing a new 132kV GIS (40kA) with double-bus configuration within KPC-I, replacing existing 132kV KTPS, and reconnecting all 4 outgoing lines of KTPS to the new GIS.

(2) Expanding the existing 220kV GIS with 2 transformer feeders bays, and the electrical arrangement of 220kV GIS will be kept as double bus configuration

(3) Installing 2×250MVA (220kV/132kV) auto-transformers, connecting with 220kV GIS and 132kV new GIS.

(4) Under normal operation, the existing KPC-I-KCR double-circuit transmission lines will be opened for standby.

The alteration scheme of KPC-I evacuation system is displayed in Fig.4.2-1.

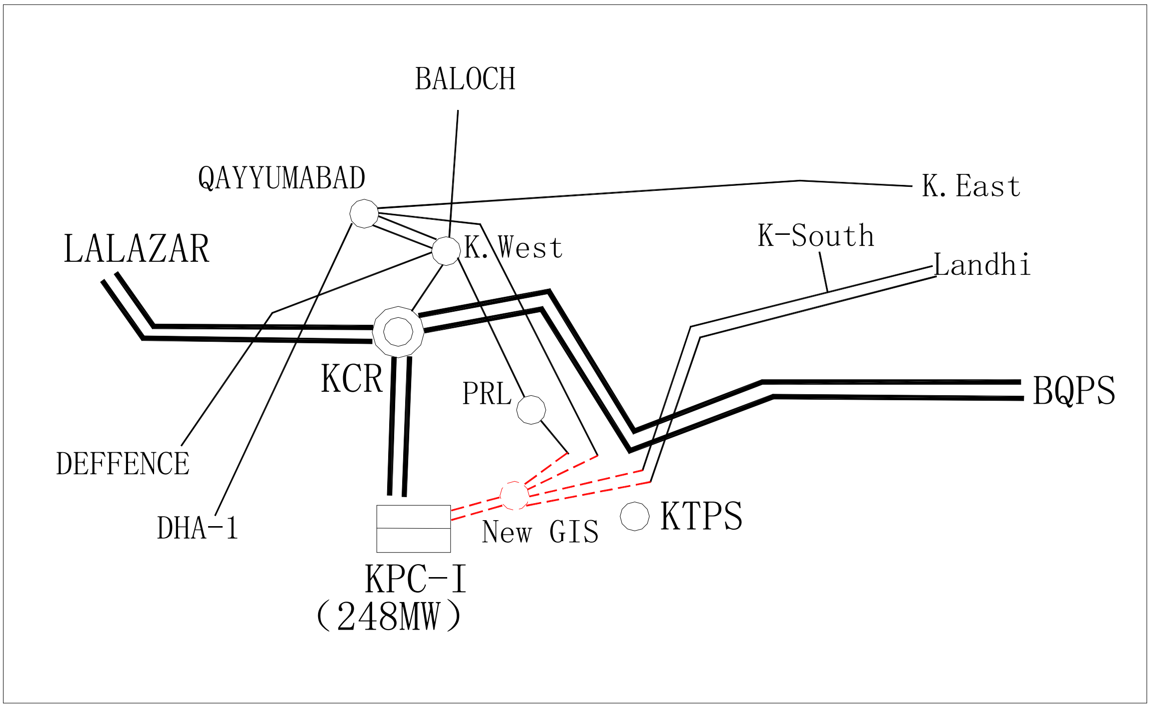

Fig.4.2-1 Alteration Scheme Sketch of KPC-I Evacuation System

4.2.3 220kV PIPRI WEST Substation

The existing PIPRI WEST 220kV substation has a total capacity of 3×250MVA and nine 132kV outgoing lines. PIPRI WEST 220kV substation is supplying more than ten 132kV substations, including P/QASIM, LANDHI and KEPZ.

The maximum transmission capability of Pipri West—P/QASIM, Pipri West—LANDHI and Pipri West—KEPZ are 375MW in total, and the present load ratios of these 132kV lines are from 53% to 103% in peak load period. During peak load period, PIPRI WEST-P/QASIM transmission line will be overloaded. As the increase of load demand, without new 132kV power sources, the power supply pressure of PIPRI WEST substation will rise further.

4.2.4 Grid Adaptability Analysis for Karachi 220kV Grid

Because of the relatively small cross-section of conductors (400mm^2

overhead line+800mm^2 underground cable), the maximum transmission capability of 220kV KCR-LALAZAR double-circuit lines is only about 600MW.

In peak load period, KPC-I power plant and BQPS power plant are delivering 200MW and 400MW power via KPC-I-KCR and BQPS-KCR double-circuit 220kV transmission lines to KCR substation respectively. After step-down transformation in KCR (about 200MW), the rest 400MW power is delivered to LALAZAR through double-circuit 220kV KCR-LALAZAR transmission lines. The load ratio of the line is 67%, which cannot meet the N-1 contingency requirement.

After the commissioning of BQPS-3 and decommissioning of #3 and #4 units in BQPS-1, Karachi 220kV grid will have 480MW additional net power under normal operation mode. Load flow through KCR-LALAZAR transmission lines will be heavier, or even overloaded. To ensure the safe power supply, it is needed to upgrade the existing 220kV grid with reinforcement.

Table 4.2-1 Transmission Capability of Related Transmission Lines

Line	Circuits No.	Voltage	Conductor	Capability
BQPS-PIPRI WEST	4	220kV	2×400mm^2	1524MW
BQPS-KCR	2	220kV	2×400mm^2	762MW
KPC-I-KCR	2	220kV	800 MCM	600MW
KCR-LALAZAR	2	220kV	400mm^2	600MW
PIPRI WEST-P/QASIM	1	132kV	240mm^2	130MW
PIPRI WEST-KEPZ	1	132kV	240mm^2	130MW
PIPRI WEST-LANDHI	1	132kV	240mm^2	130MW
KTPS-LANDHI	2	132kV	400mm^2	360MW
KTPS-PRL	1	132kV	500 MCM	130MW
KTPS-QAYYUMABAD	1	132kV	400mm^2	180MW

4.3 Transmission Project TP-1000

In order to improve the power transmission capability of 220kV and 132kV grid, solve the overloaded problems for some part of grid and satisfy the evacuation requirements of planned generation, KE has planned to undertake TP1000 plan. The scope includes adding six 220kV transformers (1500MVA) and twenty-five 132kV transformers (1000MVA), constructing or rebuilding 96km 220kV transmission lines and 39km 132kV transmission lines before Oct. 2018. Main projects of TP-1000 are listed as following:

(1) 220kV Transmission and Transformation Projects

- New Port Qasim 220kV Switch Station
- Gulshan 220kV Substation (2×250MVA)
- Surjani 220kV Substation (1×250MVA)
- Expansion of Mauripur 220kV Substation (1×250MVA)
- Expansion of Baldia 220kV Substation (1×250MVA)
- Expansion of KCR 220kV Substation (1×250MVA)
- New KDA-Gulshan Double-Circuit 220kV transmission lines
- New KDA-Baldia in/out Surjani 220kV transmission lines
- New Port Qasim-KDA Double-Circuit 220kV transmission lines
- Reinforcement of KCR-LALAZAR Double-Circuit 220kV lines

(2) 132kV Transmission and Transformation Projects

- Labour Square 132kV Substation (2×40MVA)
- Shadman Town 132kV Substation (2×40MVA)
- Old Golimar 132kV Substation (2×40MVA)
- Gadap 132kV Substation (2×40MVA)
- New Maymar-Gadap 132kV transmission line

- Reinforcement of Pipri West-Port Qasim 132kV transmission line
- Other 132kV substations and transmission lines projects

The network diagram for 132kV and above grid in 2020 is shown in Fig.4.3-1.

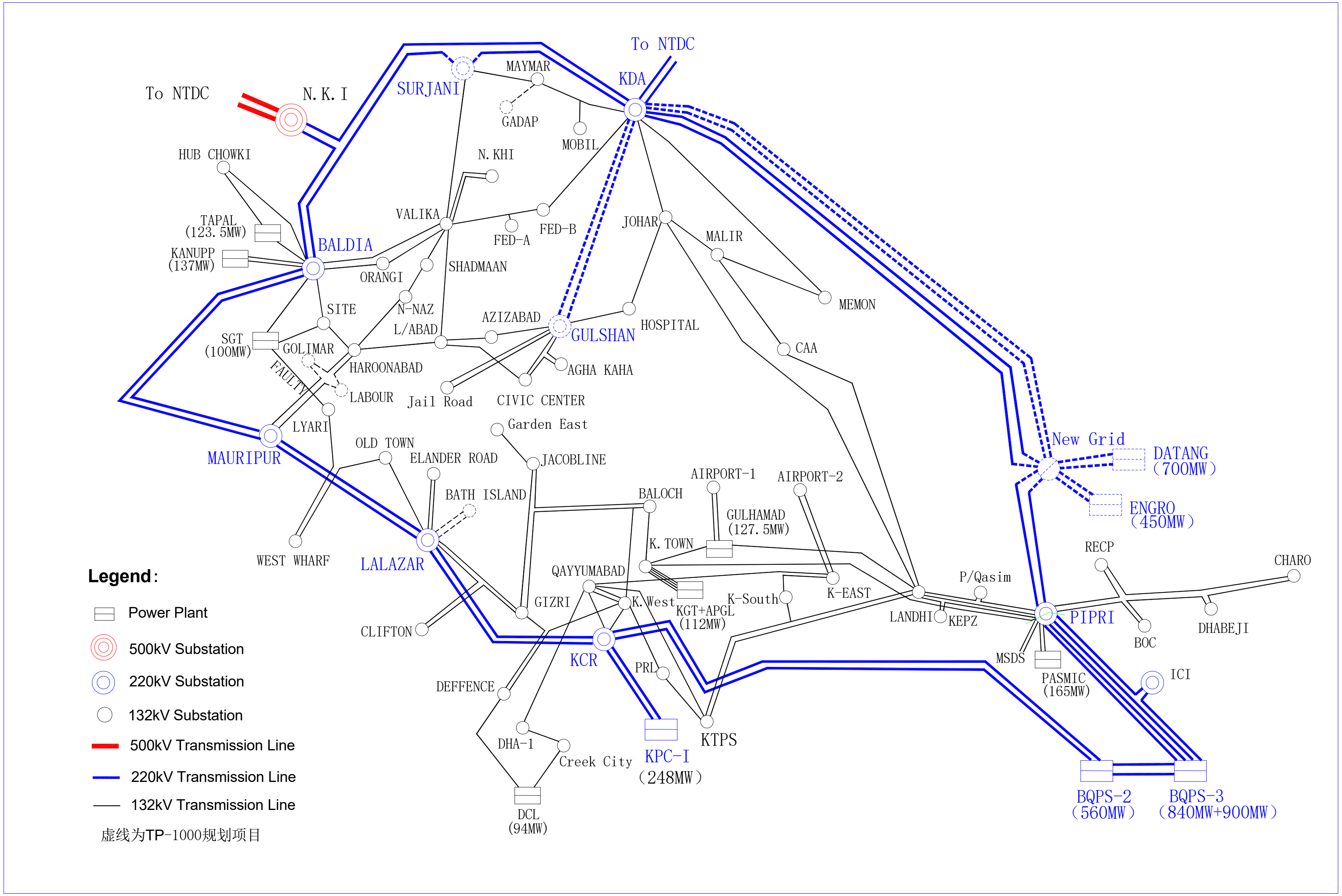

Fig.4.3-1 Network Diagram for 132kV and 220kV Grid in 2020

4.4 Interconnection Scheme of BQPS-3

Keeping in view of the 220kV network situation mentioned above in the vicinity of BQPS power plant, the interconnection scheme of BQPS-3 is proposed as follows:

2×450MW units of BQPS-3 will be connected to the new constructed 220kV GIS via two-winding transformers. Electrical arrangement of the new constructed GIS will be double-bus double subsection configuration with 6 outgoing lines including 3 to Pipri West and 1 to ICI reconnected from BQPS-1 and 2 new constructed short links with current limiters between BQPS-3 and BQPS-2. The existing short links between BQPS-1 and BQPS-2 will be demolished.

In coordination with commissioning of BQPS-3 and decommissioning of #3 & #4 units in BQPS-1, #1, #2, #5 and #6 units of BQPS-1 will be reconnected to BQPS-3 GIS step by step, and the existing 220kV GIS of BQPS-1 will be decommissioned finally.

Interconnection scheme of BQPS-3 is displayed in Fig.4.4-1.
The final electrical single line diagram for BQPS is shown in Fig.4.4-2.

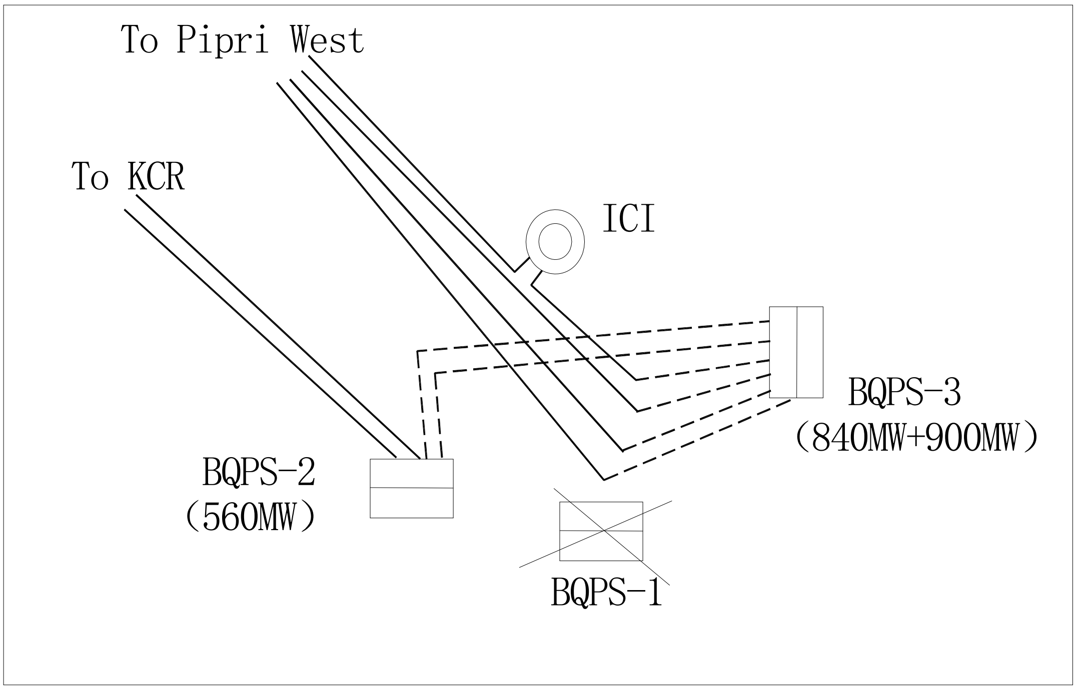

Fig.4.4-1 Interconnection Scheme Sketch of BQPS-3

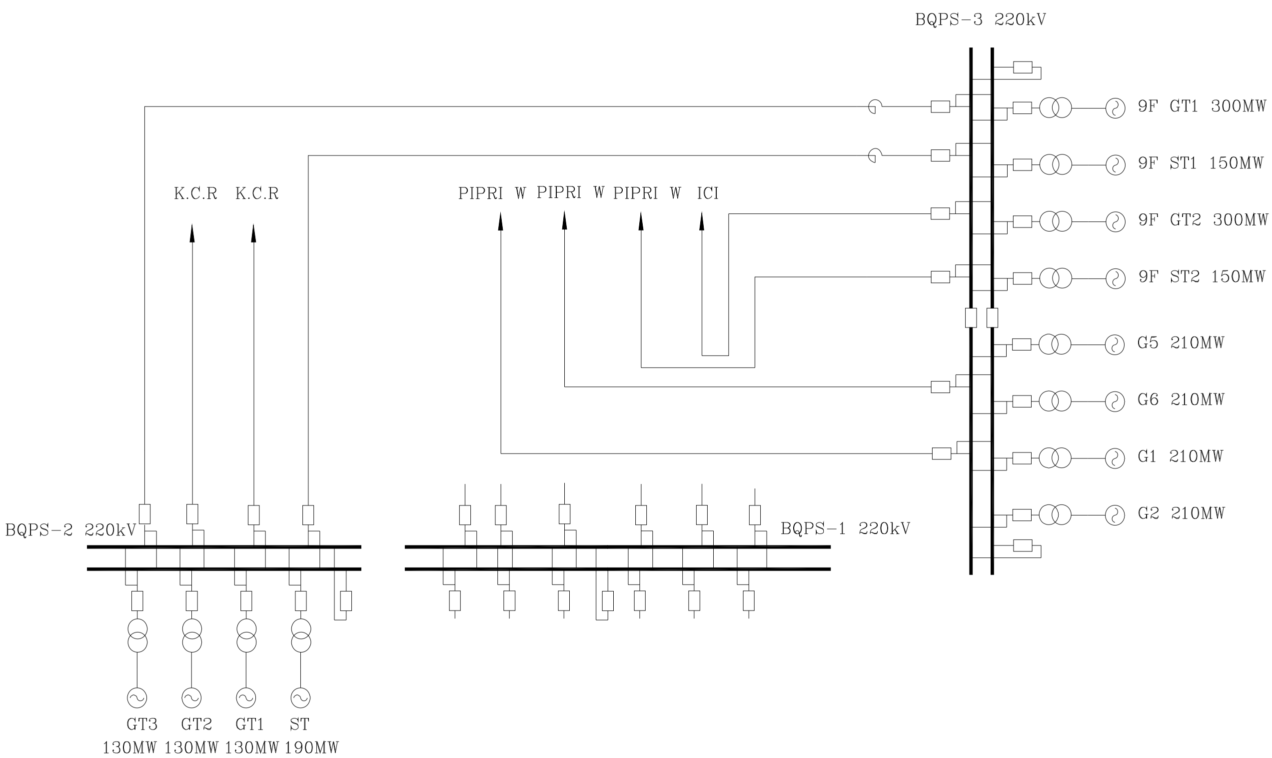

Fig.4.4-2 Final Electrical Single Line Diagram of BQPS

Temporary Interconnection Scheme during Construction Period:

During the BQPS-3 construction period, in order to avoid critical impact on Karachi power grid, the 220kV GIS of BQPS-1 will be kept running before the second combined cycle generator unit of BQPS-3. In such a situation, 220kV BQPS—ICI transmission line will be altered to BQPS-3 from BQPS-1 firstly, and the short links between BQPS-1 and BQPS-2 will be replaced by short links between BQPS-3 and BQPS-2. Additionally, a short link will be constructed between BQPS-1 and BQPS-3.

During construction period, the temporary interconnection scheme of BQPS-3 is shown in Fig.4.4-3 and the electrical single line diagram of BQPS is shown in Fig.4.4-4.

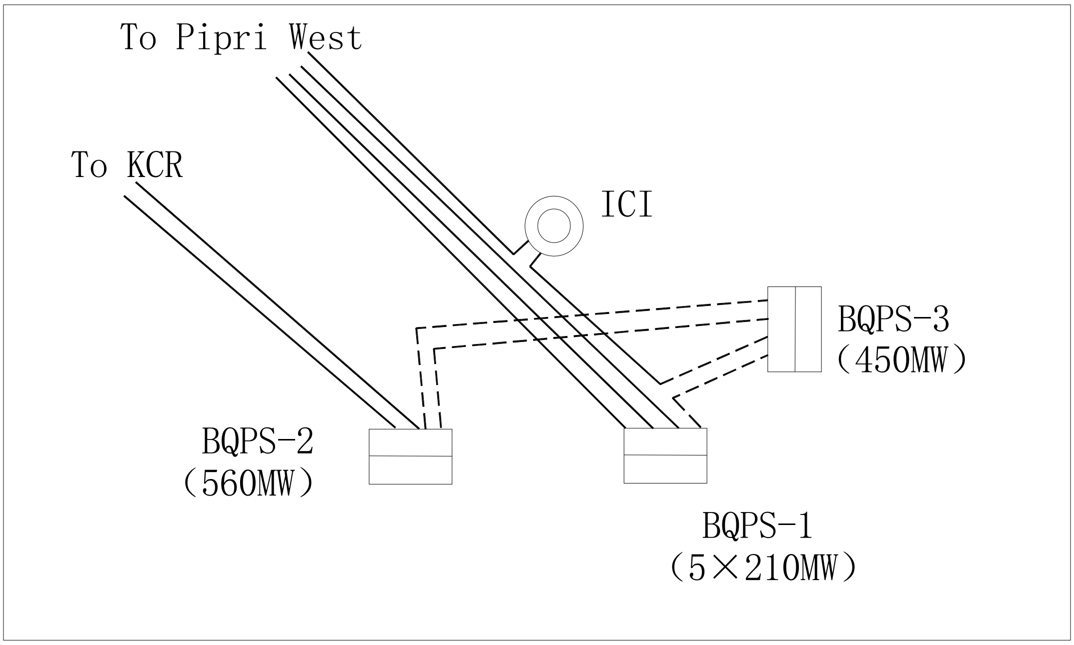

Fig.4.4-3 Temporary Interconnection Scheme Sketch of BQPS-3

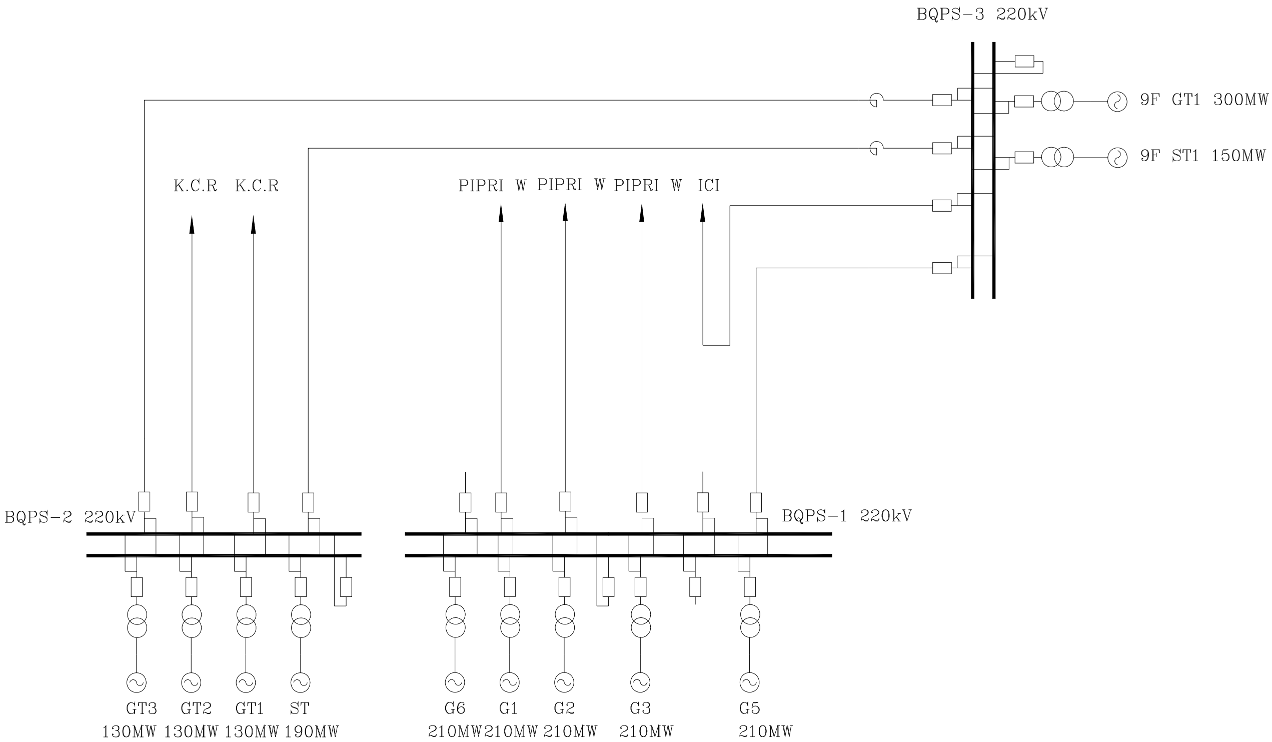

Fig.4.4-4 Electrical Single Line Diagram of BQPS during Construction Period

Before the second combined cycle generator unit of BQPS-3, three 220kV transmission lines from BQPS to Pipri West and #1, #2, #5 and #6 units of BQPS-1 will be reconnected to BQPS-3 GIS step by step. Furthermore, the short link between BQPS-3 and BQPS-1 will be demolished. Hereto, the final interconnection scheme of BQPS-3 is realized.

5 Electrical Calculations & Analysis

5.1 Load Flow Study

5.1.1 Calculation Conditions and Assumptions

- Software: PSS/E (V33.5.2)
- Level Years: 2018, 2019 and 2020
- Generation: Planned Generation could be in commission in time
- Load: Peak Load of the year as the load forecast results

✧ Load Power Factor: 0.95

✧ Network Connection : Interconnection with NTDC though KDA—Jamshore double-circuit, KDA—NKI single circuit and Baldia—NKI single circuit 220kV transmission lines

✧ Calculation Modes: “N-0” and “N-1”

✧ 220kV Transmission Capability: Considering Aging Capacity offered by KE.

5.1.2 Load Flow Results

(1) Peak Load in summer of 2018

It is assumed that:

- The first open cycle unit (280MW) of BQPS-3 is in commission
- The alteration of KPC-I evacuation system is completed.

Under “N-0”:

2×301.5MW is delivered from BQPS to KCR substation by 220kV double circuit transmission lines. Some of the power is step-down in KCR substation, and the rest 2×172.7MW power will be delivered to LALAZAR substation by 220kV double circuit KCR-LALAZAR lines. The load ratios of BQPS-KCR and KCR-LALAZAR are 80% and 57% respectively. Load flow through the three lines from BQPS to PIPRI WEST are 2×271.4MW and 280.8MW, load ratios of which are 71% and 74%. The load flows though BQPS-ICI and ICI-PIPRI WEST are 268.4MW and 283.4MW, the load ratios are 70% and 75%.

Load flow though 132kV PIPRI WEST-P/Qasim is 152.6MW and the load ratio is **117%**.

There is about 210MW power transformed from 220kV to 132kV in KPC-I power plant, which is delivered to PRL (83.1MW), QAYYUMABAD (90.8MW) and LANDHI (K-South) (46.9MW) via 132kV new KTPS. And the load ratios of these lines are 65%, 51% and 30% respectively. Around 9.1MW power is delivered to KTPS from Landhi 132kV substation, and the load ratio of KTPS-Landhi is 11%.

Thus, under “N-0”, except 132kV PIPRI WEST-P/Qasim **(117%)**, 220kV and 132kV transmission lines around BQPS and KPC-I could meet evacuation requirements. The detailed load flow result under “N-0” is shown as following table 5.1-1. The load flow diagrams are shown in Fig.5.1-1 to Fig.5.1-3.

Table 5.1-1 Detailed Load Flow Results under “N-0” in 2018

Line	Circuit No.	Voltage	Load Flow	Load Ratio
BQPS-PIPRI WEST I、II	2	220kV	2×271.4MW	71%
BQPS-PIPRI WEST III	1	220kV	280.8MW	74%
BQPS-KCR	2	220kV	2×301.5MW	80%
BQPS-ICI	1	220kV	268.4MW	70%
ICI-PIPRI WEST	1	220kV	283.4MW	75%
KCR-LALAZAR	2	220kV	2×172.7MW	57%
KTPS-PRL	1	132kV	83.1MW	65%
KTPS-QAYYUMABAD	1	132kV	90.8MW	51%
KTPS-LANHDI	1	132kV	9.1MW	11%
KTPS-LANDHI(K.South)	1	132kV	46.9MW	30%
Pipri West-P/Qasim	1	132kV	152.6MW	**117%**

Under “N-1”:

(1) One of BQPS-KCR lines trips off, load flow of the other line is 472.8MW

(**125%**). One of any other outgoing line of BQPS tripping off will not cause overload on the other lines.

(2) One of KCR-LALAZAR lines trips off, load flow of the other line is 306.8MW (**101%**).

(3) 132kV PIPRI WEST-LANDHI trips off, load flow of PIPRI WEST-P/Qasim is 186.1MW (**143%**), and P/Qasim-Landhi is 138.2MW (**108%**).

(4) 132kV Pipri West-P/Qasim trips off, load flow of Pipri West-Landhi is 135.1MW (**104%**).

(5) 132kV PIPRI WEST-KEPZ trips off, load flow of PIPRI WEST-P/Qasim is 183.6MW (**141%**), and P/Qasim-Landhi is 135.8MW (**106%**).

(6) 132kV KTPS-QAYYUMABAD trips off, load flow of KTPS-PRL is 137.2MW (**106%**).

(7) 132kV KTPS-PRL trips off, load flow of KTPS-Qayyumabad is 153.9MW (88%).

To sum up, under N-1 contingency of related lines, 220kV BQPS-KCR and KCR-LALAZAR transmission lines, 132kV Pipri West-P/Qasim-Landhi, Pipri West-Landhi and KTPS-PRL transmission lines will be overloaded, especially 220kV BQPS-KCR and 132kV Pipri West-P/Qasim transmission lines.

The diagrams of load flow under N-1 contingency in 2018 are shown in Fig. 5.1-4 to Fig.5.1-13.

(2) Peak Load in summer of 2019

It is assumed that:

- The first combined cycle unit (280MW+170MW) and the second open cycle unit (280MW) of BQPS-3 are in commission.
- #4 unit (210MW) of BQPS-1 is decommissioned.
- Reinforcement of KCR-LALAZAR is completed.
- Surjani and Gulshan 220kV substations are in commission.
- Reinforcement of Pipri West-P/Qasim is considered in existing status due to lack of sufficient technical details.

Under "N-0":

2×322MW is delivered from BQPS to KCR substation by 220kV double circuit transmission lines. Some of the power is step-down in KCR substation, and the rest 2×193.9MW power will be delivered to LALAZAR substation by 220kV double circuit KCR-LALAZAR lines. The load ratios of BQPS-KCR and KCR-LALAZAR are 85% and 39% respectively. Load flow through the three lines from BQPS to PIPRI WEST are 2×327.8MW and 339MW, load ratios of which are 86% and 89%. The load flows though BQPS-ICI and ICI-PIPRI WEST are 327.2MW and 342.2MW, the load ratios are 86% and 90%.

Load flow though 132kV PIPRI WEST-P/Qasim is 155MW and the load ratio is **119%**.

There is about 210MW power transformed from 220kV to 132kV in KPC-I power plant, which is delivered to PRL (86.3MW), QAYYUMABAD (94MW) and LANDHI (K-South) (45MW) via 132kV new KTPS. And the load ratios of these lines are 67%, 53% and 29% respectively. Around 13.8MW power is delivered to KTPS from Landhi 132kV substation, and the load ratio of KTPS-Landhi is 12%.

Thus, under "N-0", except 132kV PIPRI WEST-P/Qasim **(119%)**, 220kV and 132kV transmission lines around BQPS and KPC-I could meet evacuation requirements. The detailed load flow result under "N-0" is shown as following table 5.1-2. The load flow diagrams are shown in Fig.5.1-14 to Fig.5.1-16.

Table 5.1-2 Detailed Load Flow Results under "N-0" in 2019

Line	Circuit No.	Voltage	Load Flow	Load Ratio
BQPS-PIPRI WEST I、II	2	220kV	2×327.8MW	86%
BQPS-PIPRI WEST III	1	220kV	339.1MW	89%
BQPS-KCR	2	220kV	2×322MW	85%
BQPS-ICI	1	220kV	327.2MW	86%
ICI-PIPRI WEST	1	220kV	342.2MW	90%
KCR-LALAZAR	2	220kV	2×193.9MW	39%
KTPS-PRL	1	132kV	86.3MW	67%
KTPS-QAYYUMABAD	1	132kV	94MW	53%
KTPS-LANHDI	1	132kV	13.8MW	12%
KTPS-LANDHI(K.South)	1	132kV	45MW	39%
Pipri West-P/Qasim	1	132kV	155MW	119%

Under "N-1":

(1) One of BQPS-KCR lines trips off, load flow of the other line is 504MW (**133%**).

(2) One of KCR-LALAZAR lines trips off, load flow of the other line is 344.3MW (70%).

(3) One of BQPS-Pipri West lines trips off, load flow of BQPS-ICI, ICI-Pipri West, BQPS-Pipri West are 438.1MW (**115%**), 453.1MW (**119%**), 2×434.2MW (**114%**) respectively.

(4) 220kV BQPS-ICI trips off, load flow of BQPS-Pipri West are 2×430.8MW (**113%**) and 445.7MW (**117%**) respectively.

(5) 132kV PIPRI WEST-LANDHI trips off, load flow of PIPRI WEST-P/Qasim is 188.7MW (**145%**), and load flow of P/Qasim-Landhi is 137.7MW (**107%**).

(6) 132kV PIPRI WEST-P/Qasim trips off, load flow of PIPRI WEST-Landhi is 135.8MW (**104%**).

(7) 132kV PIPRI WEST-KEPZ trips off, load flow of PIPRI WEST-P/Qasim is 186.3MW (**143%**), and load flow of P/Qasim-Landhi is 135.4MW (**105%**).

(8) 132kV KTPS-QAYYUMABAD trips off, load flow of KTPS-PRL is 140.7MW (**108%**).

(9) 132kV KTPS-PRL trips off, load flow of KTPS-Qayyumabad is 157.6MW (88%).

To sum up, in 2019, any of the 220kV outgoing lines of BQPS trips off, other 220kV outgoing lines will be overloaded. Under N-1 contingency of related lines, 132kV Pipri West-P/Qasim-Landhi, Pipri West-Landhi and KTPS-PRL transmission lines will be overloaded at different degrees.

The diagrams of load flow under N-1 contingency in 2019 are shown in Fig.

5.1-17 to Fig.5.1-26.

(3) Peak Load in summer of 2020

It is assumed that:

- Two combined cycle units (2×450MW) of BQPS-3 are all in commission.
- #3 and #4 units (2×210MW) of BQPS-1 are decommissioned.
- #1 and #2 units (2×210MW) of BQPS-1 are shut down.
- Datang (700MW) and Engro (450MW) Power Plants are all in commission, interconnected to 220kV Grid via New Port Qasim switch station.
- Karachi 220kV Grid is interconnected with NTDC via KDA-Jamshore double-circuit 220kV transmission lines.
- Transformers of NKI substation are shut down.

Under "N-0":

2 × 27.7MW power is delivered from Karachi Grid to NTDC through KDA-Jamshore double-circuit transmission lines. 2×335.2MW is delivered from BQPS to KCR substation by 220kV double circuit transmission lines. Some of the power is step-down in KCR substation, and the rest 2×204.6MW power will be delivered to LALAZAR substation by 220kV double circuit KCR-LALAZAR lines. The load ratios of BQPS-KCR and KCR-LALAZAR are 89% and 41% respectively. Load flow through the three lines from BQPS to PIPRI WEST are 2×248.7MW and 257.3MW, load ratios of which are 65% and 68%. The load flows though BQPS-ICI and ICI-PIPRI WEST are 244.8MW and 259.8MW, the load ratios are 64% and 68%.

Load flow though 132kV PIPRI WEST-P/Qasim is 165.8MW and the load ratio is **127%**.

There is about 210MW power transformed from 220kV to 132kV in KPC-I power plant, which is delivered to PRL (88.4MW), QAYYUMABAD (95MW) and LANDHI (K-South) (44.6MW) via 132kV new KTPS. And the load ratios of these lines are 69%, 53% and 30% respectively. Around 16.9MW power is delivered to KTPS from Landhi 132kV substation, and the load ratio of KTPS-Landhi is 13%.

Thus, under “N-0”, except 132kV PIPRI WEST-P/Qasim **(127%)**, 220kV and 132kV transmission lines around BQPS and KPC-I could meet evacuation requirements. The detailed load flow result under “N-0” is shown as following table 5.1-3. The load flow diagrams are shown in Fig.5.1-27 to Fig.5.1-29.

Table 5.1-3 Detailed Load Flow Results under “N-0” in 2020

Line	Circuit No.	Voltage	Load Flow	Load Ratio
BQPS-PIPRI WEST I、II	2	220kV	2×248.7MW	65%
BQPS-PIPRI WEST III	1	220kV	257.3MW	68%
BQPS-KCR	2	220kV	2×335.2MW	89%
BQPS-ICI	1	220kV	244.8MW	64%
ICI-PIPRI WEST	1	220kV	259.8MW	68%
KCR-LALAZAR	2	220kV	2×204.6MW	41%
KTPS-PRL	1	132kV	88.4MW	69%
KTPS-QAYYUMABAD	1	132kV	95MW	53%
KTPS-LANHDI	1	132kV	16.9MW	13%
KTPS-LANDHI(K.South)	1	132kV	44.6MW	30%
Pipri West-P/Qasim	1	132kV	165.8MW	**127%**

Under "N-1":

(1) One of BQPS-KCR lines trips off, load flow of the other line is 525.6MW (**140%**). One of any other outgoing line of BQPS tripping off will not cause overload on the other lines.

(2) 132kV PIPRI WEST-LANDHI trips off, load flow of PIPRI WEST-P/Qasim is 201.5MW (**155%**), and load flow of P/Qasim-Landhi is 146.9MW (**114%**).

(3) 132kV PIPRI WEST-P/Qasim trips off, load flow of PIPRI WEST-Landhi is 144.9MW (**112%**), and load flow of PIPRI WEST-KEPZ is 134.1MW (**104%**),

(4) 132kV PIPRI WEST-KEPZ trips off, load flow of PIPRI WEST-P/Qasim is 198.9MW (**153%**), and load flow of P/Qasim-Landhi is 144.3MW (**112%**).

(5) 132kV KTPS-QAYYUMABAD trips off, load flow of KTPS-PRL is 145MW (**112%**).

(6) 132kV KTPS-PRL trips off, load flow of KTPS-QAYYUMABAD is 162.4MW (90%).

To sum up, under N-1 contingency of related lines in 2020, 220kV BQPS-KCR transmission lines, 132kV Pipri West-P/Qasim-Landhi, Pipri West-Landhi, Pipri West-KEPZ and KTPS-PRL transmission lines will be overloaded at different degrees.

The diagrams of load flow under N-1 contingency in 2020 are shown in Fig. 5.1-30 to Fig.5.1-38.

5.1.3 Conclusions of Load Flow Study

According to the results of load flow calculation from 2018~2020:

(1) Under N-0, the existing six 220kV transmission lines of BQPS could meet the evacuation requirements, but the load ratios are high because of aging problem of these lines.

(2) Under N-0, the existing four 132kV transmission lines of KTPS could meet the evacuation requirement of KPC-I power plant. However, the load flows through KTPS-Qayyumabad and KTPS-PRL are heavier than KTPS-Landhi and KTPS-Landhi (K.South).

(3) Under N-1, BQPS-KCR is overloaded severely.

(4) Under N-1, KCR-LALAZAR is overloaded.

(5) The Four lines from BQPS to Pipri West direction could meet N-1 requirement in 2018 and 2020, but will be overloaded at different degrees in 2019.

(6) Under both N-0 and N-1, 132kV Pipri West-P/Qasim transmission line will be overloaded severely.

(7) Under N-1, 132kV Pipri West-Landhi, Port Qasim-Landhi, Pipri West-KEPZ will be overloaded at different degrees.

(8) Under N-1, 132kV KTPS-PRL transmission line will be overloaded.

As known so far, reinforcement of KCR-LALAZAR 220kV transmission line and Pipri West-Port Qasim 132kV transmission line have been included in TP-1000, and expected to be completed by end of 2018. However, other overloaded transmission lines mentioned above are not taken into plan yet. Therefore, in order to guarantee safe evacuation of BQPS and reliable power supply, reinforcement of related transmission lines should be conducted as soon as possible.

5.2 Short Circuit Current Calculation

5.2.1 Claculation Conditions and Assumptions

- ✧ Software: PSS/E (V33.5.2)
- ✧ Level Years: 2018~2019 FY, 2019~2020 FY and 2020~2021 FY
- ✧ Network Connection: Full Connection of 220kV and 132kV Gird
- ✧ Calculation Model: IEC 60909
- ✧ Xd'' of planned Generators: 20%~22%
- ✧ Xt of new Transformers: 20%
- ✧ Power Plants are operated in single bus
- ✧ Neutral points of step-up transformers are directly grounding
- ✧ Current limiters (10Ω) in short links between BQPS-3 and BQPS-2
- ✧ **Assumptions for 2018~2019 FY:**
  - ✓ The 1st combined cycle unit of BQPS-3 is in commission
  - ✓ #4 unit of BQPS-1 is decommissioned
  - ✓ Alteration of KPC-I is completed
- ✧ **Assumptions for 2019~2020 FY:**
  - ✓ The 2nd combined cycle unit of BQPS-3 is in commission
  - ✓ Engro (450MW) power plant is in commission
  - ✓ #3 and #4 units of BQPS-1 are decommissioned

✧ **Assumptions for 2020~2021 FY:**

- ✓ KDA-Jamshore are kept closing， exporting 50MW to NTDC
- ✓ Transformers of NKI are shut down
- ✓ BQPS-3: 2×450MW
- ✓ #1 and #2 units of BQPS-1are shut down
- ✓ #3 and #4 units of BQPS-1are decommissioned
- ✓ Datang: 2×350MW
- ✓ Engro: 450MW

5.2.2 Results of Short Circuit Current Calculation

(1) Short Circuit Current in 2018~2019 FY

According to the calculation results, the single phase short circuit currents of BQPS-3, BQPS-2 and ICI are 43.34kA, 43.28kA and 41.82kA respectively. The three phase short circuit currents of QAYYUMABAD (KO.West) and Landhi are 32.03kA and 32.15kA. The short circuit currents of other power plant and substations around BQPS and KPC-I are all within rated breaking capacity. The detailed short circuit currents in 2018~2019 are shown in table 5.2-1.

Table 5.2-1 Short Circuit Currents of related Bus bars in 2018~2019

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-3	220kV	50	37.88	43.34
BQPS-2	220kV	40	37.85	**43.28**
ICI	220kV	40	37.05	**41.82**
KCR	220kV	40	26.53	23.62
LALAZAR	220kV	40	26.83	23.28
PIPRI WEST	220kV	40	36.09	38.42
	132kV	31.5	30.80	27.43
KPC-I	220kV	40	8.27	9.13
KTPS	132kV	40	29.56	26.00
PRL	132kV	31.5	25.71	19.81

Qayyumabad（KO.West）	132kV	31.5	**32.03**	27.94
LANDHI	132kV	31.5	**32.15**	26.70
P/Qasim	132kV	31.5	26.38	20.30
KEPZ	132kV	31.5	24.63	19.66

To avoid critical impact on system power supply, it is not considered to replace the existing GIS of BQPS-2. Instead, current limiters will be installed in the short links between BQPS-3 and BQPS-2 to restrict short circuit current of BQPS-2. Then, the short circuit current of BQPS-2 will be decreased within allowed limitation. However, the three phase short circuit currents of 132kV Qayyumabad (KO.West) and Landhi are still beyond the rated breaking capacity and single phase short circuit current of ICI is almost on the limitation. The detailed results are shown in table 5.2-2 and Fig. 5.2-1 to Fig. 5.2-3.

Table 5.2-2 Short Circuit Currents in 2018~2019-with Current Limiters

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-3	220kV	50	34.53	40.45
BQPS-2	220kV	40	26.83	32.82
ICI	220kV	40	33.87	39.15
KCR	220kV	40	25.03	22.78
LALAZAR	220kV	40	26.09	22.89
PIPRI WEST	220kV	40	33.78	36.72
	132kV	31.5	30.68	27.37
KPC-I	220kV	40	8.26	9.13
KTPS	132kV	40	29.51	25.97
PRL	132kV	31.5	25.67	19.78
Qayyumabad（KO.West）	132kV	31.5	**31.92**	27.87
LANDHI	132kV	31.5	**32.15**	26.69
P/Qasim	132kV	31.5	26.31	20.27
KEPZ	132kV	31.5	24.62	19.65

(2) Short Circuit Currents in 2019~2020

According to the calculation results, the single phase short circuit currents of 220kV ICI and Pipri West are 42.39kA and 40.01kA respectively. The three phase short circuit currents of 132kV Pipri West, QAYYUMABAD (KO.West) and Landhi are 31.86kA, 33.33kA and 33.43kA, exceeding the rated breaking current. The detailed short circuit currents in 2019~2020 are shown in table 5.2-3 and Fig. 5.2-4 to Fig.5.2-6.

Table 5.2-3 Short Circuit Currents of related Bus bars in 2019~2020

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-3	220kV	50	38.24	43.89
BQPS-2	220kV	40	28.31	34.58
ICI	220kV	40	37.44	**42.39**
KCR	220kV	40	26.51	23.87
LALAZAR	220kV	40	27.82	24.22
PIPRI WEST	220kV	40	37.45	**40.01**
	132kV	31.5	**31.86**	28.07
KPC-I	220kV	40	8.35	9.21
KTPS	132kV	40	30.61	26.64
PRL	132kV	31.5	26.52	20.19
Qayyumabad（KO.West）	132kV	31.5	**33.33**	28.79
LANDHI	132kV	31.5	**33.43**	27.33
P/Qasim	132kV	31.5	27.17	20.65
KEPZ	132kV	31.5	25.36	19.98

(3) Short Circuit Current in 2020~2021

According to the calculation results, if Karachi Grid keeps interconnection with NTDC with KDA-Jamshore 220kV double-circuit transmission lines, and transformers of NKI are shut down, the short circuit current level of overall

Karachi Grid will be decreased obviously. Except 132kV QAYYUMABAD (KO.West) and Landhi, short circuit currents of other power plants and substations around BQPS and KPC-I are all within rated breaking capacity. The detailed short circuit currents in 2020~2021 are shown in table 5.2-4 and Fig. 5.2-7 to Fig.5.2-9.

Table 5.2-4 Short Circuit Currents of related Bus bars in 2020~2021

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-3	220kV	50	33.83	40.84
BQPS-2	220kV	40	26.15	32.83
ICI	220kV	40	33.22	39.55
KCR	220kV	40	23.79	22.33
LALAZAR	220kV	40	24.36	22.10
PIPRI WEST	220kV	40	33.61	38.04
	132kV	31.5	30.46	27.50
KPC-I	220kV	40	8.24	9.12
KTPS	132kV	40	29.20	25.95
PRL	132kV	31.5	25.42	19.77
Qayyumabad （KO.West）	132kV	31.5	**31.49**	27.85
LANDHI	132kV	31.5	**31.91**	26.74
P/Qasim	132kV	31.5	26.15	20.34
KEPZ	132kV	31.5	24.48	19.67

5.2.3 Sensitivity Analysis

During the BQPS-3 construction period, in order to avoid critical impact on Karachi power grid, the 220kV GIS of BQPS-1 will be kept running before the second combined cycle generator unit of BQPS-3. In such a situation, 220kV BQPS—ICI transmission line will be altered to BQPS-3 from BQPS-1 firstly, and the short links between BQPS-1 and BQPS-2 will be replaced by short links between BQPS-3 and BQPS-2. Additionally, a short link will be constructed between BQPS-1 and BQPS-3. The temporary interconnection scheme is shown in Fig. 5.2-10.

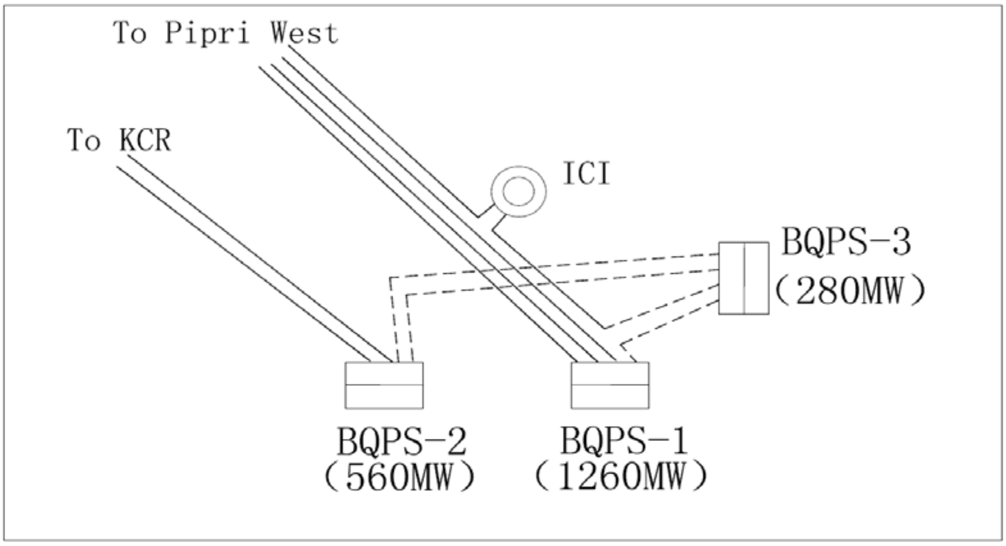

Fig.5.2-10 Temporary Interconnection Scheme Sketch of BQPS-3 (Single Bus)

If all the three GIS are in single bus operation, the single phase short circuit current of BQPS-1 and ICI will be over 40kA even with current limiters in the short links between BQPS-2 and BQPS-3. Detailed calculation results are shown in table 5.2-5.

Table 5.2-5 SC Currents of BQPS during Construction Period (Single Bus)

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-1	220kV	40	35.21	**41.40**
BQPS-2	220kV	40	27.52	33.76
BQPS-3	220kV	50	35.21	41.40
ICI	220kV	40	34.52	**40.04**
Pipri West	220kV	40	34.34	37.41

In order to decrease the short circuit currents of BQPS-1 and ICI, it is recommended to operate BQPS with split bus, as shown in Fig. 5.2-11.

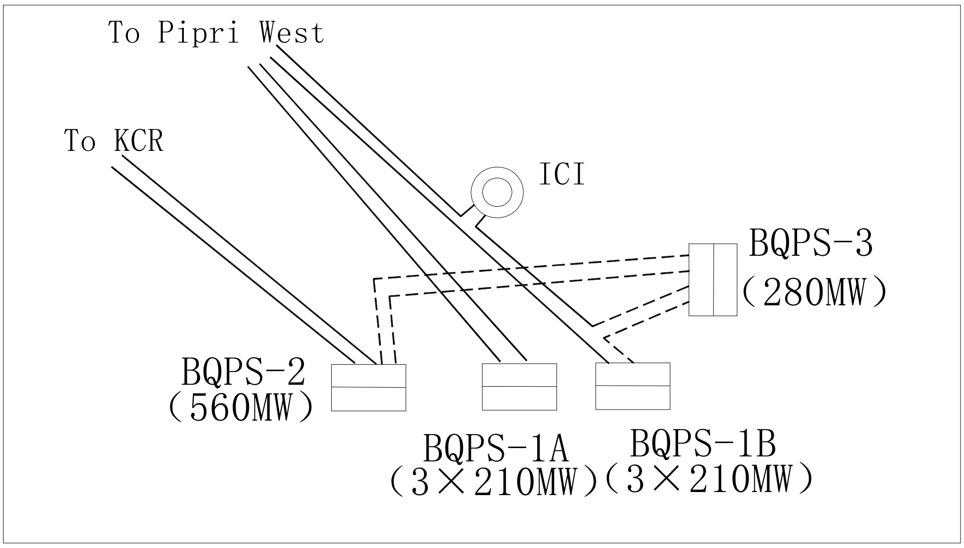

Fig.5.2-10 Temporary Interconnection Scheme Sketch of BQPS-3 (Split Bus)

Under this operation mode, the short circuit currents of BQPS-1 and ICI could be restricted within 40kA, as shown in table 5.2-6.

Table 5.2-5 SC Currents of BQPS during Construction Period (Split Bus)

Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
BQPS-1A	220kV	40	27.89	29.51
BQPS-1B	220kV	40	32.73	37.95
BQPS-2	220kV	40	27.02	32.38
BQPS-3	220kV	50	32.73	37.95
ICI	220kV	40	32.38	37.15
Pipri West	220kV	40	33.98	36.68

5.2.4 Conclusions of Short Circuit Current Calculation

According to the results of short circuit calculation from 2018~2020:

(1) 220kV electrical equipments of BQPS-3 GIS should be selected as 50kA.

(2) 132kV electrical equipments of new KTPS GIS should be selected as 40kA.

(3) Current limiters in the short links between BQPS-3 and BQPS-2 could effectively decrease the short circuit current of BQPS-2 after commissioning of BQPS-3.

(4) The short circuit current of ICI will exceed the rated breaking current 40kA. And installation of current limiter in BQPS-ICI transmission line will affect the load flow distribution from BQPS to Pipri West, leading to heavier load flow through BQPS-Pipri West transmission lines. Thus, it is recommended to replace the existing AIS of ICI with 50kA equipments by May 2019 when the 2nd combined cycle unit of BQPS-3 is in commission.

(5) 2019, after commissioning of Engro, the 220kV and 132kV short circuit currents of Pipri West exceed rated breaking currents a little bit. It is recommended to replace the existing 220kV GIS and 132kV GIS with 50kA and 40kA equipments respectively. Or, it should be studied and analyzed further in the grid interconnection study of Engro.

(6) Short circuit currents of 132kV Qayyumabad (KO.West) and Landhi will exceed rated breaking current 31.5kA from 2018 to 2020. It is recommended to replace the existing switchgears (AIS/GIS) with 40kA equipments respectively.

(7) SC currents will keep increasing as the development of both generation and transmission. It is recommended to study the whole system SC current in next stage combining the power development plan, replace old switchgears step by step, popularize 50kA CBs for 220kV and 40kA CBs for 132kV in new projects, and operate 132kV grid in separated divisions when available.

5.2.5 Temporary Solutions to Exceeding 132kV Short Circuit Current

If the replacement of 132kV Qayyumabad, KO.West and Landhi switchgears could not be completed by May 2018 when the 1st open cycle unit of BQPS-3 is in commission. It is recommended to open the 132kV interconnection between Pipri West supply division and KCP-LALAZAR supply division to decrease 132kV short circuit current.

In view of supply divisions, Landhi belongs to Pipri West supply division while Qayyumabad and KO.West belong to KCR-LALAZAR supply division. In view of load flow results, load flow through 132kV Landhi-KTPS and Landhi-KTPS (K. South) transmission lines are light. It means that even open these two 132kV transmission lines, there will not be much impact on load flow distribution of surrounding grid. Hence, in order to decrease short circuit currents of 132kV Qayyumabad, KO.West and Landhi, it is recommended to open 132kV Landhi-KTPS and Landhi-KTPS (K. South) transmission lines temporarily in contingency. The short circuit current results after opening these two lines are listed in table 5.2-7.

Table 5.2-7 Short Circuit Currents after opening 132kV KTPS-Landhi

Year	Bus bar	Voltage	Breaking Current(kA)	3-Phase(kA)	1-Phase(kA)
2018	Qayyumabad （KO.West）	132kV	31.5	27.12	24.90
	LANDHI	132kV	31.5	26.23	20.91
	Pipri West	132kV	31.5	28.33	25.65
2019	Qayyumabad （KO.West）	132kV	31.5	27.02	23.85
	LANDHI	132kV	31.5	25.73	20.38
	Pipri West	132kV	31.5	28.80	25.92
2020	Qayyumabad （KO.West）	132kV	31.5	25.67	23.11
	LANDHI	132kV	31.5	24.93	20.12
	Pipri West	132kV	31.5	27.73	25.49

6 Electrical Arrangement and Selection of Main Electrical Equipments

6.1 Electrical Arrangement

Electrical arrangement of the new constructed BQPS-3 GIS will be double-bus double subsection configuration with 50kA equipments.

6.2 Selection of Main Transformers

6.2.1 Step-Up Transformer for 280MW Open Cycle Unit

Rated Capacity: 330MVA;

Transformer Type: Two-Winding On-load Tap;

Capacity Ratio: 100/100;

Rated Voltage: 232(+8×1.25%~-16×1.25%)/18kV;

Short Circuit Voltage: 20%;

Vector Group: YNd1;

Neutral points of step-up transformers could be grounding directly

6.2.2 Step-Up Transformer for 170MW Combined Cycle Unit

Rated Capacity: 200MVA;

Transformer Type: Two-Winding On-load Tap;

Capacity Ratio: 100/100;

Rated Voltage: 232(+8×1.25%~-16×1.25%)/18kV;

Short Circuit Voltage: 20%;

Vector Group: YNd1;

Neutral points of step-up transformers could be grounding directly

6.2.3 Requirements for Generator Unit Parameters

Power Factor of new constructed generator units in BQPS-3 should be 0.85

lagging and 0.95 leading.

7 Conclusions & Suggestions

The existing total installation capacity of BQPS is 1820MW, including 1260MW BQPS-1 and 560MW BQPS-2. In this project, it is planned to construct 2×450MW 9F class gas-steam combined cycle units (BQPS-3) within BQPS-1 power plant. Units of BQPS-3 will be in commission step by step from May 2018 to January 2020. In coordination with decommissioning plan of BQPS-1, the commissioning sequence of units of BQPS-3 is shown as following:

(1) May 2018, the 1st open cycle unit (280MW) in commission;

(2) November 2018, #4 unit(210MW) of BQPS-1 decommissioned;

(3) January 2019, the 1st combined cycle unit (170MW) in commission;

(4) May 2019, the 2nd open cycle unit (280MW) in commission ;

(5) November 2019, #3 unit (210MW) of BQPS-1 decommissioned;

(6) January 2020, the 2nd combined cycle unit(170MW) in commission

7.1 Interconnection Scheme of BQPS-3

The final interconnection scheme:

2×450MW units of BQPS-3 will be connected to the new constructed 220kV GIS via two-winding transformers. Electrical arrangement of the new constructed GIS will be double-bus double subsection configuration with 6 outgoing lines including 3 to Pipri West and 1 to ICI reconnected from BQPS-1 and 2 new constructed short links with current limiters between BQPS-3 and BQPS-2. The existing short links between BQPS-1 and BQPS-2 will be demolished.

In coordination with commissioning of BQPS-3 and decommissioning of #3 &

#4 units in BQPS-1, #1, #2, #5 and #6 units of BQPS-1 will be reconnected to BQPS-3 GIS step by step, and the existing 220kV GIS of BQPS-1 will be decommissioned finally.

Interconnection scheme of BQPS-3 is displayed in Fig.4.4-1.
The final electrical single line diagram for BQPS is shown in Fig.4.4-2.

Temporary Interconnection Scheme during Construction Period:
During the BQPS-3 construction period, the 220kV GIS of BQPS-1 will be kept running before the second combined cycle generator unit of BQPS-3. In such a situation, 220kV BQPS—ICI transmission line will be altered to BQPS-3 from BQPS-1 firstly, and the short links between BQPS-1 and BQPS-2 will be replaced by short links between BQPS-3 and BQPS-2. Additionally, a short link will be constructed between BQPS-1 and BQPS-3.

During construction period, the temporary interconnection scheme of BQPS-3 is shown in Fig.4.4-3 and the electrical single line diagram of BQPS is shown in Fig.4.4-4.

7.2 Requirements for Electrical Parameters

- Two-winding step-up transformers is adopted for open cycle unit, with rated capacity of 330MVA, rated voltage 232(+8×1.25% ~-16×1.25%)/18kV, short circuit voltage 20% and neutral points of step-up transformers could be grounding directly.
- Two-winding step-up transformers is adopted for combined cycle unit, with rated capacity of 200MVA, rated voltage 232(+8×1.25% ~-16×1.25%)/18kV, short circuit voltage 20% and neutral points of step-up transformers could be grounding directly.

- Power Factor of new constructed generator units should be 0.85 lagging and 0.95 leading.

7.3 Suggestions on Reinforcement of Grid

7.3.1 Reinforcement of Transmission Lines and Time Requirements

According to load flow calculation:

(1) Under N-1, BQPS-KCR is overloaded severely.

(2) Under N-1, KCR-LALAZAR is overloaded.

(3) The Four lines from BQPS to Pipri West direction could meet N-1 requirement in 2018 and 2020, but will be overloaded at different degrees in 2019.

(4) Under both N-0 and N-1, 132kV Pipri West-P/Qasim transmission line will be overloaded severely.

(5) Under N-1, 132kV Pipri West-Landhi, Port Qasim-Landhi, Pipri West-KEPZ will be overloaded at different degrees.

(6) Under N-1, 132kV KTPS-PRL transmission line will be overloaded.

As known so far, reinforcement of KCR-LALAZAR 220kV transmission line and Pipri West-Port Qasim 132kV transmission line have been included in TP-1000, and expected to be completed by end of 2018. However, other overloaded transmission lines mentioned above are not taken into plan yet.

Therefore, in order to guarantee safe evacuation of BQPS and reliable power supply, reinforcement of 220kV KCP-LALAZAR and 132kV Pipri West-Port Qasim transmission lines should be speeded up and reinforcement of following transmission lines should be conducted as soon as possible:

（1）BQPS-KCR 220kV transmission lines

（2）KTPS-PRL 132kV transmission line

（3）Pipri West-Landhi 132kV transmission line

（4）Pipri West-KEPZ 132kV transmission line

（5）Port Qasim-Landhi 132kV transmission line

7.3.2 Replacement of Substations and Time Requirements

According to short circuit current calculation:

(1) The short circuit current of ICI will exceed the rated breaking current 40kA.

(2) 2019, after commissioning of Engro, the 220kV and 132kV short circuit currents of Pipri West exceed rated breaking currents a little bit.

(3) Short circuit currents of 132kV Qayyumabad (KO.West) and Landhi will exceed rated breaking current 31.5kA from 2018 to 2020.

In order to guarantee safe operation of grid, it is suggested:

(1) Replacing the existing switchgears (AIS/GIS) of 132kV Qayyumabad, KO.West and Landhi with 40kA equipments respectively by May 2018 when the 1st open cycle unit of BQPS-3 is in commission. If the replacement could not be completed in time, it is recommended to open 132kV Landhi-KTPS and Landhi-KTPS (K. South) transmission lines temporarily in contingency.

(2) Replacing the existing AIS of ICI with 50kA equipments by May 2019 when the 2nd combined cycle unit of BQPS-3 is in commission.

(5) Replacing the existing 220kV GIS and 132kV GIS of Pipri West with 50kA and 40kA equipments respectively by the end of 2019 when Engro is in commission. Or, it should be studied and analyzed further in the grid interconnection study of Engro power plant.

Energy That Moves Life

Environmental and Social Impact Assessment

(ESIA) of BQPS-III 900 MW RLNG Based Combined Cycle Power Plant (BQPS-III RLNG CCPP).

Global Environmental Management Services (Pvt.) Ltd.

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K-Electric Limited

Environmental & Social Impact Assessment (ESIA) of BQPS-III 900 MW RLNG Based Combined Cycle Power Project (BQPS-III RLNG CCPP).

Final Report

June, 2017

Global Environmental Management Services (Pvt.) Ltd.
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ES EXECUTIVE SUMMARY

OVERVIEW

Study Type	Environmental and Social Impact Assessment (ESIA).
Study Title	ESIA of BQPS-III 900 MW RLNG Based Combined Cycle Power Project (BQPS-III RLNG CCPP).
Location	Port Qasim, Karachi Pakistan.
Project Proponent	K-Electric.
Project Consultant	Global Environmental Management Services (Pvt) Ltd. (GEMS)

This report discusses the Environmental and Social Impact Assessment (ESIA) of K-Electric, BQPS-III 900 MW RLNG Based Combined Cycle Power Project. The report also analyzes the impacts associated with the construction and operational phase of the proposed project and its surroundings, suggest mitigation measures, and identify residual impact which needs monitoring.

PROPONENT'S PROFILE AND INTRODUCTION

KE
Energy That Moves Life

K-Electric, commonly referred to as KE is a vertically integrated electric company involved in generating, transmitting and distributing power to over 2.5 million customers in Karachi and in the nearby towns of Dhabeji and Gharo in Sindh, and Hub, Uthal, Vinder and Bela in Balochistan. It employs over 10,000 people and covers 6,500 square kilometers with industrial, commercial, agricultural and residential areas falling under its network.

K-Electric has its own generation capacity of 2,267 MW, predominantly from its major Thermal Power Plants (BQPS I, BQPS II and KPC) and two Gas Engines Power Plants (SITE & Korangi), inclusive of 2 x 450 MW that has been added owing to the initiatives of the new management and the company inaugurated an additional 560 MW project in 2012. K-Electric being a prestigious and environmentally conscious organization wants to comply with all applicable laws and therefore intends to carry out the environmental impact assessment of its new Power Plant Project in Karachi.

ENVIRONMENTAL CONSULTANT'S PROFILE AND INTRODUCTION

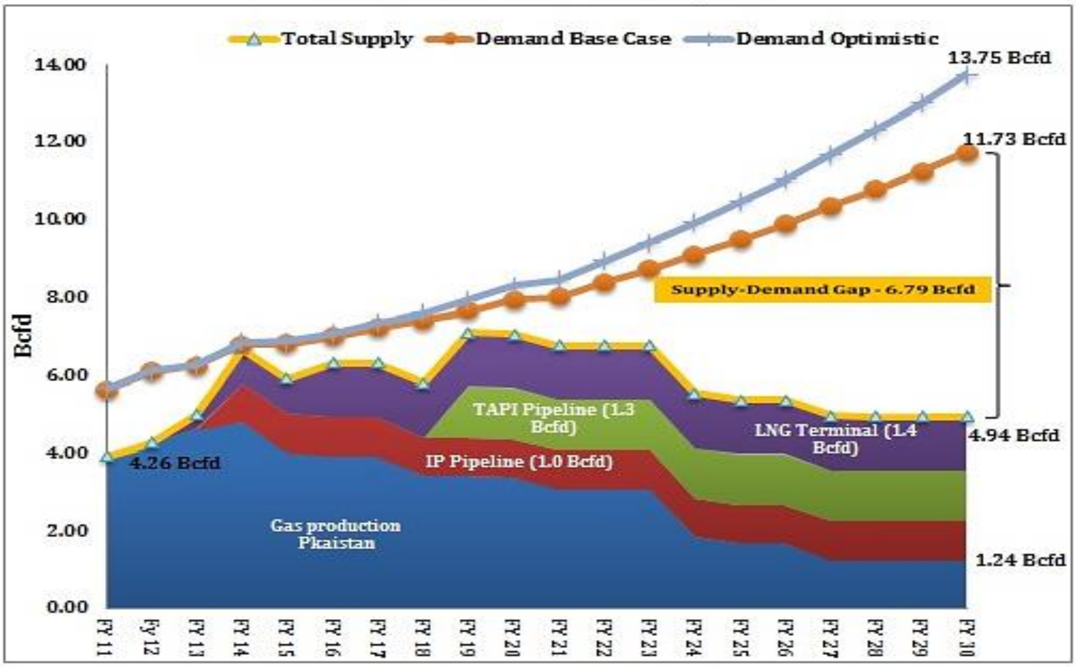
Global Environmental Management Services (Pvt.) Ltd. (GEMS) is an Environmental Consultancy which provides broad range of Environmental Solutions which are and not limited to Environmental Audits, Initial Environmental Examinations (IEE), Environmental and Social Impact Assessments (ESIA), Baseline studies and Training & Capacity building. GEMS is one of the few environmental firm having its own renowned ISO 17025 Certified Environmental Laboratory by the name of Global Environmental Laboratory (Pvt) Ltd.

BACKGROUND INFORMATION AND NEED ASSESSMENT OF THE PROPOSED PROJECT

Pakistan is in the midst of a severe energy crisis that largely stemmed from mismanagement of natural resources in the country. Weak regulatory and pricing mechanisms in the natural gas sector have led to huge disparities between demand and supply. Pakistan has a large demand for natural gas and a well-established gas market and distribution system. At present, demand of natural gas is estimated at around 8 Billion Cubic Feet (BCF) against a total supply of 4 BCF, creating a shortfall of 4 BCF.

As per Pakistan Gas Supply-Demand Study conducted in 2012 by ILF BeratendeIngenieure GmbH, over the next 17 years gas demand is projected to stand at 11.73 BCFD, while domestic supplies are expected to reach the level of 4.94 BCFD resulting in a huge shortfall of about 6.79 BCFD by FY 2030. The analysis was done considering the existing and planned capacity. Below given Exhibit shows the yearly natural gas supply-demand project. A base case scenario is considered based on existing scenario i.e. business as usual.

Natural Gas Demand Projections



Source: ILF Report on Gas/ Supply Demand Analysis and Base Gas Demand 2012

In order to meet the future energy challenges, to sustain and support economic growth, to mitigate the impact of widening shortfall, the Government has encouraged private investment LNG sector to establish an LNG Import projects under the LNG Policy 2002, 2006 & 2011.

To meet the shortfalls of electricity and to enhance the efficiency by reducing the demand-supply gap for the power consumers, KE has decided to install the Re-gasified Liquefied Natural Gas (RLNG) based 2 X 450 MW Combined Cycle Power Generation Units which will replace existing 2 x 210 MW unit 3 & 4 within the existing premises of BQPS-I along with new 132kv GIS Stations at Korangi west and Qayyumabad gridsand the project will be titled as BQPS-III project. The proposed project aims to reduce environmental pollution while enhancing the system efficiency and power generation capacity in order to meet future energy challenges.

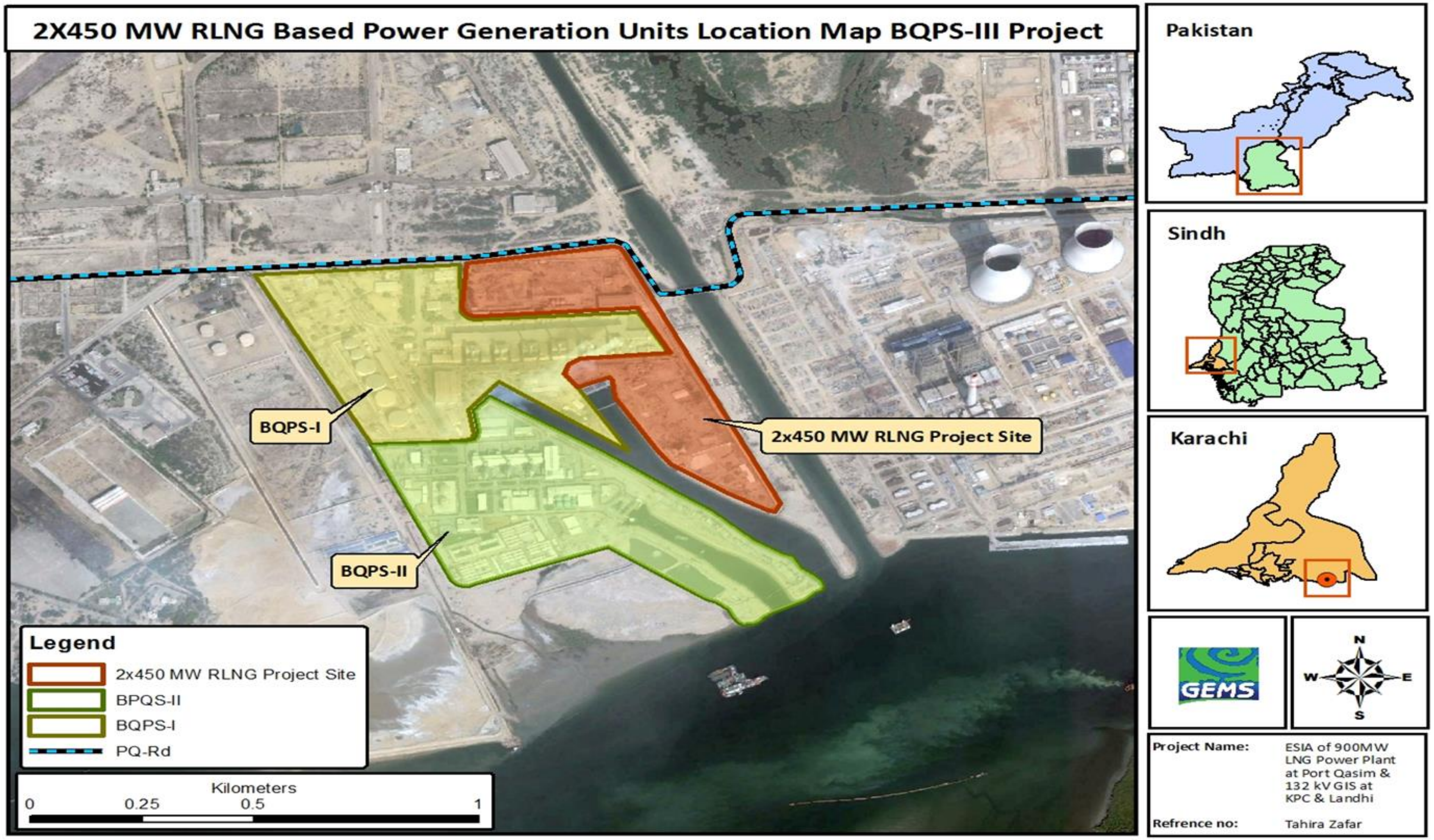
PROPOSED PROJECT LOCATION

The proposed project mainly deals with 02 X 450 MW RLNG Based Combined Cycle Power Generation Units. It also includes installation of mechanical structures for power generation units at Port Qasim and at two Grid Stations and two Substations. Proposed installations for BQPS-III power project are presented below:

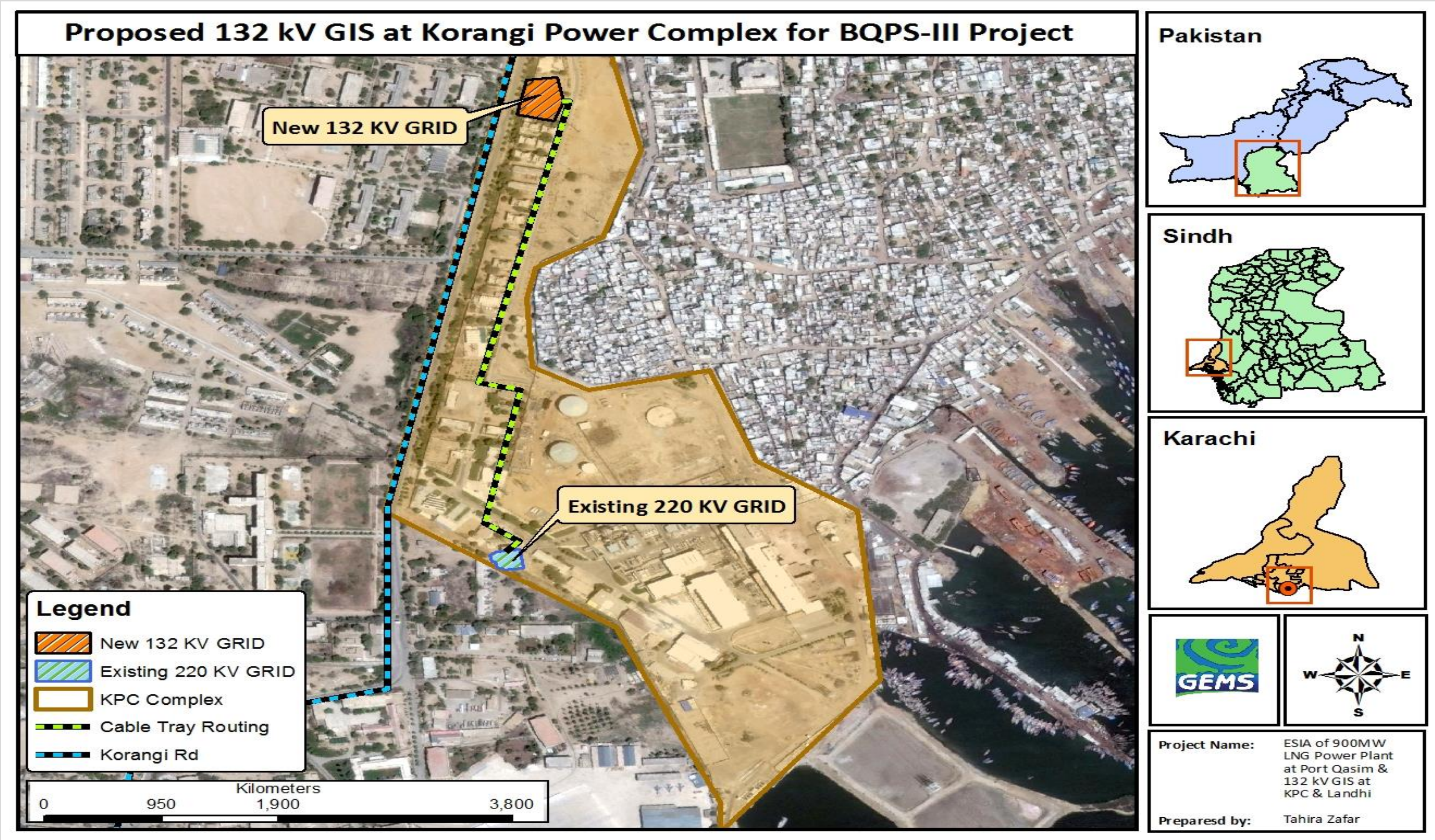
Proposed Installations for BQPS-III Power Project

<table>
<tr><th>Proposed Installations</th><th>Location</th><th>Attachments</th></tr>
<tr><td>02 X 450 MW of RLNG Based Power Generation Unit</td><td>BQPS-I</td><td rowspan="3">Shown Below</td></tr>
<tr><td>01 X 220 kV GIS Grid Station</td><td>BQPS-I</td></tr>
<tr><td>01 X 220 kV ICI Switch Station</td><td>Opposite BQPS-I</td></tr>
<tr><td>01 X 132 kV GIS Grid Station</td><td>KPC</td><td>Shown Below</td></tr>
<tr><td>01 X 132 kV GIS Substation</td><td>Landhi Grid Station</td><td>Shown Below</td></tr>
<tr><td>01 X 132 kV GIS Substation</td><td>Korangi West and Qayyumabad</td><td>Shown Below</td></tr>
</table>

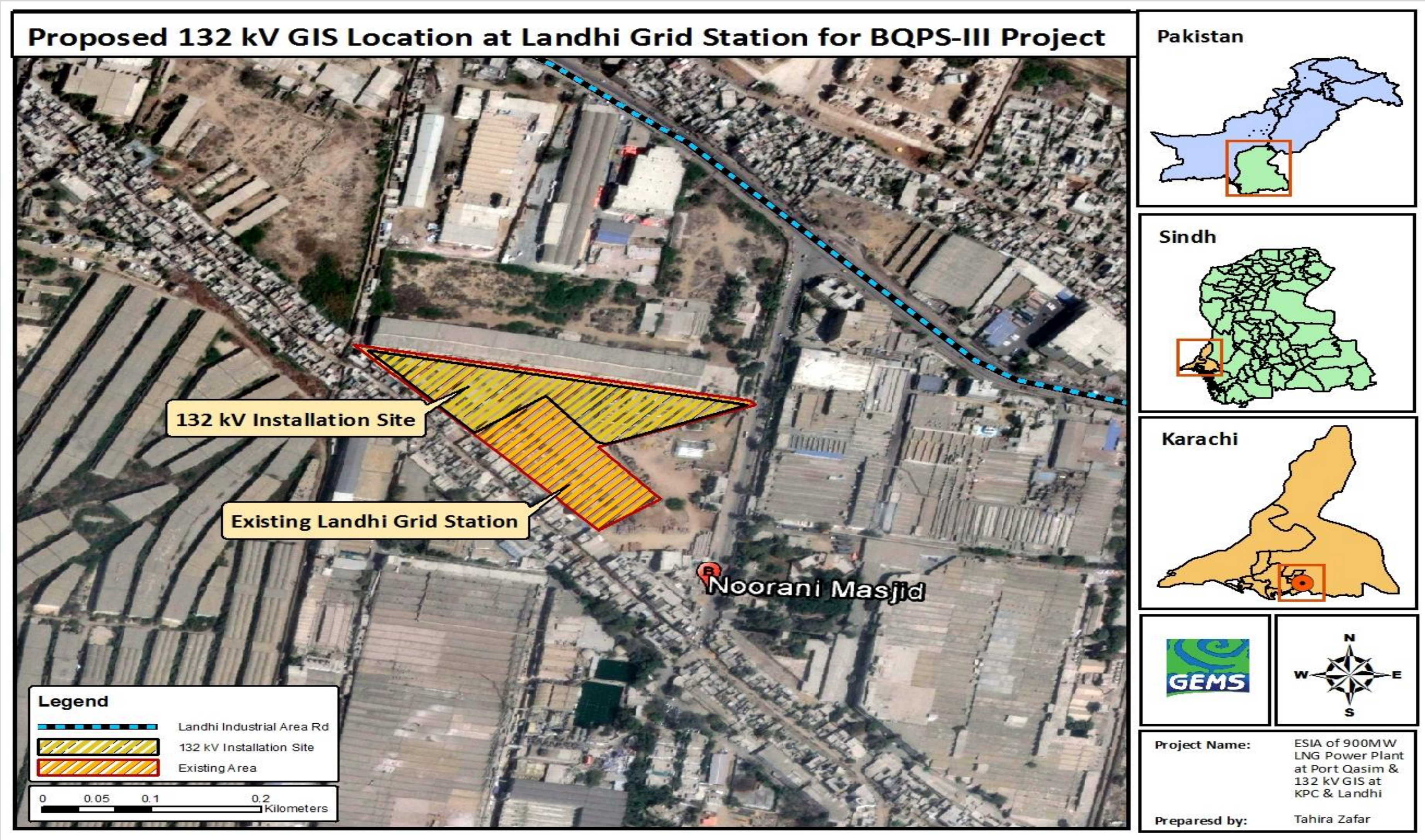
2 X 450 RLNG Based Power Generation Units Location Map for BQPS-III Project



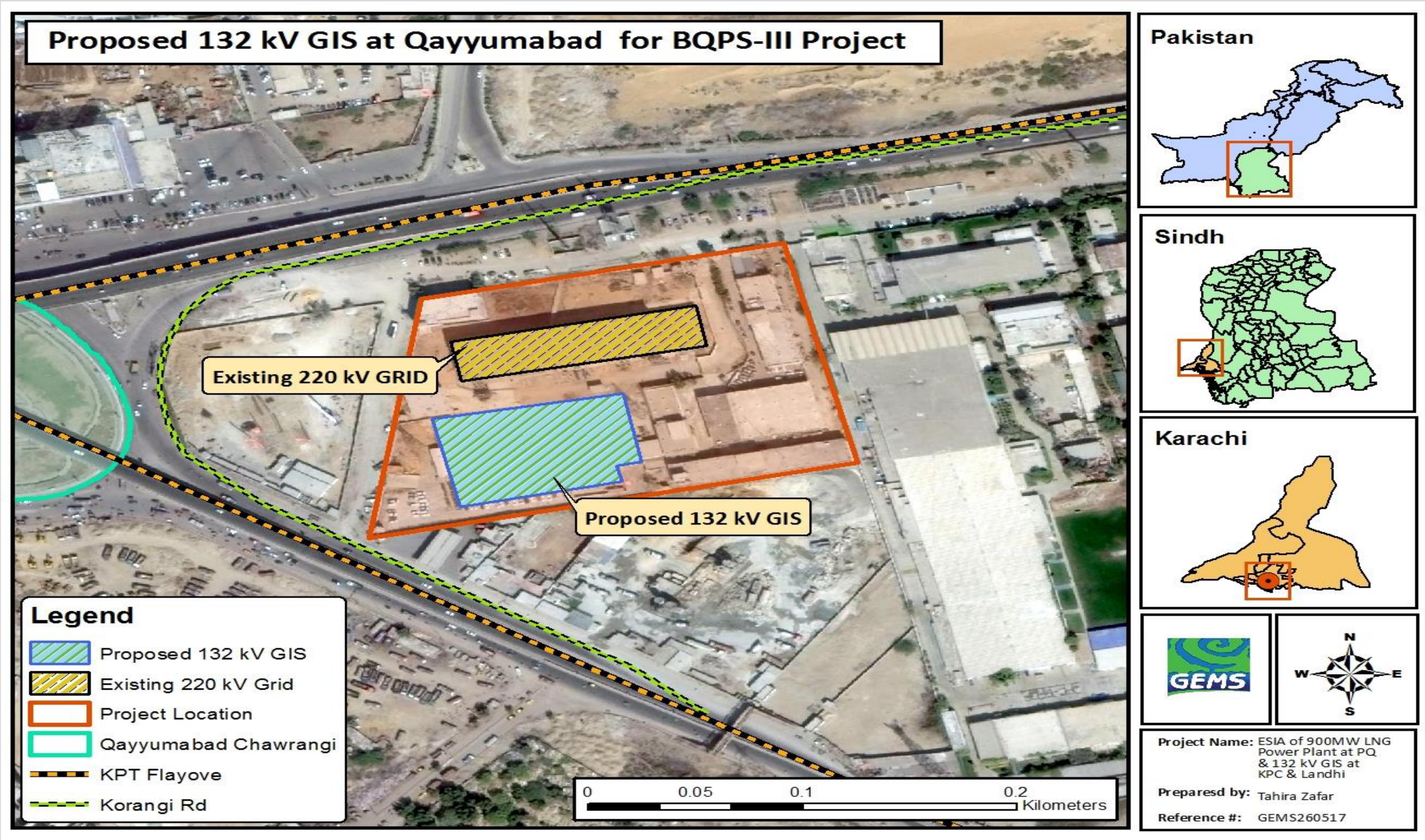
01 132 kV GIS Grid Station at KPC for BQPS-III Project



01 132 kV GIS Grid Station at Existing Landhi Grid Station



01 GIS Grid Station at Existing Qayyumabad Grid Station



PROJECT DESCRIPTION

The proposed project includes construction of 02 X 450 R-LNG sets of 1+1+1 configuration Gas Turbine F class combined-cycle power generation units namely unit 7 & 8 inside the boundary of BQPS-I which will replace existing unit 3 and 4 with the installations of four Grid Stations at four different locations. The existing unit 3 and 4 are NG and HFO based power generation units of BQPS-I. Initially newly proposed unit-7 will operate in open cycle then unit-7 will be operated in combined cycle after decommissioning of unit-4 of BQPS-I. Then unit-8 will be installed after decommissioning of unit-3 and will operate in combined cycle. The proposed project needs a number of installations. The Proposed installation of 2 X 450 MW R-LNG Based Combined Cycle Power Generation Units 7 & 8 is given below:

- Gas Turbine House
- Heat Recovery Steam Generators (HRSG)
- Steam Turbine
- Bypass Stacks
- Gas Insulated Switchgear (GIS)
- Gas Compressor Station
- Transformers
- Cooling Water System
- Centralized Control Room (CCR)

KEY BENEFITS OF THE PROPOSED POWER PROJECT

- Enhanced power capacity
- Efficient power generation
- Reduces emissions
- Greater operational flexibility

LEGISLATIVE REQUIREMENT

The ESIA of the proposed Project activity will be subjected to the pertinent legislative and regulatory requirements of the Government of Sindh including State laws. Legislation presents a synopsis of environmental policies, legislation and other guidelines that have relevance to the proposed project.

The proposed project falls under the project category of **Schedule II, Category A Energy “Thermal power generation over 100MW”** as per the guidelines issued by the SEPA under the SEPA ACT, 2014. According to Sindh Environmental Protection Agency (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2014, project under this category require an ESIA to be conducted at planning stage.

The two primary deliberations of the Act are the conduct of projects only after approval of environmental assessments from the SEPA and adherence with Sindh Environmental Quality Standards (SEQS).

It is stated under section 17 of SEPA 2014:

"No proponent of a project shall commence construction or operation unless he has filed with the EPA an IEE or EIA, and has obtained from the EPA approval in respect thereof".

ENVIRONMENTAL BASELINE

The proposed project area lies in the Malir District of Karachi at Port Qasim. The proposed 2 X 450 MW RLNG CCPGU project will include modifications within BQPS-I, KPC, Landhi and Qayyumabad Grid for power evacuation of the proposed project. However key focus remained on the main Project site, i.e. BQPS-III, which is located within the vicinity of PQA. The proposed project may impact the ambient air and noise quality during all phases through the release of gases and high noise level from construction and operation machinery and equipment. There are no significant natural freshwater resources observed in the proposed project area. The water used for drinking purpose was collected from BQPS-I facility and subjected to microbial and chemical analysis. Seawater samples were also collected from BQPS-I intake and outfall channel and subjected to environmental monitoring and testing.

Based on information available in the ESIAs for projects in Port Qasim, Korangi, Landhi aswell as Qayyumabad and literature review, no threatened or endemic terrestrial plant species has been reported from the Study Area, with an exception on mangroves at Port Qasim. The Mangrove species Avicenna marina found in the proposed project area and Rhizophora mucronanta in the surroundings has been listed as least concern (LC), in IUCN red list of species, which endorsed its justification, as "This species is widespread and common throughout its range. It is a fast growing and fast regenerating, hardy species. It is threatened by the loss of mangrove habitat throughout its range, primarily due to extraction and coastal development. None of the MBI are listed as threatened, near threatened or as declining populations under the IUCN Red list of 2014.

SOCIOECONOMIC BASELINE

The proposed project surrounding is less populated but it is rapidly growing as administrative towns of Karachi city. No human settlements are observed in the immediate vicinity of the proposed project however small Goths such as Rehri Goth and Lath Basti are small-scale settlements, which are about 10 to 13 km from the proposed project site on the North Western Zone of PQA. Pakistan Steel Mills is one of the significant landmarks of that area. Ibrahim Haidiri and Rehri Goth are the two biggest fishing communities of the proposed project site. Almost 90% of the fishing communities are directly or indirectly attached with fishing business and they totally rely on the mangroves forest for hunting of fish, crabs and shrimps. The proposed project surrounding sustains a number of industrial units, therefore a fully functional association referred to as Bin Qasim Association of Trade and Industry (BQATI) looks after general industrial matters and affairs.

The consultation meetings conducted specifically for this assignment, informal and focused group discussions with the primary and secondary stakeholders were carried out to disseminate information about the project and its expected impact on the primary and secondary stakeholders. A number of relevant stakeholders were consulted regarding the proposed project activities during different KIIs

(Key Informant Interviews) FGDs (Focused Group Discussions) and meetings. List of stakeholders consulted during the consultative workshop, FGDs and KIIs is presented below:

List of Participants of Scoping Meeting Conducted on 26th April, 2017

S. No	Name	Designation	Organization
1.	Dr. Sami uz Zaman	Chairman	Global Environmental Management Services (GEMS) Pvt. Ltd.
2.	Dr Shahid Amjad	Marine Biodiversity Expert	Institute of Business Management (IOBM)
3.	Mr. Rafi Ul Haq	Consultant Ecologist	Coastal Restoration Alliance for Biodiversity (CRAB)
4.	Mr. Imran Sabir	Deputy Director Technical	Sindh Environmental Protection Agency (SEPA)
5.	Mr. Saleem uz Zaman	Chief Executive	Global Environmental Management Services (GEMS) Pvt. Ltd.
6.	Mr. Chandar Parkash	General Manager – HSE G&T	K-Electric (KE)
7.	Mr. Fattah Moin Jah	Manager Strategic Planning & Business Development Department	K-Electric (KE)
8.	Muhammad Zeeshan Siddiqui	Deputy General Manager Strategic Planning & Business Development Department	K-Electric (KE)
9.	Mr. Mansoor Akram	Deputy Director	K-Electric (KE)
10.	Mr. Muhammad Tahir Qureshi	Senior Advisor	International Union for Conservation of Nature (IUCN) Pakistan
11.	Ms. Sharmeen Shafique	Information Officer	National Forum for Environment & Health (NFEH)
12.	Mr. Shoaib Abdul Razzak	Conservation officer	World Wildlife Fund (WWF) PAK
13.	Ms. Ayesha Sufyan	Conservation officer	World Wildlife Fund

S. No	Name	Designation	Organization
			(WWF) PAK
14.	Dr. Nuzhat Khan	Principle Scientific Officer	National Institute of Oceanography (NIO)
15.	Mr. Anwar Ali Memon	Legal Officer	Shehri, Citizen for Better Environment (CBE)
16.	Mr. Ali Rasheed	Executive Member	Shehri, Citizen for Better Environment (CBE)
17.	Dr. M Mansha	Director Earth Sciences	SUPARCO
18.	Mr.Jibran Khalid Kidwai	Project Coordinator	Global Environmental Management Services (GEMS)
19.	Engr:Kashif Noor	Environmental Engineer	Global Environmental Management Services (GEMS)
20.	Mr.Tayyab Shafique	Environmental & Social Consultation Expert	Global Environmental Management Services (GEMS)
21.	Ms. Kanwal Khatri	ESIA Technical Writer	Global Environmental Management Services (GEMS)
22.	Ms.Maria Kausar	Environmental Officer	Global Environmental Management Services (GEMS)
23.	Ms.Tahira	Environmental Officer	Global Environmental Management Services (GEMS)
24.	Engr: Musawir Munsif	Environmental Engineer	Global Environmental Management Services (GEMS)
List of Participants of KIIs during March, April 2017			
1.	Dr. Zafar Iqbal Shams	Professor	Institute of Environmental Studies (UoK)
2.	Dr. Hashim Zuberi	Head of Department, Professor	Deptt: Of Environmental Science Sindh Madresatulislam University (SMIU)
3.	Mr. Shabbir Anwar Kazi	Director General Technical	Port Qasim Authority (PQA)
4.	Mr. Chen	Chief Commercial and Technical Depart	SEPCO

It was unanimously agreed by almost all the consultation participants that the proposed project seems to be environmentally sound and will contribute towards economic development. On the other hand it is important to note that as a nation Pakistan is moving towards industrialization and at this stage environment should be given due consideration and treated as priority and strict implementation of environmental health and safety standards should be ensured during the entire life cycle of the proposed project.

ANALYSIS OF ALTERNATIVES

Analysis of alternatives is an integral part of the ESIA process to select the best option among all the possible project options. Analysis of alternatives is mainly based on following key aspects:

- Analysis of Project Refusal
- Analysis of Site Alternatives
- Analysis of Alternate technology/design

The “Project Refusal” alternative that means not proceeding with the proposed LNG based CCPGU and bringing no change to the baseline scenario. The proposed project aims to improve Pakistan’s energy balance and decrease the gap between its growing energy requirements and available energy supplies in the country by utilizing environmental friendly RLNG fuel instead of more expensive, diesel and furnace oil. The proposed project site is located within the existing area of BQPS-I.

BQPS-III project will be developed, adjacent to the BQPS-I which is already operational. Therefore, there was no site selection process for the present project. The power plant is designed to generate electricity by utilizing the maximum available resources. The GIS technology is designed for the proposed project and it is used as a compatible grid station option as it needs less space and is cost-effective in terms of maintenance.

ENVIRONMENTAL IMPACT AND MITIGATIONS

The mitigations for the impacts identified and monitoring requirements are summarized in the Environmental Management and Monitoring Plan (EMMP) for the proposed BQPS-III 900 MW RLNG Based Combined Cycle Power Plant.

CONCLUSION

ESIA of the proposed 02 X 450 MW RLNG Based CCPGU project has achieved the following goals:

Identification of national and provincial environmental regulatory requirements that apply to the proposed project activities;

Identification of the environmental features of the project area including the physical, biological and social disturbance and likely impact of the project on the environment;

Recommendation of appropriate mitigation measures that the project developer will incorporate and ensure as per this ESIA into the project to minimize the adverse environmental impacts.

After assessing the proposed project activities and investigating the proposed project area, the environmental consultants, GEMS have concluded that:

" If the activities are undertaken as described in this ESIA report, and the recommended mitigation measures along with environmental management plan is adopted specifically, the proposed BQPS-III 900 MW RLNG Based Combined Cycle Power Plant project will not result in any long-term impacts on the physical and biological environment of the proposed project area. Additionally the proposed project installation will significantly contribute towards reduced environmental pressure in terms of air quality as natural gas is recognized as a comparatively clean burning fuel and it emits less particulates and negligible SO_2, as well as less NOx and CO_2 than other fossil fuels. Moreover the proposed project will create employment opportunities for local residents and play vital role in overcoming the power shortfall in the country, since Karachi is the industrial hub of Pakistan thus the continuous power supply will not only boost the industrial and economic development of country but also result in a long-term net beneficial impact on air quality as well as social wellbeing of local community”.

Impact Scaling Criteria

IMPACT SCALING CRITERIA			
Severity	**Rating**	**Likelihood**	**Rating**
HIGH	3	HIGH	3
MEDIUM	2	**MEDIUM**	2
LOW	1	**LOW**	1
IMPACT SCALE = SEVERITY X LIKELIHOOD			
HIGH = 7-9			
MEDIUM = 4-6			
LOW = 1-3			

SEVERITY

Impact severity has been categorized as follows:

HIGH: The anticipated environmental impact may adversely affect the environmental conditions.

MEDIUM The anticipated environmental impact may exhibit moderate affect onto the environmental conditions.

LOW The anticipated environmental impact is insignificant and may not affect the environmental conditions.

LIKELIHOOD

HIGH: The anticipated environmental impact is most likely to occur.

MEDIUM The anticipated environmental impact is likely to occur.

LOW The anticipated environmental anticipated environmental impact is less likelv to occur.

Environmental Management and Monitoring Plan

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Construction Phase								
Topography & Landscape	Formation of heaps due to improper handling of construction residue	1 X 2 = 2 LOW	- Proper site leveling should be ensured, in order to minimize the probability of topographic changes at and project site flooding during rainy season - Ensure that construction material such as cement and or ready mix is handled properly and no residual material is left unattended so as to avoid the probability of formation of heaps and uneven structures	1 X 1 = 1 LOW	Surface topography	Project sites at Port Qasim and Korangi Power Complex	Monthly	KE by engaging IEMC
Ambient Air Quality	Construction activities may result in following impacts:	2 X 2 = 4 MEDIUM	- Use of standard construction equipment and vehicles; - Scheduled maintenance of back-up generators, equipment and vehicles including engine tuning, filter cleaning, etc.;	2 X 1 = 2 LOW	Emissions of CO, NOX, PM10, and SOx from sources such as construction machineries and vehicle movement	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	Impairment of ambient air quality Chronic health issues Upper respiratory disorders		- Water spraying will be done to reduce dust emissions; - Enclosed painting booths and dedicated fabrication areas in favor of wind direction so the fumes may divert away from the site; - The vehicle speeds on graded roads will be limited in order to minimize dust emissions					
Noise	Headaches Hearing problems Accumulation of stress hormones Hypertension	2 X 2 = 4 MEDIUM	- On site workers will be provided with adequate 'personal protective equipment' (PPE); - Construction equipment/ machineries will be provided with suitable silencers; - Regular maintenance of construction machinery and equipment will be ensured	2 X 1 = 2 LOW	Noise levels and Construction Equipment/Machinery Maintenance Report	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- Construction activities will be scheduled / planned in such a way as to prevent high noise activities during night times and simultaneous operation of multiple high noise equipment will be avoided to the extent feasible					
Surface and Ground Water Quality	Seawater contamination by oil spillage from construction vehicles and equipment	2 X 2 = 4 MEDIUM	- All liquid raw material such as oil, lubricants and chemical at all project sites will be stored within the storage yard with impermeable floors and roof top. - The storage yard should be protected with secondary containment facility with appropriate labeling, to significantly reduce the chances of liquid waste or material discharge into the sea during the accidental spill or rain water runoff.	1 X 1 = 1 LOW	pH, TSS, Temperature Oil and Grease and visual inspection of Surface Water Quality	Proposed project Site at Port Qasim	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Terrestrial Ecology	Minimal mortality to plant life Loss of foraging area for avifauna	2 X 1 = 2 LOW	- Green areas will be developed in vacant portions of proposed project areas; - Best and safe industrial practices should be adopted for the less disturbance of ecology of the area.	1 X 1 =1 LOW	Visual Inspection	Korangi Power Complex	Monthly Basis	KE by engaging IEMC
Soil Quality	Small scale excavations and site leveling may result in following impacts: Soil erosion Contamination of soil.	2 X 2 = 4 MEDIUM	- Careful use of heavy machineries and equipment should be ensured in order to prevent leakages onto the soil. - A spill prevention response team will be available throughout all the activities for immediate action on site	2 X 1 = 2 LOW	Visual Inspection	Proposed project sites at Port Qasim and Korangi Power Complex	Monthly Basis	KE by engaging IEMC
Aquatic Ecology	Small scale impact on aquatic ecosystem	2 X 2 = 4 MEDIUM	- Existing drainage has bearing capacity of more effluent and will sustain rise in effluent	2 X 1 = 2 LOW	Fish population density and productivity by fauna sampling and its laboratory analysis.	Proposed project Site at Port Qasim	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			discharge caused during construction activities; - Construction activities will be performed with complete standard procedures and minimal discharge will be produced					
Health & Safety	Lack of awareness among general laborers about safety may lead to accidents Unskilled and untrained workers might cause harm to themselves and others Construction works may	3 X 2 = 6 MEDIUM	- Ensure that hazards associated with manual lifting are controlled by proper lifting techniques, work rotation system will reduce the chances of being exposed to work related stress associated with construction activities. - Trained personnel will be appointed for the specific work - Unauthorized personnel will not be allowed to access the project site without permission and safety permits. - Arrangement of proper first aid unit and emergency vehicle to	2 X 1 = 2 LOW	HSE inspections Risk assessment reports Record of Safety Talks Record of safety Incidents (Major & Minor) Record of PPEs Visual Assessments	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	include many risks and hazards that may lead to severe injuries		take affected personnel to the nearest medical facility. - Workers should be facilitated by providing appropriate work specific PPE's; - Accidents records will be maintained					
Road Safety and Traffic Management	Traffic Congestion Risk of accident	2 X 1 = 2 LOW	- Trained drivers and operators to drive the construction vehicles - Obey traffic and safety rules/precautions and traffic management plan.	1 X 1 = 1 LOW	Driver's license and traffic rules	NIL	NIL	NIL

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Livelihood & Economy	The proposed project will have positive impacts on local economy, however small scale conflicts between local vendors and project developer may occur	2 X 1 = 2 **LOW**	- Specify time scale for construction activities - People from neighboring areas will be considered for unskilled employment - Suppliers and Vendors of neighboring areas will be given priority - Employment opportunities will be increased and the preference will be given to locals.	1 X 1 = 1 **LOW**	Complaint register and Grievance Redress Mechanism (GRM)	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC
Solid waste	Health hazards Unaesthetic conditions	3 X 2 = 6 **MEDIUM**	- Separate bins will be placed for different type of wastes - plastic, paper, metal, glass, wood, and cotton; - The material to be used during construction phase should be limited and should not exceed the needed amount so as to prevent solid waste production at project site.	1 X 1 = 1 **LOW**	Visual inspections Assessment of solid waste quantity and type	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- No waste will be dumped at any location outside the proposed site boundary; - All hazardous waste will be separated from other wastes. Hazardous wastes will be disposed of through approved waste contractors; - Record all waste generated during the construction period will be maintained. - Training will be provided to personnel for identification, segregation, and management of waste.					
Operational Phase								
Air	Chronic Respiratory health effects	2 X 3 = 6 MEDIUM	- Ensure Fuel to Air Ratios are maintained; - Ensure power plant maintenance.	2 X 1 = 3 LOW	CO and NOx	Project Site at Port Qasim	Quarterly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- Ensure Fuel to be used of approved quality					
Noise	Power plant operations may result in elevated levels of noise which may result in following impacts: Stress Hypertension Hearing loss Headache	1 X 3 = 3 LOW	- KE Employees accessing the area will always wear PPE's like ear protection muffs or ear plugs; - Proper maintenance of all the equipment to be utilized during operational phase will be maintained throughout the entire life cycle of the proposed project - Unauthorized personnel will not be allowed to access high noise areas.	1 X 2 = 2 LOW	Noise levels	Project Site at Port Qasim	Quarterly	KE
Aquatic Environment	Change in diversity of benthic community Water pollution	2 X 3 = 6 MEDIUM	- Retain effluent prior to final discharge for treatment unless the quality remains within SEQS; - The treated water can be reutilized for green areas	2 X 1 = 2 LOW	MBI Marine outfall Parameters as per SEQS or SEPA requirement	Benthic faunal sampling stations at outfall and intake channel of BQPS-III at Port Qasim	Quarterly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Health & Safety	Lack of awareness among general laborers about safety may lead to accidents Unskilled and untrained workers might cause harm to themselves and others Health hazards	2 X 3 = 6 MEDIUM	- Ensure that all the safety and security procedures are in place and implemented in true spirit. - Ensure proper maintenance of firefighting systems during the entire life cycle of the proposed project. - Necessary training regarding safety aspects to the personnel working at the project site will be given. - Material Safety Data Sheet (MSDS) for chemicals, if any, will accompany the consignment. - The project developer must ensure implementation of proper HSE policy at all project locations so as to reduce the chances of occurrence of frequent hazards.	2 X 2 = 4 MEDIUM	Record of Safety Talks Record of safety Incidents (Major & Minor) Record of PPEs Visual Assessments	All Project Installation and Modification Sites	Monthly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Livelihood and Economy	Proposed project will reduce the energy deficit of Karachi. people will benefit in form of employment and business activities Operational phase activities can cause health and safety risk	2 X 1 = 2 LOW	- Possibility of recruitment of local workers having pertinent education skills will be explored; - Local businesses such as fabricators, maintenance service providers, food suppliers, transporters, etc., are likely to have business opportunities associated with the operation of the plant - Mechanism will be developed for local community engagement for complaints and suggestions;	1 X 1 = 1 LOW	Complaint register and Grievance Redress Mechanism (GRM) Local Consultations records		As and when required	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Water and Waste Water	Heated effluent discharge and untreated wastewater may result in seawater pollution and impacts on aquatic ecology	2 X 2 = 4 MEDIUM	- Appropriate facilities to be provided for collection, storage and routing the wastewater streams to treatment plant and facilities are to be provided; - Appropriate sludge handling and disposal facilities are to be provided for waste treatment sludge. - Effluent sewers to be periodically cleaned and inspected for integrity; - Sanitary wastewater from all sections of the facility to be collected and routed to sanitary treatment system - All run off from the process area to be routed for treatment prior to disposal.	2 X 1 = 2 LOW	Parameters as per SEQS or SEPA requirements	Water sampling stations at outfall and intake channel of BQPS-III at Port Qasim	Monthly	KE
Solid waste	Health impacts	2 X 3 = 6 MEDIUM	- The solid waste management plan will be developed and facilities for collection, storage	2 X 1 = 2 LOW	Within the site premises	All Project Installation and	Monthly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	Unaesthetic view Property loss Unhygienic conditions		and transportation will be established and organized; - A safe and designated area will be selected for disposal of waste and EPA certified contractors will be hired; - Dumping of solid waste will be prohibited around the facilities.			Modification Sites		

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Chapter: 6 SOCIO-ECONOMIC & CULTURAL ENVIRONMENT

CHAPTER

1 INTRODUCTION

1.1 OVERVIEW

Study Type	Environmental and Social Impact Assessment (ESIA).
Study Title	ESIA of BQPS-III 900 MW RLNG Based Combined Cycle Power Project (BQPS-III RLNG CCPP).
Location	Port Qasim, Karachi Pakistan.
Project Proponent	K-Electric.
Project Consultant	Global Environmental Management Services (Pvt) Ltd. (GEMS)

This report discusses the Environmental and Social Impact Assessment (ESIA) of K-Electric, BQPS-III 900 MW RLNG Based Combined Cycle Power Project. The report also analyzes the impacts associated with the construction and operational phase of the proposed project and its surroundings, suggest mitigation measures, and identify residual impact which needs monitoring.

1.2 PROJECT BACKGROUND

Karachi is the industrial, financial and trading hub of Pakistan. The availability of port facilities has attracted energy related investments over several decades thus positioning Karachi as the focal point of the energy corridor of Pakistan. However K-Electric commonly referred to as KE is a vertically integrated electric company involved in generating, transmitting and distributing power recorded a peak demand of 2565 in 2010 and increased by nearly 735 MW in Last 7 years. [1] Moreover it is important to note that K-Electric has its own generation capacity of 2,267dee MW, predominantly from its major Thermal Power Plants (Bin Qasim Power Station (BQPS)-I, II and Korangi Power Complex (KPC) and two Gas Engines Power Plants (SITE & Korangi), inclusive of 450 MW that has been added owing to the initiatives of the new management and the company inaugurated an additional 560 MW project in 2012. While on the other hand it is important to note that existing power station namely BQPS-I at Port Qasim is one of the oldest power station of K-Electric which is currently running on dual fuel i.e. Natural Gas (NG) and Heavy Furnace Oil (HFO). The existing power generation units Insufficient to cater the power generation needs of the city. While, the current demand for electricity is increasing

[1] Environmental & Social Impact Assessment of 250 MW Dual Fuel Power Plant KPC-II Karachi Sindh

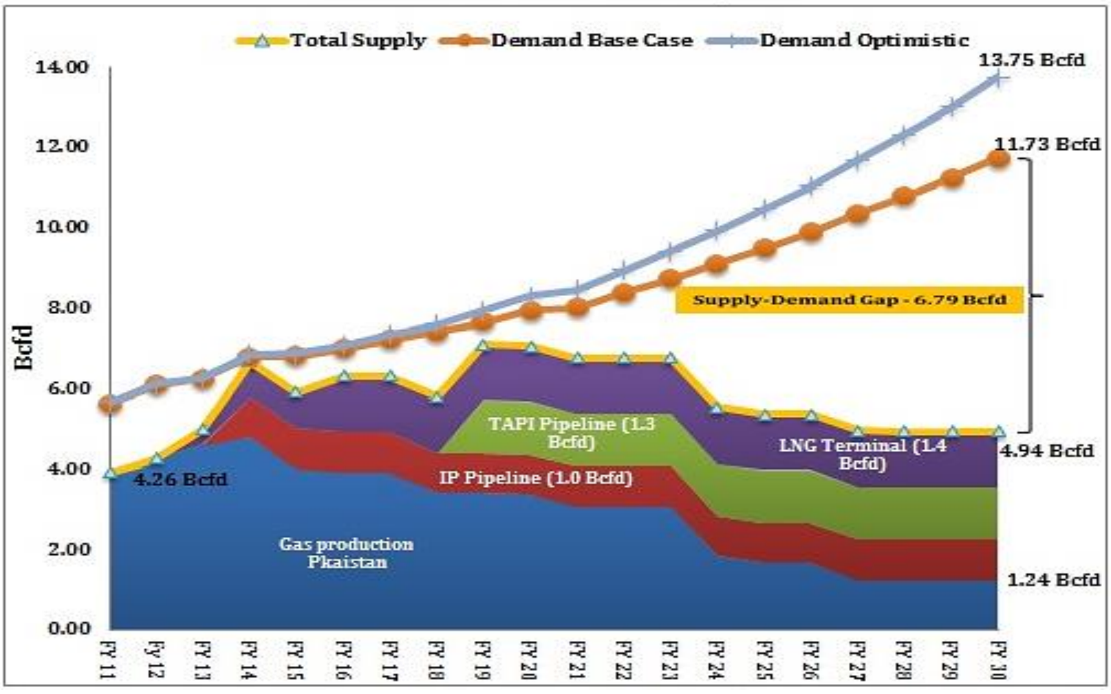
with the passage of time. To meet the shortfalls of electricity and to enhance the efficiency by reducing the demand-supply gap for the power consumers, KE has decided to install the Re-gasified Liquefied Natural Gas (RLNG) based 2 X 450 MW Combined Cycle Power Generation Units which will replace existing 2 x 210 MW unit 3 & 4 within the existing premises of BQPS-I along with new 132kv GIS at Korangi west and Qayyumabad gridsand the project will be titled as BQPS-III project. The detailed description of installation and modification at different grid stations has been discussed in the chapter 2 of this ESIA report.

1.3 NEED ASSESSMENT

Pakistan is in the midst of a severe energy crisis that largely stemmed from mismanagement of natural resources in the country. Weak regulatory and pricing mechanisms in the natural gas sector have led to huge disparities between demand and supply. Pakistan has a large demand for natural gas and a well-established gas market and distribution system. At present, demand of natural gas is estimated at around 8 Billion Cubic Feet (BCF) against a total supply of 4 BCF, creating a shortfall of 4 BCF.[2]

As per Pakistan Gas Supply-Demand Study conducted in 2012 by ILF BeratendeIngenieure GmbH, over the next 17 years gas demand is projected to stand at 11.73 BCFD, while domestic supplies are expected to reach the level of 4.94 BCFD resulting in a huge shortfall of about 6.79 BCFD by FY 2030. The analysis was done considering the existing and planned capacity. Below given Exhibit shows the yearly natural gas supply-demand project. A base case scenario is considered based on existing scenario i.e. business as usual.

Exhibit 1.1: Natural Gas Demand Projections



Source: ILF Report on Gas/ Supply Demand Analysis and Base Gas Demand 2012

2 Total Gas Demand on System, 2013. Internal Documents of Ministry of Petroleum and Natural Resources. Islamabad, Pakistan

In order to meet the future energy challenges, to sustain and support economic growth, to mitigate the impact of widening shortfall, the Government has encouraged private investment LNG sector to establish an LNG Import projects under the LNG Policy 2002, 2006 & 2011.

The Government of Pakistan has decided to place heavy reliance on LNG Imports and has projected a market potential of 30 MTPA which is targeted to be achieved by 2020. Based on the above stated facts and figures KE being one of the sensible custodian of Environment has also decided to place their reliance on imported LNG and initially replace their existing 2 x 220 MW NG and HFO based power generation units of BQPS-I by adding 2 X 450 MW RLNG based power generation units within the existing premises of BQPS-I. The proposed project aims to reduce environmental pollution while enhancing the system efficiency and power generation capacity in order to meet future energy challenges.

1.4 PROPONENT'S PROFILE

K-Electric, commonly referred to as KE is a vertically integrated electric company involved in generating, transmitting and distributing power to over 2.5 million customers in Karachi and in the nearby towns of Dhabeji and Gharo in Sindh, and Hub, Uthal, Vinder and Bela in Balochistan. It employs over 10,000 people and covers 6,500 square kilometers with industrial, commercial, agricultural and residential areas falling under its network. K-Electric has its own generation capacity of 2,276 MW, predominantly from its major Thermal Power Plants (BQPS I, BQPS II and KPC) and two Gas Engines Power Plants (SITE & Korangi), inclusive of 450 MW that has been added owing to the initiatives of the new management and the company inaugurated an additional 560 MW project in 2012. K-Electric being a prestigious and environmentally conscious organization wants to comply with all applicable laws and therefore intends to carry out the environmental impact assessment of its new Power Plant Project in Karachi.

1.5 CONSULTANT'S PROFILE

Global Environmental Management Services (Pvt.) Ltd. (GEMS) is an Environmental Consultancy which provides broad range of Environmental Solutions which are and not limited to Environmental Audits, Initial Environmental Examinations (IEE), Environmental Impact Assessments (EIA), Baseline studies and Training & Capacity building. GEMS is one of the few environmental firm having its own renowned ISO 17025 Certified Environmental Laboratory by the name of Global Environmental Laboratory (Pvt) Ltd.

GEMS have several divisions at work which provides core quality services. They are as follows:

1.5.1 Consultancy Division:

GEMS offer the following services to various industries, government institutions and international development organizations:

- Environmental impact assessments

- Environmental audits and management plans
- Baseline studies and habitat mapping
- Capacity building and trainings
- Cleaner production for industries

1.5.2 Laboratory Division:

GEMS Laboratory, Global Environmental Lab (Pvt.) Ltd. is the leading source of environmental solutions. It is providing 24 hours sampling and monitoring services to various sectors including:

- Liquid Effluent Analysis
- Drinking Water Analysis
- Soil and Sludge Analysis
- Microbiological Analysis
- Gaseous Emissions and Particulate Matter Analysis
- Ambient Air Monitoring
- Noise Level Measurements
- Light Intensity Measurements
- Complete Monitoring as per NEQS and SEQS

1.5.3 Waste Management Division

Waste Management Division has the following services:

- Incineration
- Bio-remediation
- Research and Division facility for disposal
- Waste minimization
- Waste recycling
- Integrated Waste Management

For over a decade GEMS have conducted ESIAs in an expanding range of Energy sector (oil and gas industry, power plants etc), Manufacturing industries (e.g. pharmaceutical, mineral fertilizers, textile, paper, food processing etc.), Infrastructure projects (roads, highway's buildings etc.), ports and harbors, tourism, aquaculture and fisheries.

1.6 ESIA STUDY TEAM

GEMS personnel have professional environmental and social experience extending throughout Pakistan and UAE. They are all qualified environmental and social scientists with complementary multi-disciplinary skills covering all major biomes of the environment. As a result GEMS is able to offer accurate, independent and appropriate services to its clients and to regulatory bodies.

The ESIA study team profile for the proposed project has been attached as **Annexure I** of the report.

1.7 LEGISLATIVE REQUIREMENT

The ESIA of the proposed Project activity will be subjected to the pertinent legislative and regulatory requirements of the Government of Sindh including State laws. Legislation presents a synopsis of environmental policies, legislation and other guidelines that have relevance to the proposed project.

The proposed project falls under the project category of **Schedule II, Category A Energy** "Thermal power generation over 100MW" as per Sindh Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2014. According to these guidelines, project under this category require an ESIA to be conducted at planning stage.

The two primary deliberations of the Act are the conduct of projects only after approval of ESIA from the SEPA and adherence with Sindh Environmental Quality Standards (SEQS).

It is stated under section 17 of SEPA 2014:

"No proponent of a project shall commence construction or operation unless he has filed with the EPA an IEE or EIA, and has obtained from the EPA approval in respect thereof".

1.8 PURPOSE OF THE STUDY

The purpose of this ESIA study is to evaluate the significant Environmental and Social aspects of the proposed project and identify requirements and standards that need to be complied specifically with SEPA Regulations, 2014.

The specific objectives of this ESIA are to:

1. Identify the relevant stakeholders that need to be consulted to evaluate Environmental and Social aspects of the project.
2. Assess the existing environmental conditions in the proposed project area, including identification of environmentally sensitive areas and significant receptors;
3. Assess various project related activities to identify potential impacts on environment and social baseline settings and determine their significance;

4. Propose appropriate mitigation measures that can be incorporated into the project design, commissioning and operating phases to minimize damaging effects or lasting negative consequences identified by the environmental assessment;
5. Assess the proposed activities and ensure their compliance with the relevant environmental regulations of the province;
6. Prepare an ESIA report for submission to the SEPA in compliance with SEPA Review of IEE and EIA Regulations 2014.

1.9 SCOPE OF THE ESIA

For the ESIA study, the scope of work is as under:

1. Description of physical, environmental, socio-economic and cultural setting and baseline conditions in the proposed project area;
2. Identification and prediction of proposed project impacts and their significance relating to the proposed project activities;
3. Identification and assessment of the applicability and effectiveness of mitigation measures to offset or minimize adverse impacts on environment.

1.10 APPROACH AND METHODOLOGY

The ESIA was performed in five main phases, which are described below.

1.10.1 Scoping

The key activities of this phase included:

Project Data Compilation: A generic description of the proposed project (i.e. construction and operation), within the proposed project area relevant to environmental assessment, was compiled with the help of PEPA Guidelines and proponent i.e. KE.

Literature Review: Secondary data and information related to weather, soil, water resources, coastal and marine ecology, and wildlife was reviewed and compiled.

Legislative Review: Information on relevant legislation, regulations, guidelines, and standards was reviewed and compiled.

Key Stakeholder Identification: Key stakeholders, including primary and secondary, were identified that were directly and indirectly related with the proposed project. Their concerns were recorded and documented.

Identification of Potential Impacts: The information collected in the previous steps was reviewed, and potential environmental issues were identified.

1.10.2 Baseline Studies

Following the scoping exercise, the proposed project area was surveyed to collect primary data. During the field visits, information was collected on ecologically important areas, ambient air quality, surface and groundwater resources, existing infrastructure, local communities and public services. The following specific studies were conducted as part of the ESIA.

Ecological Baseline: Biological experts conducted an ecological baseline study, which consisted of a thorough literature review and field data collection. During the fieldwork, the faunal species of the area were documented. The diversity of avian, large and small mammals, and reptile species were determined. Information was collected on the species found in approximately 3 km radius of the area.

Floral species of the area were also identified through fieldwork and literature review.

Physical Environment: Environmental Assessment Specialists conducted physical environmental study including, ambient air, noise, water sampling, surface water resources and the groundwater resources of the areas. Specialists also carried out the impact of proposed project on soil and water resources.

Socioeconomic Study: Sociologist conducted socioeconomic and cultural study in the proposed project area. The study team through participatory techniques collected data from the locals of the proposed project area as well as the local governing bodies. The profile included livelihood, culture, leadership, gender issues, spiritual and temporal leadership, demographic information based on field data and published sources, the existing use of land resources, community structure, employment, distribution of income, goods and services, public health, local religious and cultural values, and local customs, aspirations, and attitudes.

1.10.3 Impact Assessment

The environmental, socioeconomic, cultural, gender and project information collected in previous phases were used to assess the potential impacts of the proposed activities. The issues studied included potential project impacts on:

- Ambient air quality;
- Ecology of the area, including flora and fauna;
- Local communities;
- Water quality.

Wherever possible and applicable, the report discusses the following aspects:

- The present baseline conditions;
- The change in environmental parameters likely to be affected by proposed project related activities;
- Identification of potential impacts;

- Likelihood and significance of potential impacts;
- Mitigation measures to reduce impacts to negligible level;
- Prediction of impacts, including all long-term and short-term, direct and indirect, and beneficial and adverse impacts;
- Evaluation of the importance or significance of impacts (The significance of each impact has been judged on the basis of available local, national, and international standards. Where such standards were not available, the best practice elsewhere has been referred to);
- Implementation of mitigation measures (i.e., environmental management);
- Determination of residual impacts;
- Identification of controls and monitoring of residual impacts.

1.10.4 Documentation

At the end of the assessment, a report is prepared according to the relevant guidelines of SEPA. This report includes the findings of the assessment, proposed project impacts, and mitigation measures to be implemented during the execution of the proposed activities.

The standard report format is as follows:

- Executive Summary
- Introduction
- Project Description & impact areas
- Institutional, Legislation and Policy Framework
- Physical Environment
- Ecological Environment
- Socio-Economic and Cultural Environment
- Alternatives
- Environmental Impacts and Mitigations
- Environmental Management and Monitoring Plan
- Conclusion

CHAPTER 2 PROJECT DESCRIPTION

2.1 GENERAL OUTLINE AND SCOPE

This section of the ESIA report presents a detailed technical description of the proposed project. A detailed insight regarding the proposed project was established by reconnaissance survey, site visit, and detailed discussions between technical teams of K-Electric and GEMS (refer **Exhibit 2.1** for pictorial presentation of surveys and technical discussions).

Exhibit 2.1: Pictorial Presentation of Surveys and Technical Discussion

Key Features of Proposed Power Project

Proposed Installations	2 X 450 MW Power Generation Units 03 132 kV GIS & 01 220 kV GIS
Power Plant Technology	Combined Cycle
Project Life	30 Years
Fuel Type	RLNG/Natural Gas
Annual Fuel Consumption	90996~126384 Nm^3/a
Gross Thermal Efficiency	59 %
Cooling Water Requirement	2 x 34,811.44 m^3/h

Key Benefits of the Proposed Power Project

- Enhanced power capacity
- Efficient power generation
- Reduces emissions
- Greater operational flexibility

2.2 PROPOSED PROJECT LOCATION

The proposed project mainly deals with 02 X 450 MW RLNG Based Combined Cycle Power Generation Units. It also includes installation of mechanical structures for power generation units at Port Qasim and at two Grid Stations and two Substation. Proposed installations for BQPS-III power project are presented below as **Exhibit 2.2.**

Exhibit 2.2: Proposed Installations for BQPS-III Power Project:

Proposed Installations	Location	Attachments
02 X 450 MW of RLNG Based Power Generation Unit	BQPS-I	Exhibit 2.3
01 X 220 kV GIS Grid Station	BQPS-I	
01 X 220 kV ICI Switch Station	Opposite BQPS-I	
01 X 132 kV GIS Grid Station	KPC	Exhibit 2.4
01 X 132 kV GIS Substation	Landhi Grid Station	Exhibit 2.5
01 X 132 kV GIS Substation	Korangi West and Qayyumabad	Exhibit 2.6

Exhibit 2.3: 2 X 450 RLNG Based Power Generation Units Location Map for BQPS-III Project

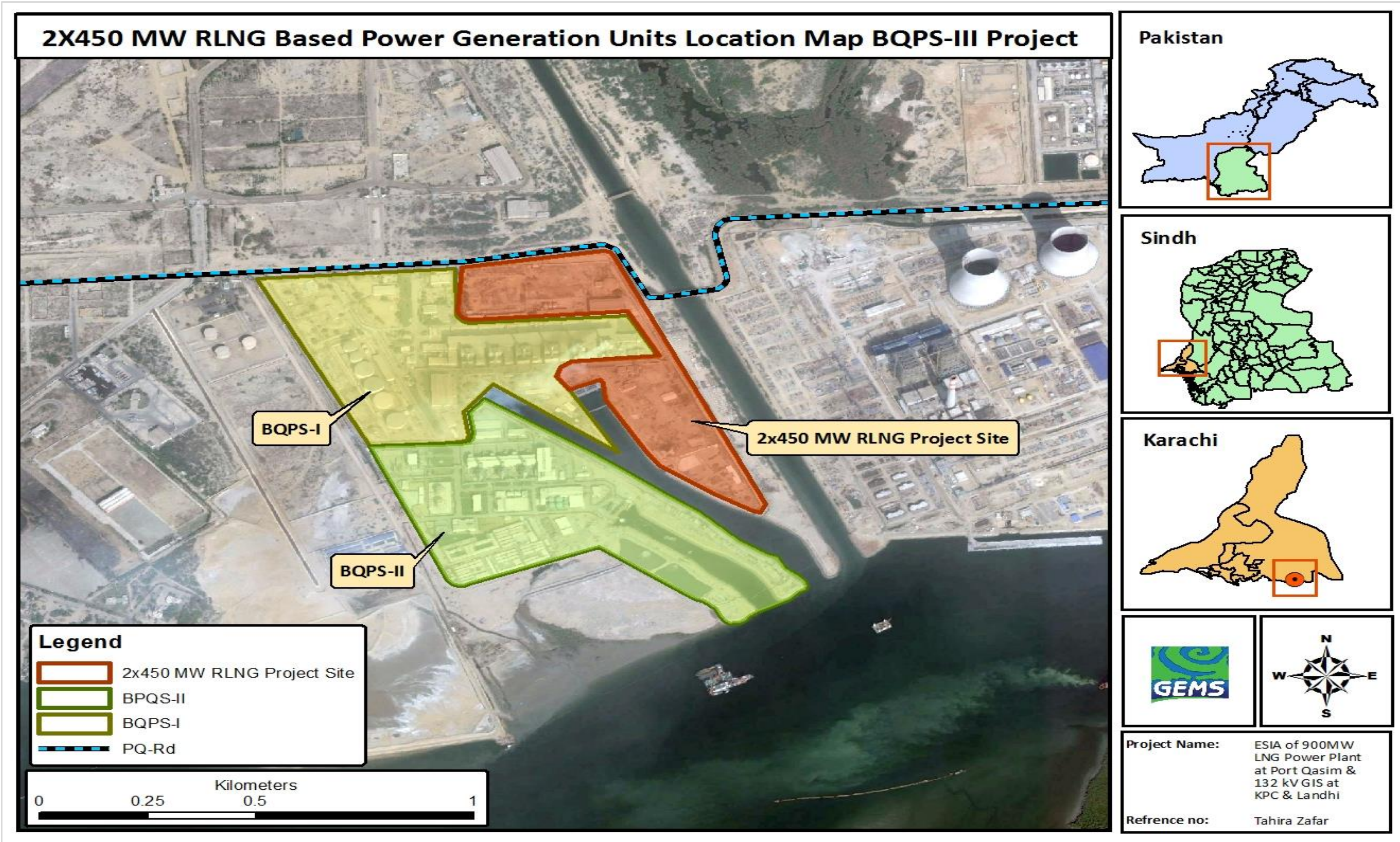


Exhibit 2.4: 01 132 kV GIS Grid Station at KPC for BQPS-III Project

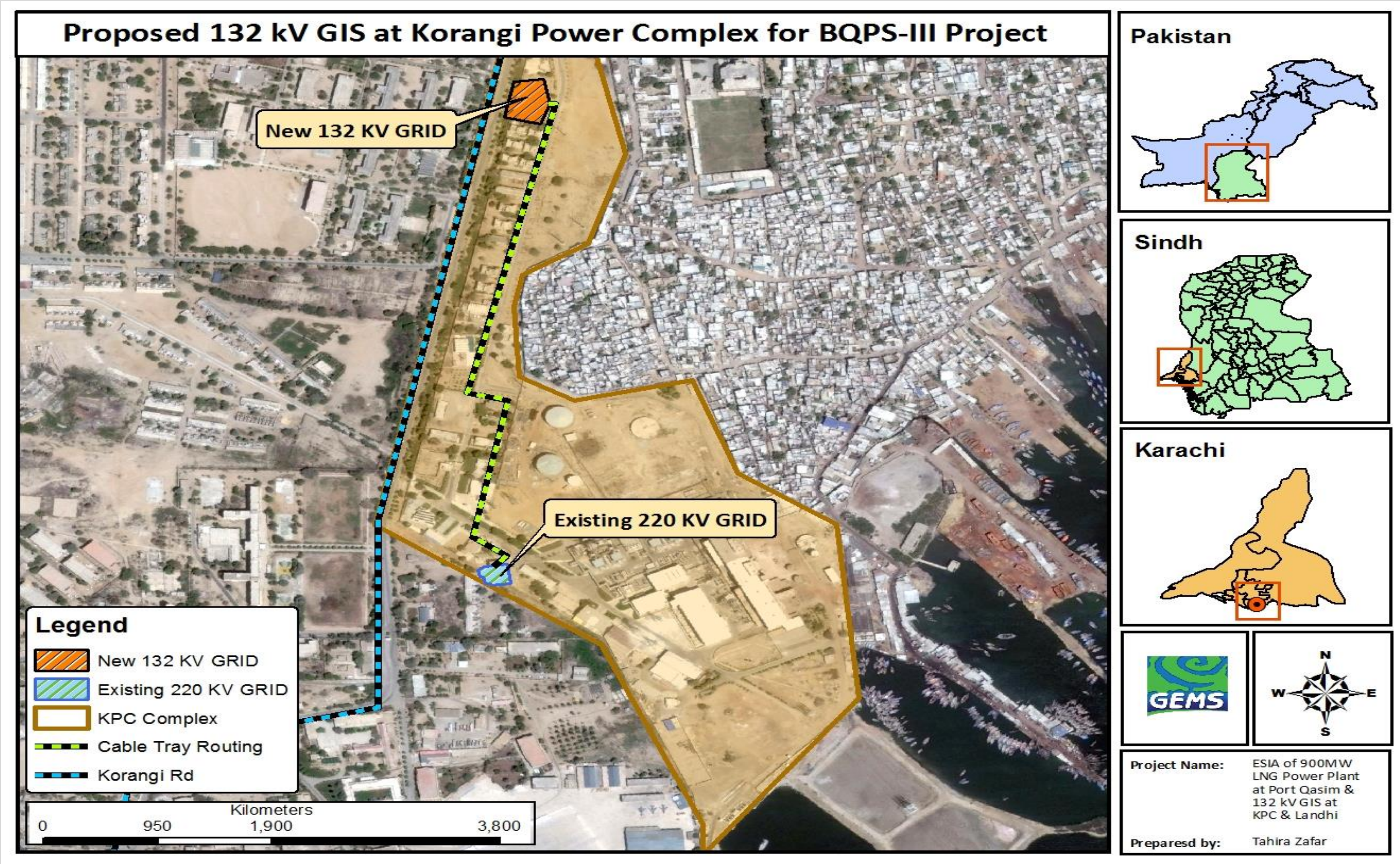


Exhibit 2.5: 01 132 kV GIS Grid Station at Existing Landhi Grid Station

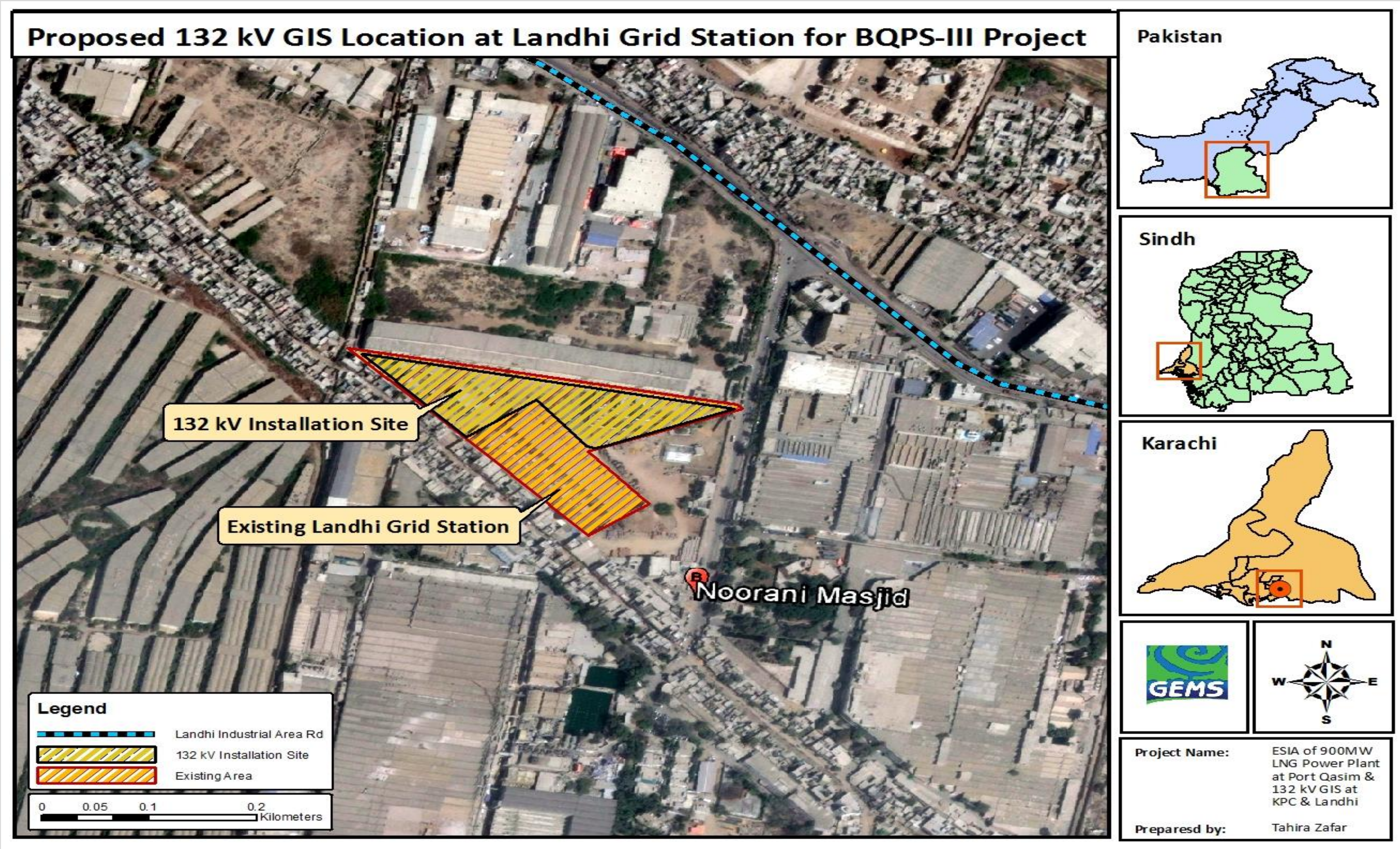
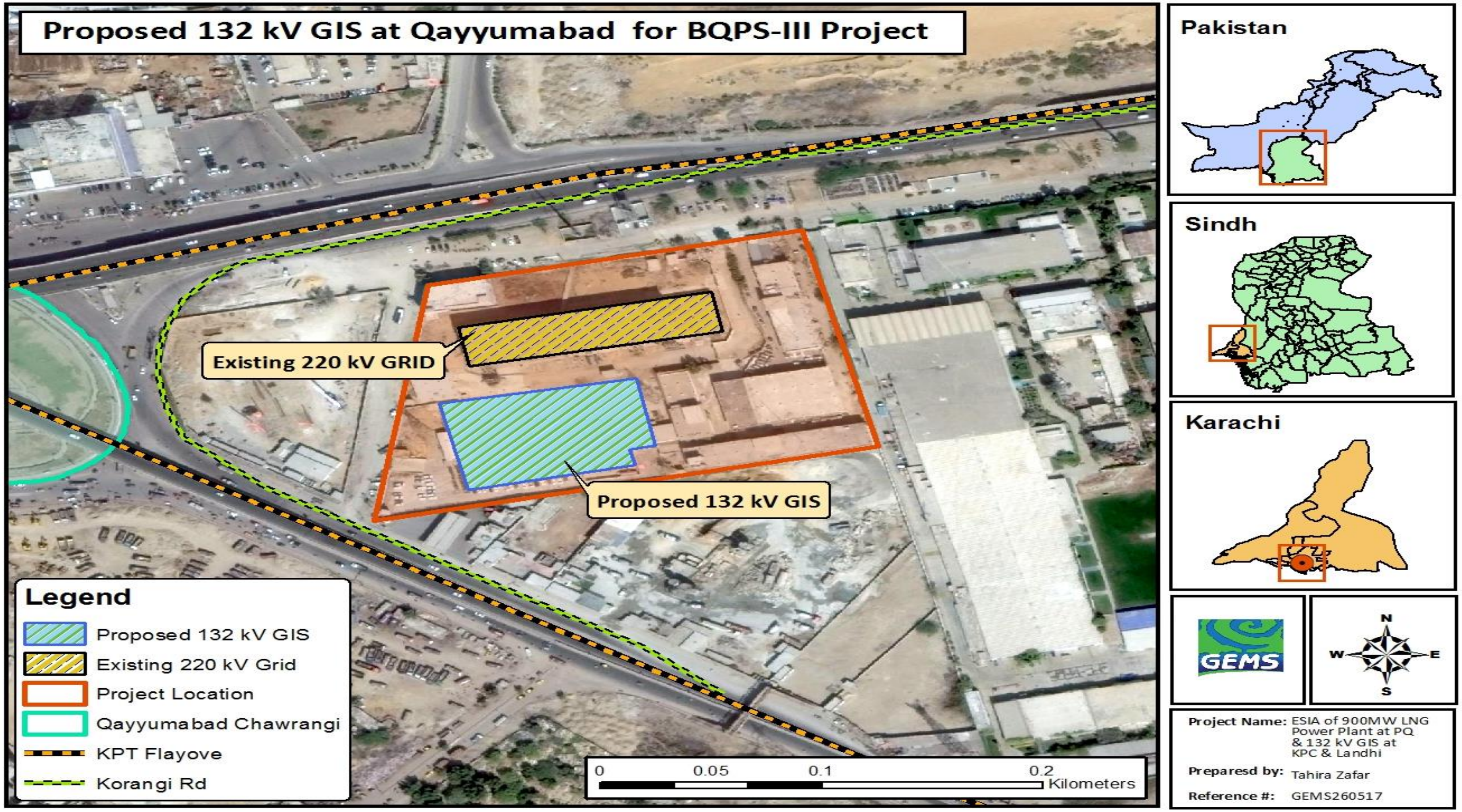


Exhibit 2.6: 01 GIS Grid Station at Existing Qayyumabad Grid Station



2.3 TECHNICAL DESCRIPTION

The proposed project needs a number of installations, detailed description of the installations for BQPS-III Power Project are defined as under:

2.3.1 Installations within the Existing Premises of BQPS-I for Proposed BQPS-III Power Project:

The proposed project includes construction of 02 X 450 R-LNG sets of 1+1+1 configuration Gas Turbine F class combined-cycle power generation units namely unit 7 & 8 inside the boundary of BQPS-I which will replace existing unit 3 and 4. These units are NG and HFO based power generation units of BQPS-I. Proposed installation for 2 X 450 MW R-LNG Based Combined Cycle Power Generation Units 7 & 8 are presented below as **Exhibit 2.7**.

Exhibit 2.7: Proposed installation for 2 X 450 MW R-LNG Based Combined Cycle Power Generation Units 7 & 8

Proposed Installation	Specifications
Gas Turbine House	Proposed installation specifications are defined on the next page of this section of ESIA document under heading 2.3.1.1 till 2.3.1.9
Heat Recovery Steam Generators (HRSG)	
Steam Turbine	
Bypass Stacks	
Gas Insulated Switchgear (GIS)	
ICI 220 kV Swith Station	
Gas Boosting and Regulating Station	
Generators and Transformers	
Cooling Water System	
Centralized Control Room (CCR)	
Hydrogen Generation System	
Water Treatment Plant	
Workshop and Laboratories	
Fire Fighting System	

2.3.1.1 Gas Turbine House

The gas turbine house will be constructed within the existing premises of BQPS-I. The gas turbines will be arranged indoors and the waste heat boiler will be arranged in the open air. The gas turbine building will be equipped with a ventilation system of natural air inlet through the electric-drive blinds and mechanical exhaust by the explosion-proof roof fan, the ventilation system will also be used for emergency ventilation. Exhaust from the exhaust housing, gas turbine casing and HP/MP casing will be directed outdoors.

Figure 1: Schematic of a Typical Gas Turbine House

A standby exhaust fan will be installed in Gas Turbine House. The ventilation systems of the exhaust housing, gas turbine casing and HP/MP casing will be designed and supplied by the manufacturer of the related equipment. In order to prevent accumulation of hydrogen and natural gas, the natural vent cap will be arranged at the highest point on the roof of the gas turbine building. The roof fan will be of an explosion-proof type. Local jet fans will be arranged at the points with possible process leakage and the dead corners of ventilation so that local accumulation of explosive gas and heat can be avoided. All the HVAC equipment to be placed in hazardous areas will be of an explosion-proof type. (Refer figure 1 to observe a typical gas turbine house)

Figure 2: F Class Gas Turbine

2.3.1.2 Heat Recovery Steam Generators (HRSG)

HRSGs will be provided for exhaust gases of RLNG/NG for heating and producing steam. Steam generated in an HRSG from the gas turbine exhaust will be used to supply steam to steam turbine and the fuel heating system.

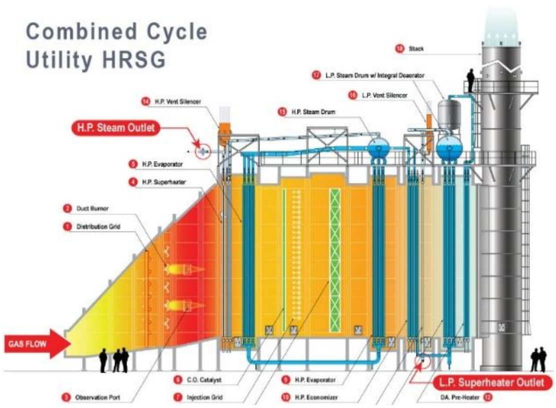


Figure 3: Schematic Representation of a Typical HRSG

The HRSG will be of a proven robust horizontal design, requiring minimal maintenance and suitable for the full range of operational flue gas temperatures and profiles. The effect of differential expansion between system components, caused by cooling and heating rates during static and transient operating conditions, will be taken into account in the design. The HRSG design will ensure that no parts suffer from fatigue failure under the range of operating conditions. **Figure 3** is the schematic representation of a typical HRSG system.

The HRSG design is based on the followings essential criteria

- Conformity with the particular requirements of the engine exhausts characteristics;
- Suitability for fast changing in working conditions;
- Long life and reliability to ensure high plant availability;
- Modular design based on factory built modules with as much equipment as practicable factory assembled;
- Easy access for inspection and maintenance;
- Protection of relevant HRSG components from attack by acidic condensation.

2.3.1.3 Steam Turbine

The steam turbine sends its energy to the generator drive shaft, where it is converted into additional electricity. In the multiple shaft arrangement, the steam turbine will be connected only with the water conduit with steam on the waste heat boiler equipped for the gas turbine. In the gas-steam combined cycle system, the exhaust from the gas turbine will be sent to the waste heat boiler and bring about water steam; and the high pressure steam from the waste heat boiler will go into the steam turbine to work. (Refer figure 3 for Combined Cycle Turbine System)

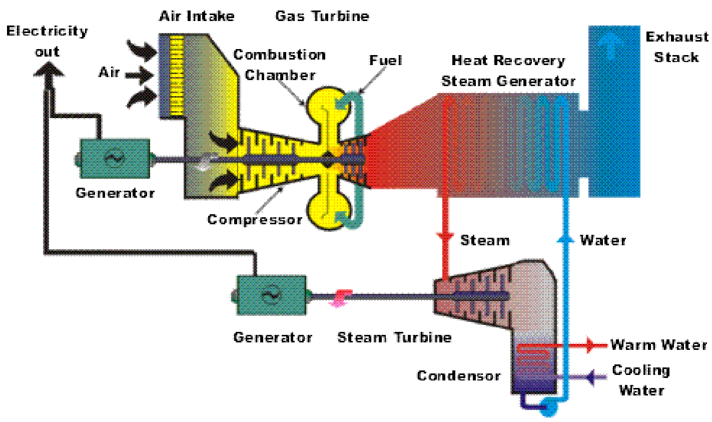


Figure 4: Combined Cycle Turbine System

2.3.1.4 Bypass Stacks

Two bypass stacks of 45 m height will be installed for the proposed project, a typical gas turbine bypass system is designed to divert the flue gases from the HRSG to a bypass stack with a silencer assembly to allow the plant to operate in simple cycle mode. This allows the HRSG to be inspected, repaired, or have maintenance performed while it is isolated completely from the gas turbine. Using a bypass stack also allows for combined cycle operation during the day and

Figure 5: Schematic of a Typical Bypass Stack

simple cycle operation at night when power demand is lowest, providing a greater savings in operation cost and efficiency over the life of the power plant. The bypass stack permits power to be generated by the gas turbine even when the steam turbine cycle is down for a scheduled or unscheduled shut down, keeping the plant functional and avoiding potential power outages. (Refer figure 4 to observe a typical bypass stack).

2.3.1.5 Gas Insulated Switchgear (GIS)

Generally a GIS is much more reliable, compact and maintenance free. Because of compactness of equipment, a very small area of land and civil work is required resulting in substantial savings. They are at present mostly used in space constraint areas. SF6 Sulfur hexa fluoride gas is being extensively used as a dielectric and extinguishing arc media in the area of high voltage electrical switchgear. Each individual item of switchgear is metal enclosed which is at earth potential. Figure 5 is the schematic representation of a typical GIS system.

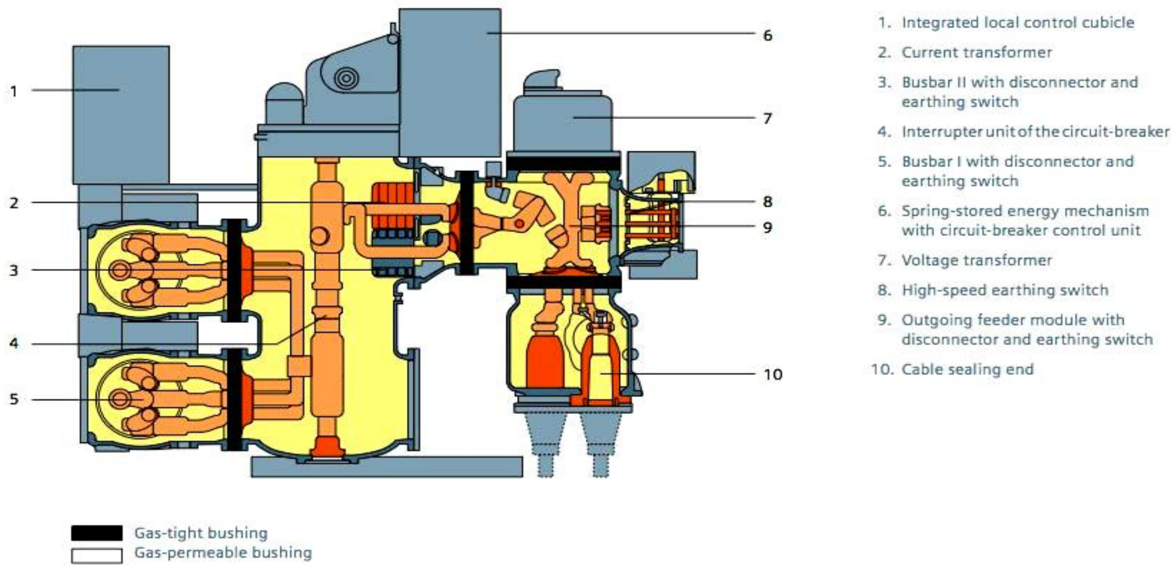


Figure 6: Schematic Representation of a Typical GIS

2.3.1.5.1 Specifications of Proposed 220 kV GIS substation within the Existing Premises of BQPS-I for Proposed BQPS-III Power Project:

As far as proposed project installations area is concerned, a new 220 kV GIS substation will be installed and Four (04) generators will be connected to this new 220kV substation via four unit step-up transformers. The new GIS bus bar will be double bus with two bus section CBs and two bus coupler CBs. The original 4 outgoing overhead lines in BQPS-I GIS will be used as the outgoing lines of the new GIS and for incoming lines there will be two 9F gas turbine unit step-up transformers and unit auxiliary transformers, two 9F steam turbine unit step-up transformers, one new middle-voltage standby transformer, G1, G2, G5, G6 unit step-up transformers and startup transformers.

Existing Incoming and Outgoing Lines Connection with Proposed 220 kV GIS substation.

2 short link lines of BQPS-I GIS connected to BQPS-II GIS, will be transferred to the new GIS, and two series reactors will be set between new GIS switchyard and BQPS-II GIS switchyard. All incoming lines of the new GIS will use 220 kV cable. 4 outgoing lines will be connected to the overhead lines in BQPS-1 GIS using 220 kV cable.

2.3.1.6 ICI 220 kV Switch Station

The existing ICI 220 kV Switch Station is located opposite to the BQPS-I Power Plant, as the BQPS-III power plant will come into operation, the short circuit current of 220 kV ICI Switching Station will exceed from 40 kA. At present, ICI Switching Station uses single-bus segmented wiring and five (05) loops of incoming and outgoing lines. (Refer Figure 6 for the main electrical connections)

In this proposed activity, five (05) sets of 40 kA AIS equipment including circuit breakers will be replaced by rated current 3150 A and 50 kA short circuit current equipment and the length of cable will be about 2, protection relays and measuring control devices will remain unchanged.

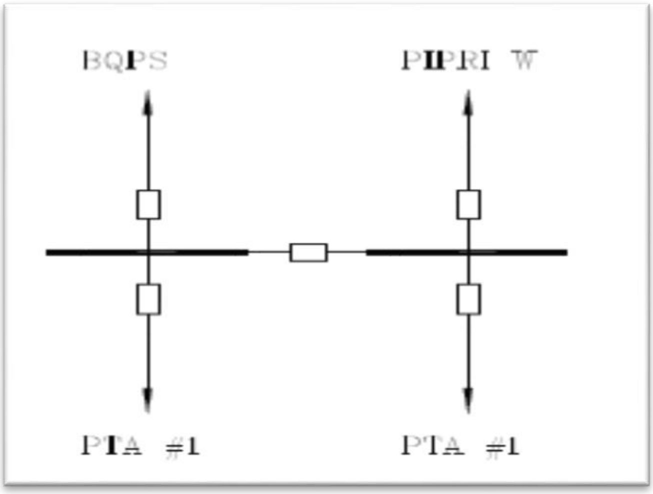


Figure 7: Main Electrical Connections

2.3.1.7 Gas Boosting and Regulating Station

The function of the boosting and pressure regulating station is to regulate the pressure of the natural gas and keep it in the range of the inlet pressure accepted by the gas turbine. It shall be kept stable as well, for it fluctuates with the natural gas consumption along the pipeline. Therefore, a pressure regulating station shall be arranged in the plant area so that the natural gas going into the gas turbine will be kept at a stable pressure.

For the project in question, a set of boost station and a set of pressure regulating station will be arranged for two gas turbines. The pressure regulating station will be equipped with two main pressure regulating pipelines, on which the main and auxiliary pressure regulators, emergency shutoff valve and isolation valve will be installed. Accompanied by a bypass pressure regulating pipeline with the same capacity, each main pressure regulating pipeline will correspond to a gas turbine. The two main pipelines will not serve as a standby for each other. Each pressure regulating station will be equipped with two filters of 100% capacity and dewatering equipment, with one in operation and the other standby. And Flow meter, Gas Chromatograph and Gas Heater are in the gas treatment station.

The boost station and pressure regulating station can be arranged in three ways: outdoor arrangement; semi-outdoor arrangement with a rain hood; indoor arrangement. The semi-outdoor arrangement with a rain hood is recommended for the project in question.

SSGC are providing gas to both existing BQPS phase I and II through pipeline. Currently SSGC pipe has been laid to the northwest of the project. Pipeline design parameters are 12bar, DN750. The pressure at SSGC natural gas source for the project in question is rather low (about 1.8 bar to 4.5 bar). Natural gas from SSGC will be pressurized in boosting station using Natural Gas Compressor to the level accepted by the gas turbine prior to utilization.

Due to lack of gas, SSGC pipeline can only meet the gas consumption of one F-class gas turbine. Therefore RLNG will be used as alternative. RLNG provider shall delivered the RLNG up to Battery limit through pipeline from where it brought to Gas Condition Station. Then send to the pressure regulating station by pipeline, and transported to the two F class gas turbine. At the same time, SSGC switch to the standby gas source. The gas turbine can transfer gas source from RLNG to SSGC online.

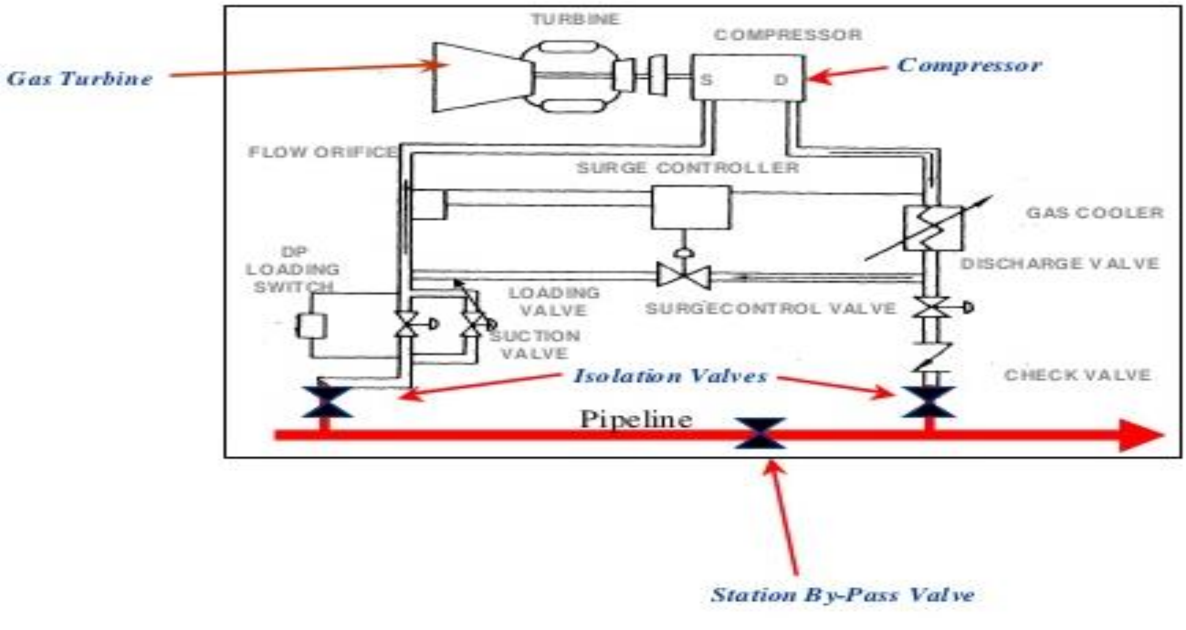


Figure 8: Schematic for Typical Gas Compressor Station

2.3.1.8 Generators and Transformers

In the proposed project, two fuel-steam combined cycle units will be constructed. Two gas turbine generators and two condensing engine generators will be connected to the low voltage side of unit step-up transformer (UT) via continuous isolated phase bus. Generator circuit breaker (GCB) will be equipped at outgoing of the gas turbine generator (GTG). The Gas Turbine Generator (GTG) will be full-hydrogen or water-hydrogen-hydrogen cooling. The rated power is temporarily determined as

300MW and the rated power factor is 0.85. The static excitation will be adopted. The Steam Turbine Generator (STG) will be air cooling. The rated power is temporarily determined as 150MW and the rated power factor is 0.85. Self-powered and static excitation will be adopted.

2.3.1.9 Cooling System

In this proposed project, once-through cooling system will be adopted. The existing water channel and CW pump facilities of decommissioned units (unit 3 & 4) of BQPS-I will be used for the proposed 7 & 8 unit.

The existing plant has six (06) 210MW gas turbine units and all circulating water systems adopt once-through cooling water supply systems. The water supply source is taken from open channel. Owing to restricted site condition, it is unable to establish new water intake facilities. Both No.3 and No.4 units are respectively equipped with two main circulating water pumps and one auxiliary cooling water pump.

Main cooling water consumption required by two grade F gas turbine is 2 × 34, 811 m^3/h and auxiliary cooling water consumption is 2×2,500m^3/h. Portable and raw water required in the new plant will come from the existing network of the old plant. The water quantity for the new plant is 55m^3/h.

The project adopts once-through cooling water supply and main cooling water consumption required by 02 X 450 MW CCPGU is about 2×26195m3/h

Length of intake channel is about ___930 m______

Length of outfall channel is about __2187 m______

Existing usage is ___36,000____ m3/hr.

Requirement of new plants is approx. ___ 2 x 34811.44____ m3/hr

Key Features of Centralized Control Room (CCR)

- Electrical equipment room
- Instrumentation equipment room
- Control system
- Firefighting system
- Safety instrument system for ESD
- CCTV
- HVAC System

2.3.1.10 Centralized Control Room (CCR)

Combined cycle generating units will be monitored and controlled in the centralized control room and control will be conducted in a unit-wise centralized manner. CCR and Electrical Control Room (ECR) will be situated in between the two gas turbines. The gas-steam combined cycle generating units will be controlled with Distributed Control System (DCS). Operator station of the HRSG, Generators and power for each set of the generating units will be placed here. The CCR will be equipped with emergency, start and shutdown buttons so that safe shutdown of the generating units can be ensured in case a failure occurs in the DCS. Circulating water dosing system and water-steam sampling system will be scheduled to be monitored and controlled in the control room of the demineralization system. Moreover, the CCR will also be equipped with the closed-circuit TV monitoring system for the generating units and the plant area making it convenient for the operators to learn about the operating status of the whole plant. The CCR and ECR will be equipped with the centralized air conditioning system.

New 220kV substation will be monitored in the new network control building.

2.3.1.11 Hydrogen generation System

There are two (02) hydrogen generation plants in the existing power station. The design capacity of each plant is 6 Nm^3/h and these old inefficient plants are working on 50% capacity therefore to increase the capacity a new hydrogen generation system will be installed. Hydrogen supply required by the hydrogen cooling system of the generator will be sourced from the new-built hydrogen generation system. The devices that regulate the hydrogen will be sent to main building by two (02) stainless steel pipes. The design capacity of the plant will be 2×5 Nm3/h.

The quality of product hydrogen is as follow:

Purity：≥99.8 %

Temperature：≤40℃

Humidity atmospheric pressure dew point≤-50℃

2.3.1.12 Firefighting System

A dedicated new fire-fighting system will be built for the proposed power plant. Design of the firefighting system is based on NFPA codes.

Independent water supply system for firefighting will be adopted. Two 800 m^3 combined service water and fire-fighting basins are considered to be designed to meet the firefighting water consumption. According to NFPA, capacity of the water tank is based on running pumps at rated capacity with all fire reals / hoses in service and deluge system for continuous 2 hours at the required operating pressure. High pressure regulation system will also be equipped.

An electric fire pump (Q＝565m3/h， H＝105m), a diesel standby fire pump (Q＝565m3/h， H＝105m) and a set of fire protection equipment will be built in the firefighting pump house. According to related specifications, diesel driven fire pump and electric fire pump will be set separately by the firewall.

Fire pipes will be arranged annularly in the plant, and indoor hydrants will be equipped in the buildings. Automatic sprinkler system, water spray system and gaseous extinguishing system will be adopted for the important equipment in turbine house and so on. Gaseous extinguishing system, water spray system or Nitrogen Suppression System will be adopted in central control building. Water spray system will be adopted in transformers. Potable extinguishers or indoor hydrants will be set in the GIS buildings.

According to related code, automatic fire alarm system will be set in steam turbine house, gas turbine house, central control building, transformer, oil tank and auxiliary buildings which have a fire risk. Automatic fire alarm system is composed of main monitoring panel, regional monitoring panel, local monitoring panel and remote diplopia panel, various detectors, manual alarm, alarm, cable and other equipment. When a fire occurs, fire signal is sent to the local monitoring panel, regional monitoring panel and the main monitoring panel by the detector, fire occurrence time and place can be displayed at all of the control panels, sound and light alarm signals are sent out and operation command is sent to the firefighting systems.

Fire protection system which is designed on NFPA codes will send out alarm signal in the early stage and can realize the concentrated, regional and local monitoring of the fire and also the remote and local control of the firefighting device, what's more, enough equipment capacity to put out the fire once a fire occurs is also equipped.

2.3.1.13 Workshop & Laboratories

New warehouse and workshop for the project in question will also built to full fill the operational need of the new power plant

2.3.1.14 Water Treatment Plant

In the proposed project, the 2×450MW gas-steam turbine combined cycle straight condensing units will be constructed. Existing water treatment plants cannot meet the demands of demineralized water required for the proposed project. Therefore, a new demineralized water treatment plant will be installed to meet the requirement. The water source for demineralized water treatment system will be city tap water.

Demineralized water produced from the new plant is expected to be qualified in accordance with the following standard:

SiO_2: ≤10μg/L

Conductivity (25℃): ≤0.10 μs/cm

For the proposed project, the quantity of makeup water for the generating units will be calculated as per the GB 50660-2011 Code for design of fossil fired power plant. Details of the loss of water-steam over the power plant are shown in **Exhibit 2.8**.

Exhibit 2.8: Loss of Water-Steam over Power Plant

Sr. No.	Item	2×450MW
1	Loss from normal water-steam circulation (t/h) (at a rate of about 2%)	16.2
2	Loss from blowdowns (t/h) (at a rate of about 1%)	8.1
3	Normal makeup water quantity (t/h)	24.3
Note: the total amount of evaporation of the triple pressure boiler is 405 t/h.		

Taking into consideration the water demand revealed from the above table as well as such factors as maintenance and repair of the related equipment, the power output of the demineralization unit for the project in question is designed as 25 m^3/h.

2.3.2 Modifications within the Existing Premises of KPC for Proposed BQPS-III Power Project:

As presented in **Exhibit 2.4** location map of KPC a new Grid will be installed right next to entrance gate of KPC cable conduit of 220 kV TR-XLPE to connect 220 kV GIS and auto transformer will be laid along the road within the existing premises of KPC. The existing evacuation system of KPC is shown as **Figure 9**.

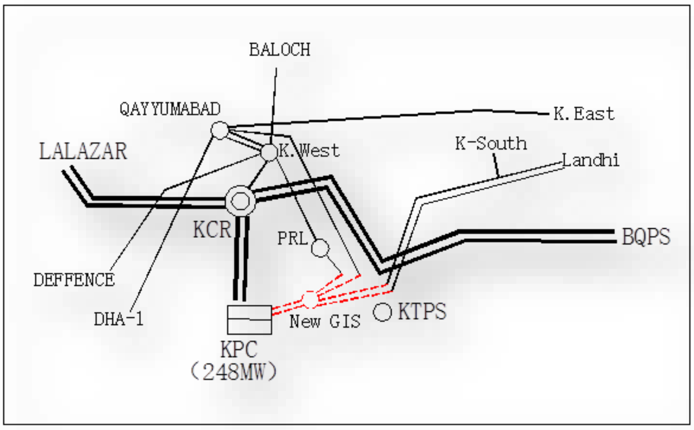


Figure 9: The Existing Evacuation System of KPC

Moreover it is important to note that for the proposed BQPS-III Power Project, following installations within KPC will take place:

- Installation of two sets of 250MVA（220kV/132kV） auto transformers to connect 220kV system with 132kV system.
- Extension of 220kV GIS bus with two transformer bays for which, switchgear room will be extended up to 6m with protection and control equipment.
- Construction of a new 132kV GIS building to accommodate the GIS and related protection and control equipment.
- Modification of 132kV outgoing transmission lines from 132kV GIS to first tower near site fence
- 220kV TR-XLPE to connect 220kV GIS and auto transformer.

2.3.3 Modifications within the Existing Premises of Landhi Grid Station for Proposed BQPS-III Power Project:

As presented in **Exhibit 2.5** location map of proposed 132 kV GIS Grid Station at Existing Landhi Grid station for BQPS-III power project the exhibit title itself suggests that a new 132 kV GIS Grid Station will be installed within the existing boundaries of the grid station (Refer **Figure 8** for Landhi evacuation system)

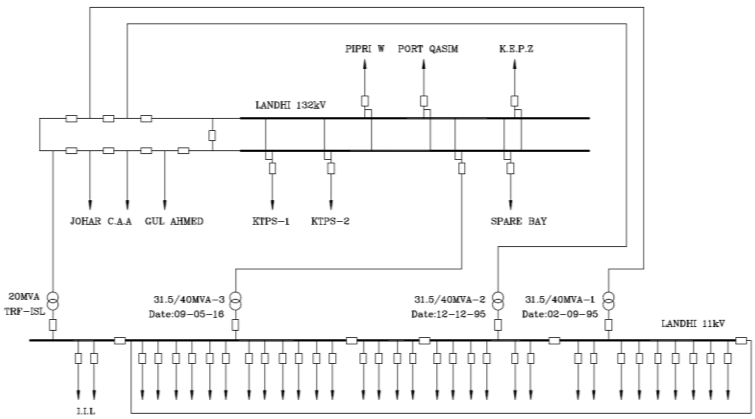


Figure 10: Landhi evacuation system

2.3.4 Modifications within the Existing Premises of Qayyumabad Grid Station for Proposed BQPS-III Power Project:

As presented in **Exhibit 2.6** location map of proposed 132 kV GIS will be installed within the existing facility. The existing 132 kV power distribution unit at Qayumabad is indoor AIS equipment and main electrical connection uses double-bus wiring. The 132 kV power distribution unit at Korangi West station is indoor AIS equipment and main electrical connection uses open-ended ring like wiring. At present, 132 kV buses of both stations are connected via tubular copper busbar.

In this proposed project, following modifications will take place:

- Two dis-connectors will be added to the 132 kV bus that will connect Qayumabad to Korangi West. Two disconnector terminal boxes in place and one Bus Bar Protection Relay Panel in relay room will be added. A monitoring and control device will be added in this project which is used to provide control and interlock signal of disconnector and collect the location of the disconnector.

- Replacements of four sets of 31.5 kA equipment at 132 kV Korangi West station with 40 kA equipment and the length of the cable will be about 8km. (Refer figure 9 for Main Electric Wiring of 132kV Qayumabad and Korangi West Grid Station)

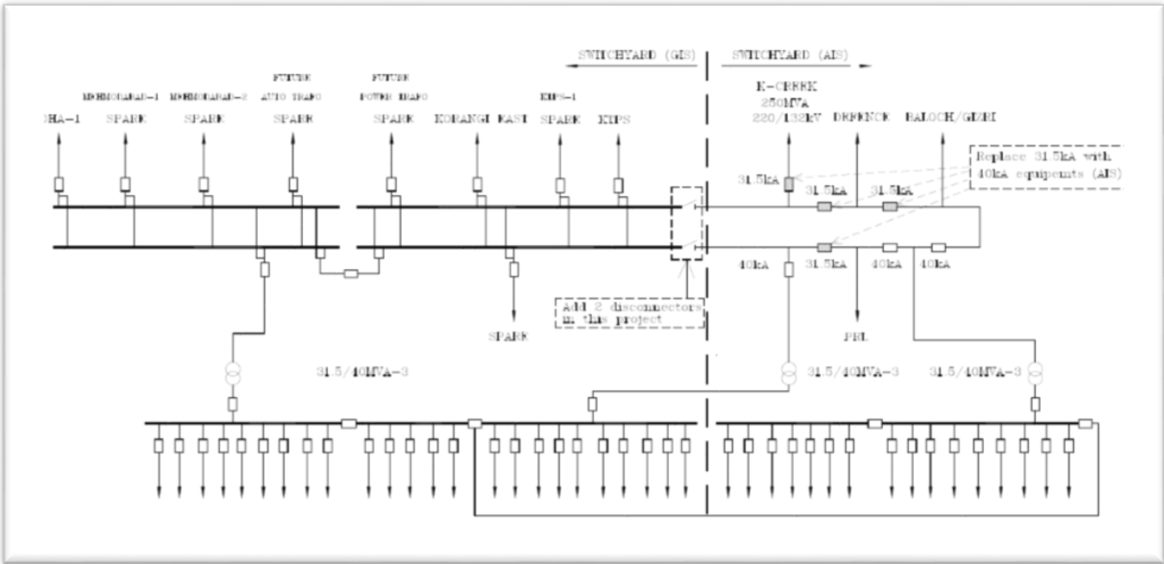


Figure 11 Main Electrical Wiring

CHAPTER 3

INSTITUTIONAL, LEGISLATION AND POLICY FRAMEWORK

3.1 GENERAL OUTLINE AND SCOPE

This section of the EIA document gives an overview of the policy framework and national legislation that applies to the proposed Project. The proposed project is expected to comply with all the applicable Provincial and National legislation guidelines relating to environmental and social aspects, and all the required regulatory clearances will be obtained.

The environmental study primarily includes review of EIA/IEE regulations 2014 of Sindh Environmental Protection Act. Other laws and guidelines relevant to the project as given in **Exhibit 3.1** have also been reviewed.

Exhibit 3.1: Policies, Legislation and Guidelines

Provincial and National Environmental Policy, Legislation and Guidelines
National Conservation Strategy (NCS)
National Environmental Policy 2005
National Climate Change Policy, 2011
National Power Policy, 2013
National Environmental Action Plan-Support program (NEAP-SP)
Sindh Environmental Protection Act 2014
Land Acquisition Act, 1894
Pakistan Penal Code (1860)
Port Qasim Authority Act, 1973 (Modified in 2002)
The Antiquities Act
The Factories Act, 1934
Electricity Act, 1910

Sindh Wildlife Protection (Amendment) Act 2008
Sindh Forest Act (2012)
The Sindh Fisheries Ordinance, 1980
Sectoral Guidelines for Thermal Power Stations, 1997
National and International Guidelines or Standards
The Pakistan Environmental Assessment Procedures, 1997
OSHA Standards Health Safety
World Bank Guidelines on Environment
World Bank EHS General Guidelines, 2007

3.2 PROVINCIAL AND NATIONAL ENVIRONMENTAL POLICY, LEGISLATION AND GUIDELINES

The enactment of comprehensive legislation on the environment, covering multiple areas of concern, is a relatively new and ongoing phenomenon in Pakistan. Whereas, a basic policy and legislative framework for the protection of the environment and overall biodiversity in the country is now in place, detailed rules, regulations and guidelines required for the implementation of the policies and enforcement of legislation are still in various stages of formulation and discussion. A brief overview of the existing national policies, legislation and guidelines is presented below.

3.2.1 National Conservation Strategy (NCS)

The National Conservation Strategy (NCS) is the primary Policy document of the Government of Pakistan on national environmental issues. The Policy was approved by the Federal Cabinet in March 1992. The Strategy also attained recognition by international donor agencies, principally the World Bank. The NCS identifies 14 core areas including conservation of biodiversity, pollution prevention and abatement, soil and water conservation and preservation of cultural heritage and recommends immediate attention to these core areas in order to preserve the country's environment.

A midterm review of the achievements of the NCS in 2000 concluded that achievements under the NCS have been primarily awareness raising and institutional building rather than actual improvement to environment and natural resources and that the NCS was not designed and is not adequately focused as a national sustainable development strategy[1]. The need therefore arose for a more focused National Environmental Action Plan (NEAP) required to bring about actual improvements in the state

[1]Arthur J. Hanson et al, Pakistan's National Conservation Strategy Renewing Commitment to Action, Report of the Mid-Term Review, 2000

of the national environment with greater emphasis on poverty reduction and economic development in addition to environmental sustainability.

The NEAP was approved by the Pakistan Environmental Protection Council under the chairmanship of the President/Chief Executive of Pakistan in February 2001. NEAP now constitutes the national environmental agenda and its core objective is to initiate actions that safeguard public health, promote sustainable livelihoods, and enhance the quality of life of the people of Pakistan.

A National Environmental Policy has been approved by the Federal Cabinet in its meeting held during June 2005[2]. This policy has already been endorsed by the Pakistan Environmental Protection Council during 2004. The new policy has total 171 guidelines on sectoral and cross-sectoral issues. The objectives of new policy include assurance of sustainable development and safeguard of the natural wealth of country. The following are the approved Sectoral Guidelines;

- Water Supply and Management;
- Air Quality and Noise;
- Waste Management;
- Forestry;
- Biodiversity and Protected Areas;
- Climate Change and Ozone Depletion;
- Energy Efficiency and Renewable;
- Agriculture and Livestock;
- Multilateral Environmental Agreements.

3.2.2 National Environmental Policy 2005

The national environmental policy aims to protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development. The objectives of the policy are:

- Conservation, restoration and efficient management of environmental resources.
- Integration of environmental considerations in policy making and planning process.
- Capacity building of government agencies and other stockholders at all level for better environmental management.
- Meeting international obligations effectively in line with the national aspirations.
- Creation of a demand for environment through mass awareness and community mobilization[3].

[2]National Environmental Policy, GoP, 2005
[3]National Environmental Policy, 2005.

3.2.3 National Climate Change Policy, 2011

To ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Pakistan towards climate resilient development. The main objectives of Pakistan's Climate Change Policy include:

- To pursue sustained economic growth by appropriately addressing the challenges of climate change.
- To integrate climate change policy with other inter-related national policies.
- To focus on pro-poor gender sensitive adaptation while also promoting mitigation to the extent possible in a cost-effective manner.
- To ensure water security, food security and energy security of the country in the face of the challenges posed by climate change.
- To minimize the risks arising from the expected increase in frequency and intensity of extreme weather events such as floods, droughts and tropical storms.
- To strengthen inter-ministerial decision making and coordination mechanisms on climate change.
- To facilitate effective use of the opportunities, particularly financial, available both nationally and internationally.
- To foster the development of appropriate economic incentives to encourage public and private sector investment in adaptation measures.
- To enhance the awareness, skill and institutional capacity of relevant stakeholders.
- To promote conservation of natural resources and long term sustainability[4].

3.2.4 National Power Policy, 2013

The Ministry of Water and Power of the Government of Pakistan has developed an ambitious power policy to support the current and future energy needs of the country. This bold strategy will set Pakistan on a trajectory of rapid economic growth and social development. Simultaneously, it will address the key challenges of the power sector in order to provide much needed relief to the citizens of Pakistan.

- Build a power generation capacity that can meet Pakistan's energy needs in a sustainable manner.
- Create a culture of energy conservation and responsibility.
- Ensure the generation of inexpensive and affordable electricity for domestic, commercial, and industrial use by using indigenous resources such as coal (Thar coal) and hydel.
- Minimize pilferage and adulteration in fuel supply

[4] National Climate Change Policy, 2011.

- Promote world class efficiency in power generation
- Create a cutting edge transmission network
- Minimize inefficiencies in the distribution system
- Minimize financial losses across the system
- Align the ministries involved in the energy sector and improve the governance of all related federal and provincial departments as well as regulators[5].

3.2.5 National Environmental Action Plan-Support program (NEAP-SP)

The government of Pakistan and united nation development program (UNDP) have jointly initiated an umbrella support program called the National Environmental Action Plan-Support program (NEAP-SP) signed in October 2001 and implemented in 2002. The development objective supported by NEAP-SP is environmental sustainability and poverty reduction in the context of economic growth.

3.2.6 Sindh Environmental Protection Act 2014

The Sindh Environmental Protection Act, 2014 (SEPA 2014) is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The SEPA 2014 is broadly applicable to air, water, soil, marine and noise pollution. Penalties have been prescribed for those contravening the provisions of the Act.

The two primary deliberations of the Act are the conduct of projects only after approval of environmental assessments from the SEPA and adherence with Sindh Environmental Quality Standards (SEQS).

3.2.6.1 EIA Approval Mechanism from Sindh Environment Protection Agency (SEPA)

As per the 2014 Regulations, Proponent will submit an EIA report for their project activities to SEPA and seek approval on the same from the agency. Ten hard copies and 2 soft copies of the EIA report will be submitted to SEPA. It will then grant its decision on the EIA as per the rules and procedures set out in the 2014 Regulations. The following rules will apply:

- A fee is payable to SEPA for review of the EIA;
- The EIA submission is to be accompanied by an application in the format prescribed in Schedule V of the 2014 Regulations;
- SEPA is bound to conduct a preliminary scrutiny and reply within four weeks of the submission of the report a) confirming completeness, or b) asking for additional information, if needed;

[5] National Power Policy, 2013

- The proponent will publish a public notice in any English or Urdu national newspaper and in a local newspaper of general circulation in the area affected by the project. The public notice will mention the following:
  - The type of project;
  - The location of the project;
  - The name and address of the proponent;
  - The places at which the EIA can be accessed;
  - The date, time and place for public hearing of any comments on the project or its EIA;
- The date set for public hearing will not be earlier than fifteen (15) days from the date of publication of the public notice
- In the review process SEPA may consult a Committee of Experts, which maybe constituted on the request of the DG SEPA;
- On completion of the review process, the decision of SEPA will be communicated to the proponent in the form prescribed in Schedule V;
- Where an EIA is approved, SEPA can impose additional controls as part of the conditions of approval;
- SEPA is required to make every effort to complete the EIA review process within four months;
- The approval will remain valid for the project duration mentioned in the EIA but on the condition that the project commences within a period of three years from the date of approval. If the project is initiated after three years from approval date, the proponent will have to apply for an extension in the validity period. The SEPA on receiving such request grant extension (not exceeding 3 years at a time) or require the proponent to submit a fresh EIA if in the opinion of SEPA changes in baseline conditions or the project so warrant;
- After receiving approval from SEPA the proponent will acknowledge acceptance of the conditions of approval by executing an undertaking in the form prescribed in Schedule VI of the 2014 Regulations;
- The 2014 Regulations also require proponents to obtain from SEPA, after completion of the project, a confirmation that the requirements of the EIA and the conditions of approval have been duly complied with;
- The SEPA in granting the confirmation of compliance may impose any additional control regarding the environmental management of the project or the operation, as it deems necessary.

3.2.6.2 Sindh Environmental Protection Agency Review of IEE and EIA Regulations, 2014

The SEPA Review of IEE and EIA Regulations, 2014 (The 2014Regulations) promulgated under SEPA 2014 were enforced on December, 2014. The 2014 Regulations define the applicability and procedures for preparation, submission and review of IEEs and EIAs. These Regulations also give legal status to the Pakistan Environmental Assessment Procedures prepared by SEPA in 2014.

The Regulation classifies projects on the basis of expected degree of adverse environmental impacts and lists them in two separate schedules. Schedule I lists projects that may not have significant environmental impacts and therefore require an IEE. Schedule II lists projects of potentially significant environmental impacts requiring preparation of an EIA. The Regulations also require that all projects located in environmentally sensitive areas require preparation of an EIA.

The following project falls under the following category:

Schedule II (EIA):

Category A Energy

“Thermal power generation over 100MW”

3.2.6.3 The Sindh Environmental Quality Standards

During the construction and post development phase of the project SEQS will apply to any effluents during operation and emissions. The complete SEQS 2015 is attached as **Annexure-II**. SEQS Standards for disposal of solid waste have as yet not been promulgated[6].

3.2.6.4 Hazardous Substance Rules, 2014

The Sindh Hazardous Substances Rules, 2014 are a set of rules derived from the Sindh Environmental Act, 2014 and are first of the very specific hazardous substances regulations brought into force in 2014 after the initial draft set of rules devised in 2003. They represent specific regulations with aspect of handling, storage and disposal of hazardous substances and issuing an approving license to the user or facility. The Schedule-I of the Rules enlists the hazardous substances that are under the scrutiny of the Sindh-EPA[7].

Under its licensing terms, the Rules highlight particular components as follows:

- Employment of Qualified technical personnel
- Packing and labelling
- Conditions of Premises
- Safety precautions
- Trainings

[6] Library, Sindh Environmental Protection Agency, 2016
[7] Hazardous Substances Rules, 2014; Attached as **Annexure-III**

- A comprehensive safety plan
- Waste management Plan and
- Transporting of hazardous substances.

3.2.6.5 The Sindh Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rules, 2014

These rules are called the Sindh Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rules, 2014, which is entirely based on the honor system, emerged from a dialogue between the government and industrial representatives. These reports are submitted by an industrial unit to agency in respect of priority parameters. Priority parameters are parameters of Sindh environmental quality standards which selected for the purpose of submission of Environmental Monitoring Reports to the Agency by an industrial unit. Industrial unit responsible for the correct and timely submission report to the agency. On the basis of the pollution level of an industrial unit, the Director General shall classify the unit into category “A”, “B” or “C” for liquid effluents, and category “A” or “B” for gaseous emissions.

Category “A” Industrial unit

An industrial unit in category “A” shall submit environmental monitoring reports on monthly basis. An industrial unit in category “A” shall maintain a record of the times during which start-up and upset conditions occur, and shall mention the total time elapsed in such conditions in its monthly environmental monitoring report.

Category “B” Industrial unit

An industrial unit in category “B” shall submit environmental monitoring reports on quarterly basis.

Category “C” Industrial unit

An industrial unit in category “C” shall submit environmental monitoring reports on biannual basis for priority parameters in respect of liquid effluents.

All measurements of priority parameters contained in the environmental monitoring report submitted by an industrial unit shall be based on test reports of a certified environmental laboratory, and attested copies of such results shall be attached with the environmental monitoring report. The gaseous emissions report shall cover the priority parameters listed in Schedule-VII, and shall include, every two years, metal analysis of all gaseous emissions from the industrial unit[8].

3.2.6.6 Tribunal Rules for Non-Compliance

A failure to comply with any provision of these Rules (except rule 8(1), 16(1), 23 or 25) or any order of the Tribunal (except for an order under rules 38 or 39) does not of itself render void the proceedings

[8] The Sindh Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rules, 2014

or any step taken in the proceedings. In the case of such non-compliance, the Tribunal may take such action as it considers just, which may include:

- Waiving or varying the requirement.
- Striking out the claim or the response, in whole or in part, in accordance with rule 34.
- Barring or restricting a party's participation in the proceedings.
- Awarding costs in accordance with rules 69 - 75[9].

3.2.7 Land Acquisition Act, 1894

The Land Acquisition Act (LAA) of 1894 amended from time to time has been the defacto policy governing land acquisition, resettlement and compensation in the country. The LAA is the most commonly used law for acquisition of land and other properties for development projects. It comprises of 55 sections pertaining to area notifications and surveys, acquisition, compensation and apportionment awards and disputes resolution, penalties and exemptions.

3.2.8 Pakistan Penal Code (1860)

The Pakistan Penal Code (1860) authorizes fines, imprisonment or both for voluntary corruption or fouling of public springs or reservoirs so as to make them less fit for ordinary use[10].

3.2.9 Port Qasim Authority Act, 1973 (Modified in 2002)

This Act provides for the establishment of the Port Qasim Authority, defines its functions, powers and internal organization and lays down rules relative to management of and navigation in marine ports and inland waterways ports. The particular sections applicable to the Project are:

- Section 71(B) (2) No Owner, Agent or Master of a vessel, or any industry, manufacturing establishment, mill, factory or any kind, cargo handling company, terminal operator, etc,. shall discharge any solid or liquid, waste, oily, noxious radioactive and hazardous substances, bilge discharges, residues and mixtures containing noxious solid and liquid wastes, de-blasting of un-washed cargo tanks and line washing, garbage, emission of any effluent or waste or air pollution or noise in any amount concentration or level in excess of the National Environmental Quality Standards, or standards, which may be specified, from time to time, by the Authority for Port limits.

- Section 71(B) (3) Any person contravening the provisions of sub-section (2) shall be liable to penalty as determined and notified by the authority from time to time for each contravention in addition to the charges for cleaning of the Port and removal of pollution therefrom.

- Section 71 (C) (1) No proponent of a project shall commence construction or operation unless he has filed with this Authority as initial environmental examination or, where the project is

[9] The Employment Tribunals Rules of Procedure 2013
[10]www.fmu.gov.pk

likely to cause an adverse environmental effect, an environment impact assessment, and has obtained from the authority approval in respect thereof.

- Section 71 (C) (2) The Authority shall: - (a) review the initial environmental examination and accord its approval, or required submission of an Environmental Impact Assessment by the proponent; or (b) review the Environmental Impact Assessment and accord its approval subject to such condition as it may deem fit to impose, or require that the Environment Impact Assessment be re-submitted after such modification as may be stipulated (pqa.gov.pk,2016)[11]

3.2.10 The Antiquities Act

The Antiquities Act of 1975 ensures the protection of cultural resources of Pakistan. The Act is designed to protect 'antiquities' from destruction, theft, negligence, unlawful excavation, trade, and export. Antiquities have been defined in the Act as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area that may contain articles of archaeological significance.

Under the Act, the project proponents are obligated to:

- Ensure that no activity is undertaken in the proximity of a protected antiquity;
- Report to the Department of Archeology, Government of Pakistan, any archeological discovery made during the course of a project[12].

3.2.11 The Factories Act, 1934

The clauses relevant to the project are those that concern to health, safety and welfare of workers, disposal of solid waste and effluent and damage to private and public property. The Factories Act also provides regulation for handling and disposal of toxic and hazardous materials[13].

3.2.12 Electricity Act, 1910

The Act provides a legal base for power distribution. A licensee under this Act is enabled to operate supply of electricity. This Act obligate licensee to pay compensation for any damages caused during the constructions and maintenance of any power distribution facilities.

3.2.13 Sindh Wildlife Protection (Amendment) Act 2008

The Sindh Wildlife Ordinance 1972 empowers the government to declare certain areas reserved for the protection of wildlife and to control activities within these areas. It also provides protection to endangered species of wildlife[14].

[11] http://pqa.gov.pk/pqa_act.php
[12] pakistancode.gov.pk, 2005
[13] The Pakistan code (The Factories Act, 1934)
[14] faolex.fao.org, 2009

3.2.14 Sindh Forest Act (2012)

The act empowers the provincial forest departments to declare any forest area as reserved or protected. The Act also empowers the provincial forest departments to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce; quarrying and felling, lopping and topping of trees, branches in reserved and protected forests[15].

3.2.15 The Sindh Fisheries Ordinance, 1980

The Sindh Fisheries Ordinance, 1980 regulates fishing in the public waters, including the coastal areas, of Sindh. It empowers the government of Sindh to issue licenses for fishing in public waters, put restriction on the type of equipment that can be used for fishing, restrict fishing in certain areas or of certain species of fish, regulate the onshore trade of fish catch, and regulate the fish processing industry. Article 8 of the Ordinance prohibits the discharge of wastewater to public waters without the consent of the Director Fisheries.

3.2.16 Sectoral Guidelines for Thermal Power Stations, 1997

The sectoral guidelines deal with major thermal power plants producing electrical energy from fossil fuels (coal, gas, oil). The guideline is prepared to assist project proponents to identify the key environmental parameters those are required to be addressed to develop mitigation measures and alternatives that need to be considered in the EIA.

3.3 NATIONAL AND INTERNATIONAL GUIDELINES OR STANDARDS

3.3.1 The Pakistan Environmental Assessment Procedures, 1997

The Pakistan Environmental Protection Agency prepared the Pakistan Environmental Assessment Procedures in 1997. They are based on much of the existing work done by international donor agencies and Non-Governmental Organizations (NGO's). The package of regulations prepared by PEPA includes:

- Policy and Procedures for Filing, Review and Approval of Environmental Assessments;
- Guidelines for the Preparation and Review of Environmental Reports;
- Guidelines for Public Consultation;
- Guidelines for Sensitive and Critical Areas; and
- Sectoral Guidelines for various types of projects.

[15] Sindhforests.gov.pk

3.3.2 OSHA Standards Health Safety

The Occupational Safety and Health Administration (OSHA) are issuing safety and health program management guidelines for use by employers to prevent occupational injuries and illnesses. The Occupational Safety and Health Act of 1970 (OSHA) representatives have noted a strong correlation between the application of sound management practices in the operation of safety and health programs and a low incidence of occupational injuries and illnesses. Where effective safety and health management is practiced, injury and illness rates are significantly less than rates at comparable worksites where safety and health management is weak or non-existent.

OSHA has concluded that effective management of worker safety and health protection is a decisive factor in reducing the extent and the severity of work-related injuries and illnesses. Effective management addresses all work-related hazards, including those potential hazards which could result from a change in worksite conditions or practices. It addresses hazards whether or not they are regulated by government standards.

3.3.3 World Bank Guidelines on Environment

The principal World Bank publications that contain environmental guidelines are listed below.

- Environmental Assessment-Operational Policy 4.01. Washington, DC, USA. World Bank 1999.
- Environmental Assessment Sourcebook, Volume I: Policies, Procedures, and Cross-Sectoral Issues. World Bank Technical Paper Number 139, Environment Department, the World Bank, 1991.

The above two publications provide general guidelines for the conduct of EIA's, and address the EIA practitioners themselves as well as project designers. While the Sourcebook in particular has been designed with Bank projects in mind, and is especially relevant for the impact assessment of large-scale infrastructure projects, it contains a wealth of useful information, for environmentalists and project proponents.

The Sourcebook identifies a number of areas of concern, which should be addressed during impact assessment. It sets out guidelines for the determination of impacts, provides a checklist of tools to identify possible biodiversity issues and suggests possible mitigation measures. Possible development project impacts on wild lands, wetlands, forests etc. are also identified and mitigation measures suggested.

3.3.4 World Bank EHS General Guidelines, 2007

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. EHS considerations into corporate and facility-level business processes in an organized, hierarchical approach that includes the following steps:

- Identifying EHS project hazards and associated risks as early as possible in the facility development or project cycle, including the incorporation of EHS considerations into the site selection process, product design process, engineering planning process for capital requests, engineering work orders, facility modification authorizations, or layout and process change plans.
- Involving EHS professionals, who have the experience, competence, and training necessary to assess and manage EHS impacts and risks, and carry out specialized environmental management functions including the preparation of project or activity-specific plans and procedures.
- Understanding the likelihood and magnitude of EHS risks, based on:
    - The nature of the project activities
    - The potential consequences to workers, communities, or the environment
- Favoring strategies that eliminate the cause of the hazard at its source, for example, by selecting less hazardous materials or processes that avoid the need for EHS controls.
- Improving EHS performance through a combination of ongoing monitoring of facility performance and effective accountability[16].

[16]Environmental, Health, and Safety General Guidelines

CHAPTER

4

PHYSICAL ENVIRONMENT

4.1 GENERAL OUTLINE AND SCOPE

This section of the ESIA document presents a detailed description of physical environmental conditions of the study area. The data collection techniques are combination of both primary and secondary means by field verifications, observations, sampling and monitoring which was supplemented by review of published literature and previous ESIA studies conducted in the proposed project surrounding areas. The base line data defines, elaborates and present physical environmental quality within the project surrounding. (Refer **Exhibit 4.1** for pictorial presentation of baseline investigations and observations)

Key Features of Physical Baseline

- Topography and land use
- Geology
- Climate
- Air Quality
- Water Resources
- Water Quality

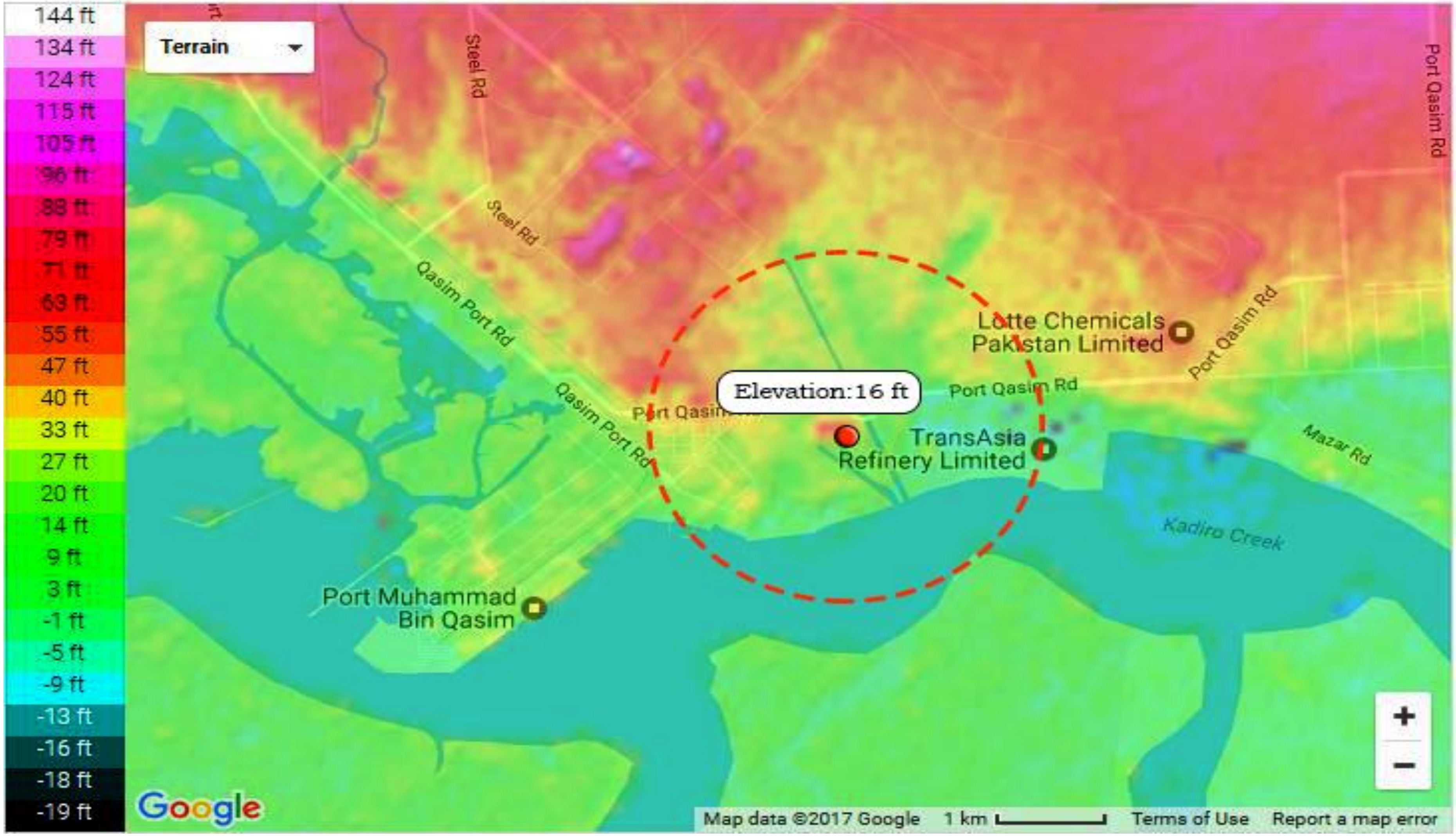
Exhibit 4.1: Pictorial Presentation of Baseline Investigations and Observations

4.2 TOPOGRAPHY

The city of Karachi has a land area of 3,640 km^2 and is located on the Arabian Seacoast in the extreme south of Pakistan; the city is located at $24^0 45''$ to $25^0 15''$ north and 66º37” to $67^0 37''$ east. It is bounded by Dadu District in the northeast, Thatta District in the southeast, the Arabian Sea to the south and the Lasbela District of Balochistan Province to the west.

Karachi can be broadly divided into two parts; the hilly areas in the north and west and the coastal area in the southeast. The hilly areas of Karachi are known to be the off-shoots of the Kirthar Range. The highest point of these hills in Karachi is about 528m in the extreme north. These hilly areas are devoid of vegetation and have wide plains, dry river beds and water channels. Karachi has a long coastline in the south. Specifically the topography of the study area is quite gentle and its elevation is increasing as we move towards the north. The land bordering the study area has an elevation less than 20 m above the sea level (amsl) while the land in the northern periphery of the study area lies in-between 10 and 60 m amsl. **Exhibit 4.2** represents the topographic elevation map of the proposed project areas.

Exhibit 4.2: Topographic Elevation Map of the Proposed Project Areas



4.3 LAND COVER & LAND USE

LAND COVER

- The physical land type on the surface of the earth.
- Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types.

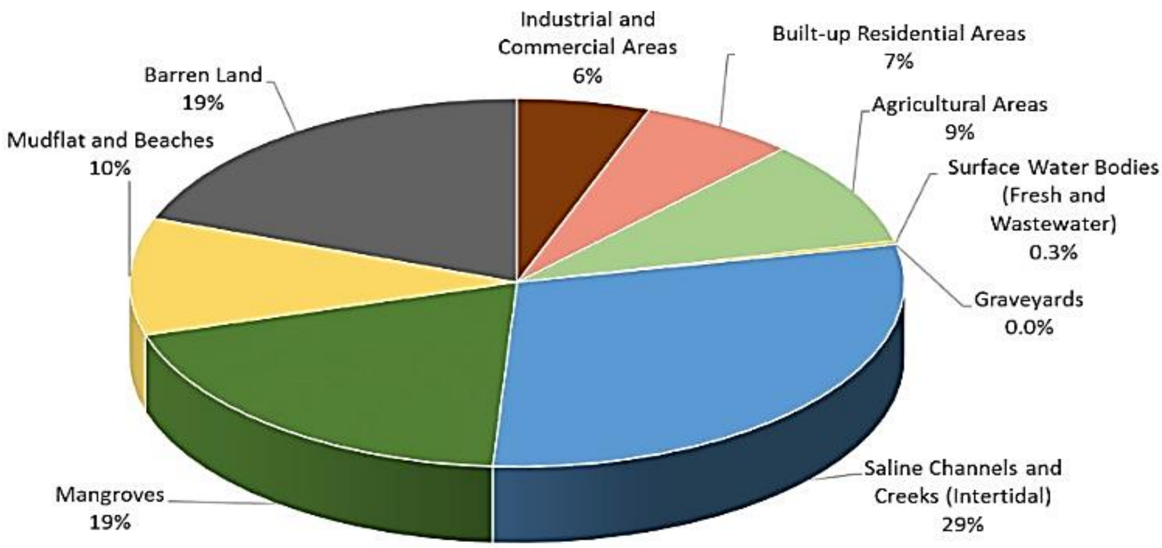
LAND USE

- Land use describes how the land cover is modified.
- There are many types of land use:
- Recreational -, non-essentials like parks.
- Transport - roads, railways, and airports.
- Agricultural - farmland.
- Residential - housing.
- Commercial - businesses and factories.

Land use and Land cover (LULC) composition and its change are the substantial factors having direct influence on urban ecological systems and conditions. The city of Karachi has been through astringent urbanization during last two decades and many studies have been performed for its LULC analysis. According to the Pakistan Economic Survey 2013-2014, Karachi is the largest and the fastest growing urban center of Pakistan offering the most complex set of urban development challenges with a population of about 20 million having annual growth rate of 5%.

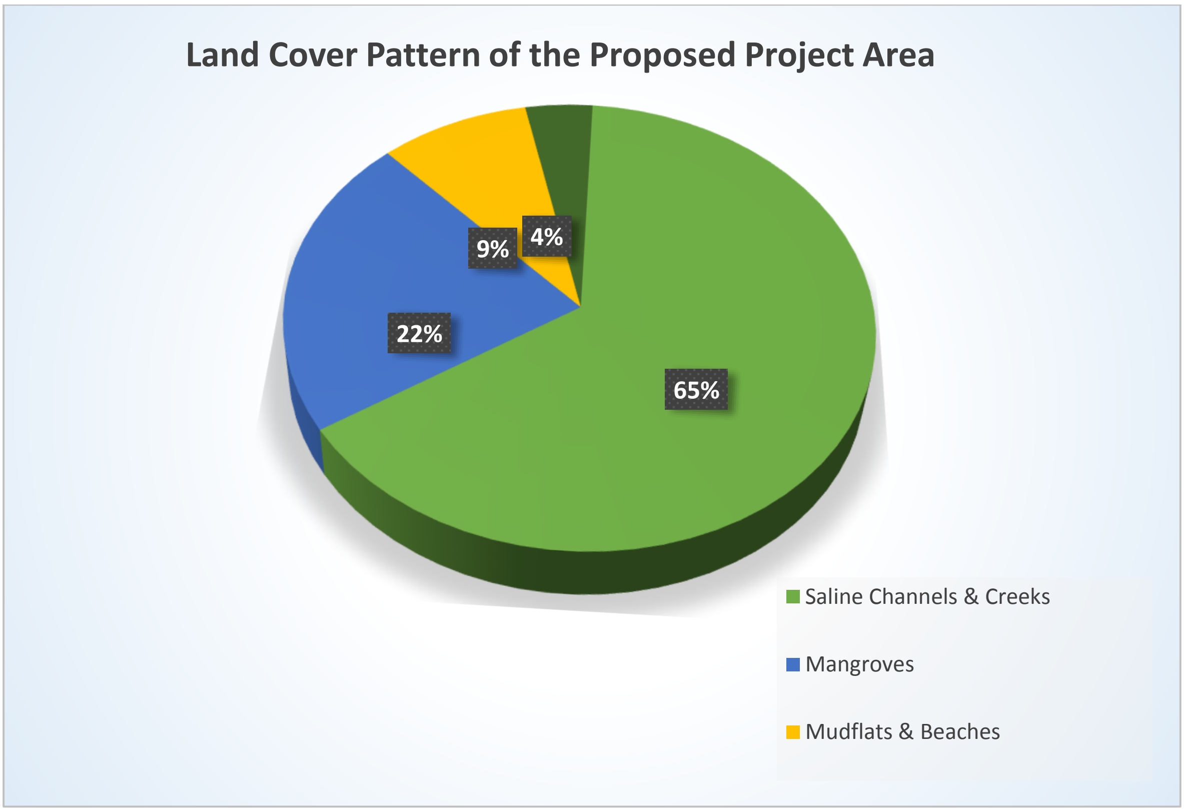
The proposed project areas lies in the Malir district of Karachi at Port Qasim to the south where a major portion (65%) of the notified area of Port Qasim comprises of saline channels and creeks of the inactive Indus Delta. The remaining portion is occupied largely by mangroves (22%), mudflats and beaches (9%) and other areas (4%) such as industrial, commercial, residential and agriculture and at other hand landhi and Korangi industrial area mostly occupied with industrial, commercial and residential setup. **Exhibit 4.3** represents the land cover pattern of Karachi, **Exhibit 4.4** represents graphical representation of the land cover pattern of the proposed project area, while Land use pattern in close proximity of the proposed project surrounding at Port Qasim, can be seen as **Exhibit 4.5** respectively.

Exhibit 4.3: Graphical Representation of Land Cover Pattern of Karachi



Source: Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Bailly Pakistan, 2016

Exhibit 4.4: Graphical Representation of the Land Cover Pattern of the Proposed Project Area

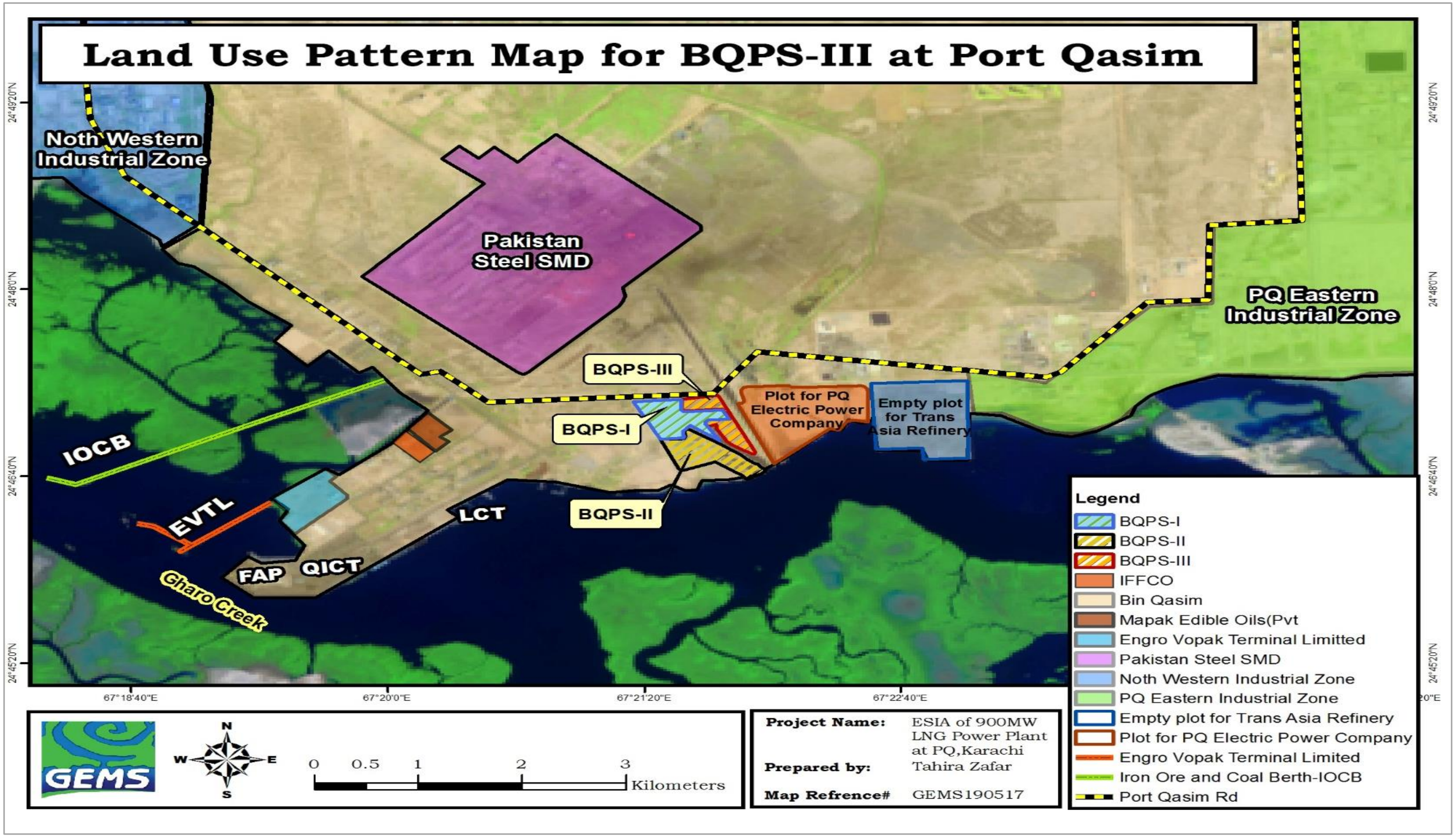


Source: Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Bailly Pakistan, 2016

Land Cover and Use Class	Area (Hectares)
Industrial and Commercial Areas	**10,210**
Built-up Residential Areas	**11,938**
Agricultural Areas	**17,130**
Saline Channels and Creeks (Intertidal)	**53,765**
Mangroves	**35,546**
Mudflat and Beaches	**18,915**
Total Study Area	**147,504**

Source: Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Bailly Pakistan, 2016

Exhibit 4.5: Land use Pattern in Close Proximity of the Proposed Project Area



4.4 GEOLOGY

Geology of the area under focus is underlain a lower Indus basin described as Indus river alluvial early Eocene*. Early deposition of sediments include silt, sand stone, conglomerate, limestone with low compact and cementing materials. Surface features syncline delta and valley region where anticline ridges are exposed. As per stratigraphic description, Gazij and Manchar inclined two formations gently northeast to southeast in offshore. The coastal region is found to be of tertiary and post-tertiary origin. Blatter et al (1929) dates it as recent as Eocene.

EOCENE

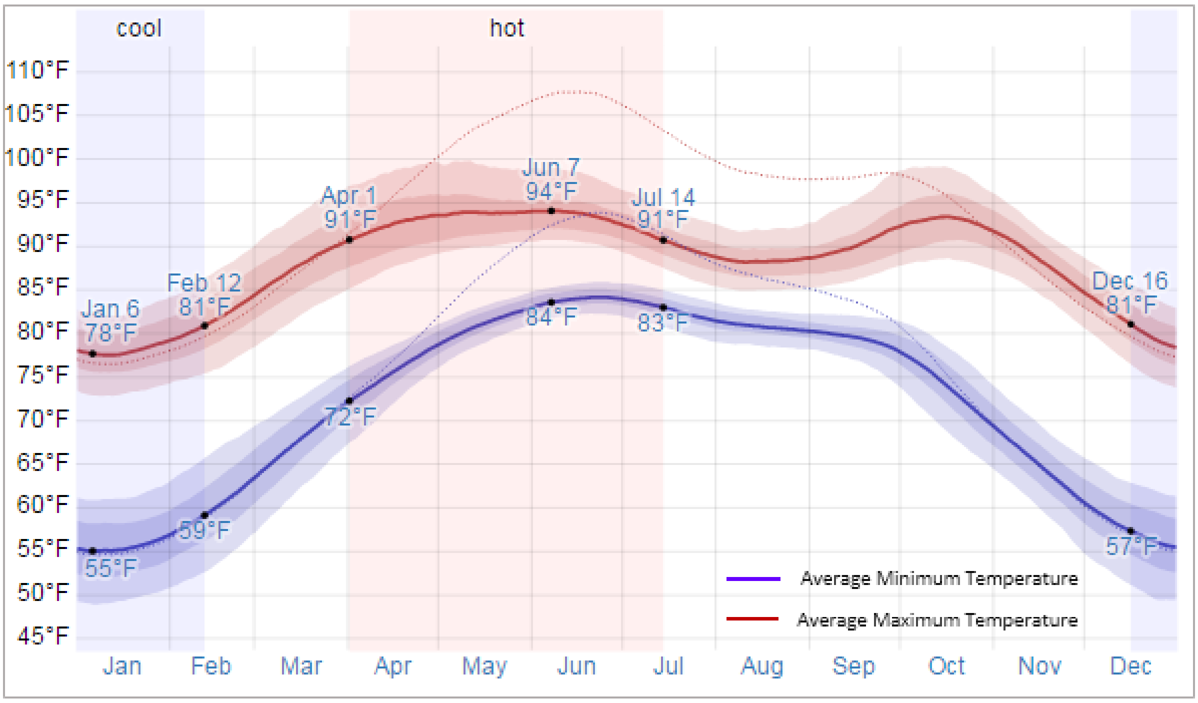
The Eocene Epoch, lasting from 56 to 33.9 million years ago, is a major division of the geologic timescale and the second epoch of the Paleogene Period in the Cenozoic Era

The region has been formed by the upheaval of land from the Tethys Sea, which once extended up to the northern border of Pakistan but, gradually withdrew with the rising of the Himalayas. The underlying rocks are mostly of marine origin, highly folded, faulted and fissured everywhere *(Sidra et al, 2010 Situation Analysis of Sindh Coast Issues and Options).*

4.5 CLIMATE

The climate of Karachi is characterized as hot and dry during summer, and mild during winter with heavy, sporadic, rainfall during the monsoon. The summer monsoon prevails in the Proposed Project area from Mid-March to Mid-June characterized by very hot temperatures, dry conditions, moderate wind from the southwest and low humidity; high rainfall, high temperatures, high humidity characterize Monsoons from Mid-June to Mid-September, and high winds from the southwest. Although the temperatures are milder compared to summer but high humidity makes the heat oppressive; Post-monsoon summer that is from Mid-September to Mid-November is characterized by cessation of rains and reduction in wind speed. Temperature increases by couple of degrees and humid decreases by about 10%; and winters monsoon from Mid-November to Mid-March is characterized by moderate temperature, dry conditions, low humidity, and low winds from the north and northeast. The monsoon is characterized by a reversal in wind direction during the remaining months and heavy rainfall occurs over most part of the Indian Subcontinent. In Karachi over the course of the year, the temperature typically varies from 55°F to 94°F and is rarely below 49°F or above 100°F.Yearly mean maximum and minimum temperatures from January 1, 1980 to December 31, 2016 are presented below in **Exhibit 4.6**.

Exhibit 4.6: Mean Maximum and Minimum Temperature (January 1-1980 to December 31-2016)



Source: *Weather Spark.com*

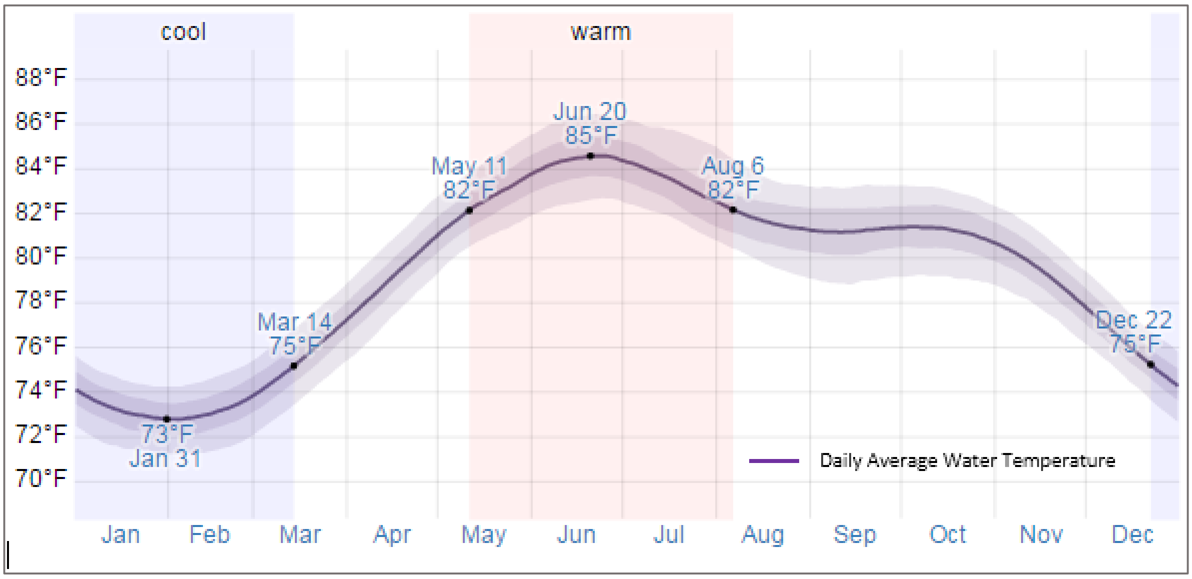
4.5.1 Water Temperature

Karachi is located near a large body of water and over the course of the year the average surface water temperature experiences *some* seasonal variation

The time of year with *warmer water* lasts for *2.8 months*, from *May 11* to *August 6*, with an average temperature above *82°F*. The day of the year with the warmest water is *June 20*, with an average temperature of *85°F*.

The time of year with *cooler water* lasts for *2.7 months*, from *December 22* to *March 14*, with an average temperature below *75°F*. The day of the year with the coolest water is *January 31*, with an average temperature of *73°F*. The mean monthly water temperature from January 1, 1980 to December 31, 2016 are presented below in **Exhibit 4.7**.

Exhibit 4.7: Mean Monthly Water Temperature (January 1-1980 to December 31-2016)



4.5.2 Rainfall

According to IPCC report, 2007 decrease in rainfall pattern has been observed along the coastal belt and arid plains of Pakistan, in upcoming years most part of Pakistan will experience dry humid conditions especially Sindh, Balochistan, Punjab and the central parts of Northern Areas will receive less than 250 mm of rainfall in a year (PMD). The yearly average rainfall pattern of Karachi from January 1, 1980 to December 31, 2016 shows some seasonal variation in monthly rainfall.

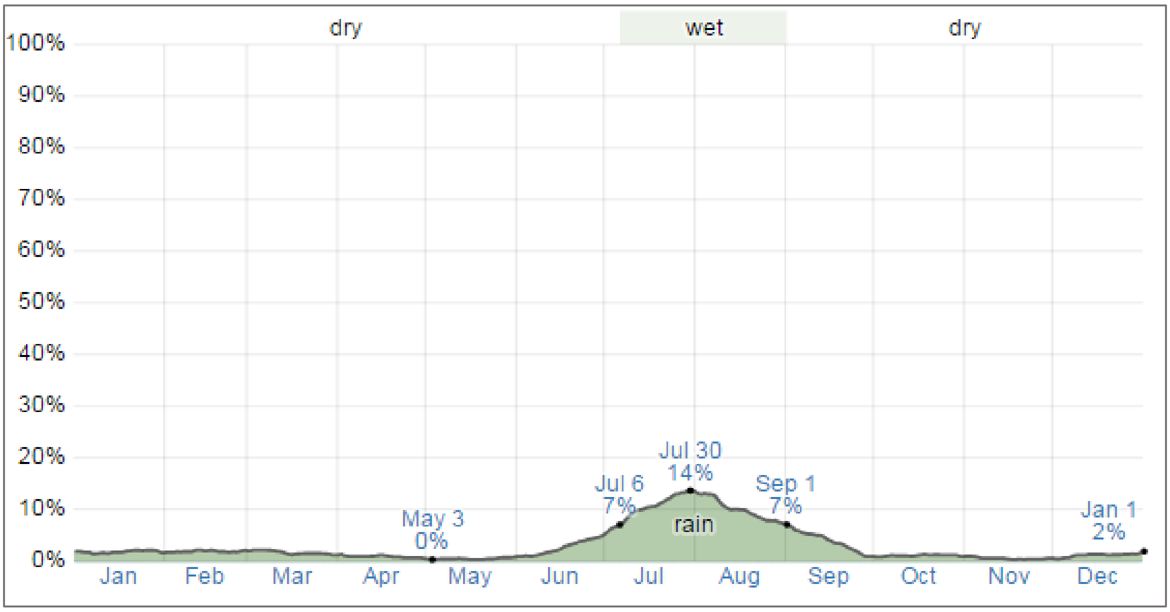
The *rainy period* of the year lasts for *2.7 months*, from June 25 to September 15, with a decrease of at least *0.5 inches* in 31-day rainfall. The most rain falls during the month of July. The *rainless period* of the year lasts for *9.3 months*, from September 15 to June 25. The least rain falls around May.

The probability of precipitation and wet days observed at Port Qasim varies throughout the year. The *wetter season* lasts 1.8 months, from July 6 to September 1, with a greater than 7% chance of a given day being a wet day. The chance of a wet day peaks at 14% on July 30.

The *drier season* lasts 10 months, from September 1 to July 6. The smallest chance of a wet day is 0% on May 3.

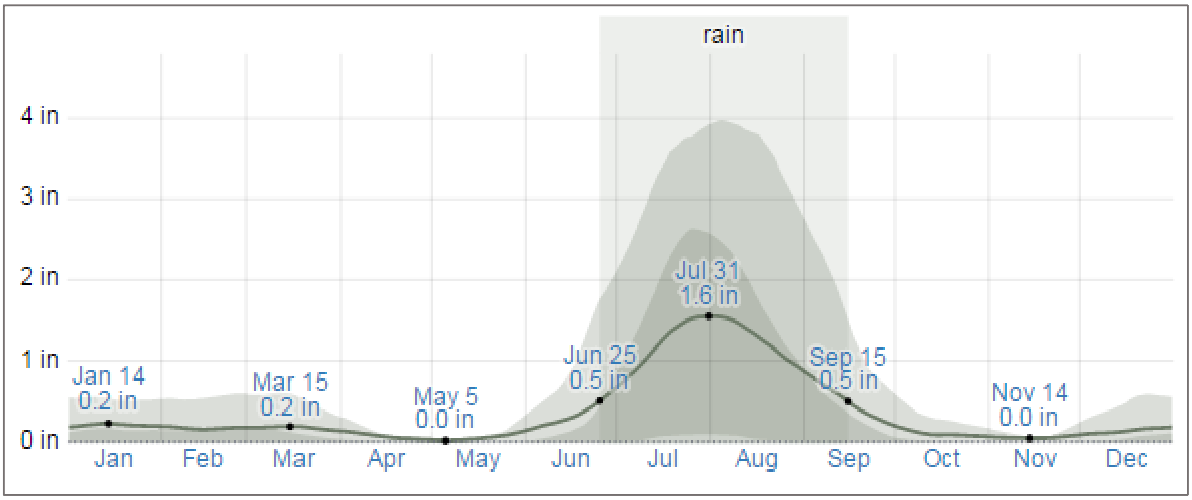
Based on the categorization of *rain alone, snow alone*, or a mixture of the two, the most common form of precipitation throughout the year is *rain alone*, with a peak probability of 14% on July 30. The mean monthly precipitation records for Karachi South District can be seen in **Exhibit 4.8**, while **Exhibit 4.9** mean monthly rainfall pattern of Karachi presented below.

Exhibit 4.8: Maximum Precipitation (%) (January 1-1980 to December 31-2016)



Source: *Weather Spark.com*

Exhibit 4.9: Average Monthly Rainfall (January 1-1980 to December 31-2016)



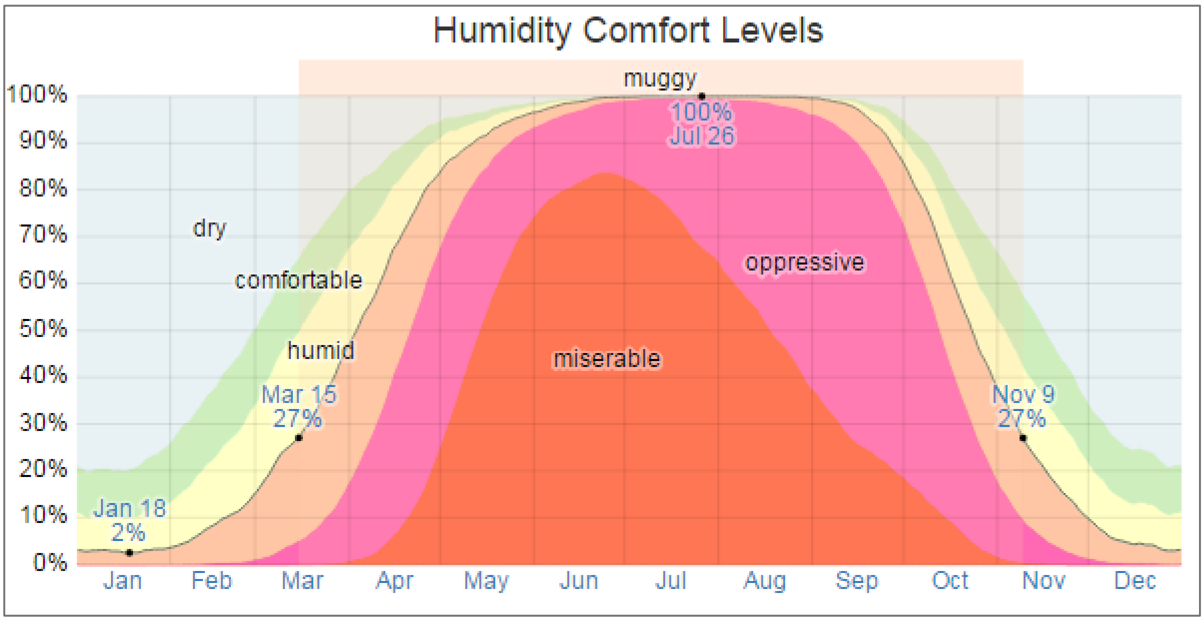
Source: *Weather Spark.com*

4.5.3 Relative Humidity

Karachi experiences *very significant* seasonal variation in the perceived humidity. The humidity comfort level is based on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between day and night, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night.

The *muggier period* of the year lasts for *7.8 months*, from *March 15* to *November 9*, during which time the comfort level is *muggy*, *oppressive*, or *miserable* at least *27%* of the time. The *muggiest day* of the year is *July 26*, with muggy conditions *100%* of the time. The *least muggy* day of the year is *January 18*, with muggy conditions *2%* of the time.The mean monthly relative humidity for Karachi South district can be seen in **Exhibit 4.10.**

Exhibit 4.10: Relative Humidity



Source: *Weather Spark.com*

4.5.4 Wind Speed and Direction

The proposed project area lies in a region where wind blows throughout the year with highest velocities. During summer, the direction of the wind is from south-west to west and during winter season the wind blows from north to northeast and it shifts southwest to west in the evening hours. The wind usually carries sand and salt with it resulting in severe corrosion and erosion. The wind direction and speed in between the two monsoon seasons, summer and winter are rather unsettled and large variations have been recorded in terms of speed and direction. The seasonal winds are dry and have a desiccating effect during May & June, in July and August the wind contains moisture.

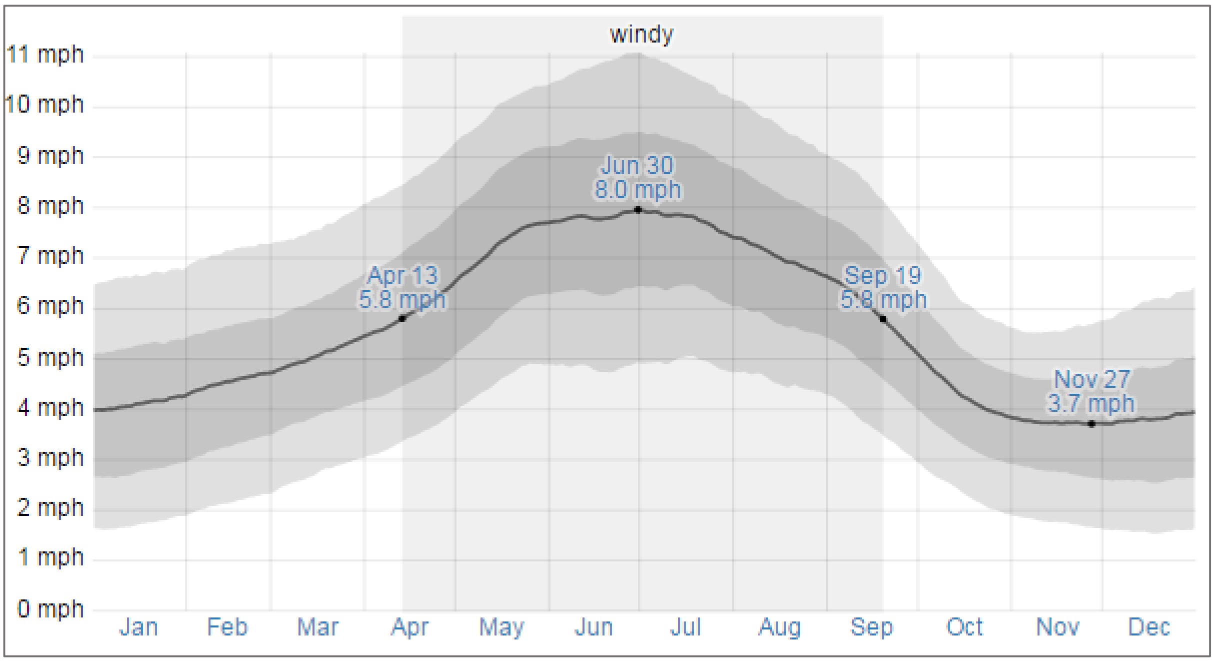
The average hourly wind speed in Karachi experiences *significant* seasonal variation over the course of the year. The *windier* part of the year lasts for *5.2 months*, from *April 13* to *September 19*, with average wind speeds of more than *5.8 miles per hour*. The *windiest* day of the year is *June 30*, with an average hourly wind speed of *8.0 miles per hour*.

The *calmer* time of year lasts for *6.8 months*, from *September 19* to *April 13*. The *calmest* day of the year is *November 27*, with an average hourly wind speed of *3.7 miles per hour*.

The predominant average hourly wind direction in Karachi varies throughout the year. The wind is most often from the *west* for *11 months*, from *January 13* to *November 30*, with a peak percentage of *92%* on *May 2*. The wind is most often from the *north* for *1.5 months*, from *November 30* to *January 13*, with a peak percentage of *39%* on *December 8*.

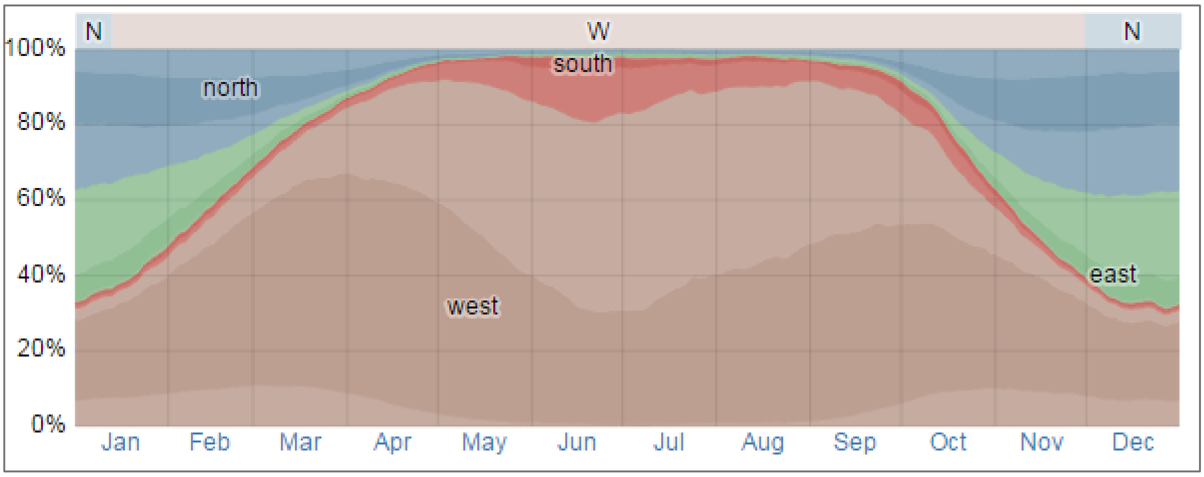
Exhibit 4.11 and **4.12** shows the average wind speed and direction of wind in the proposed project area.

Exhibit 4.11: Average Wind Speed (January 1-1980 to December 31-2016)



Source: *Weather Spark.com*

Exhibit 4.12: Wind Direction over the Entire Year (January 1-1980 to December 31-2016)



Source: *Weather Spark.com*

4.6 AMBIENT AIR AND NOISE QUALITY

Air pollution has a direct impact on the health of humans and the environment. Different emissions affect air quality. As discussed previously in the chapter-2 project description of this ESIA document, the proposed 2 X 450 MW RLNG CCPGU project will include modifications within BQPS-I, KPC, Landhi and Qayyumabad Grid for power evacuation of the proposed project, therefore several existing sources of emissions in Port Qasim, Korangi, Landhi and Qayyumabad were identified and monitored accordingly for baseline air quality establishment. However key focus remained on the main Project site, i.e. BQPS-III, which is located within the vicinity of PQA as the proposed project may contribute to the gaseous emissions and noise generation during constructional and operational phase either positive or negative.

4.6.1 Baseline Data

Subsequent to the air quality baseline parameters* subjected to monitoring, primary baseline data was compiled by mobilizing Global Environmental Laboratory (GEL) team of Environmental Sampling and Monitoring (ESM). The ESM team carried out ambient air monitoring and sampling at sites where small scale modifications and installations are required for the proposed project, the locations included Landhi and Qayyumabad Grid. However it is important to note that ESM team of GEL is already engaged in quarterly environmental monitoring and testing of existing power generation units of KE, therefore data from Quarterly Environmental Monitoring Reports (EMR) of BQPS-I and KPC has also been considered for baseline ambient air quality of the project surrounding. Pictorial profile of ambient air and noise monitoring is presented as **Exhibit 4.13** and the sampling location maps are presented as **Exhibit 4.14** till **Exhibit 4.17.** The monitoring results along with graphical representation is given in **Exhibit 4.18 and 4.19** respectively.

Ambient Air Quality Baseline Parameters*

- PM_{10}
- CO_2
- SO_2
- NOx
- Noise Levels

Exhibit 4.13: Pictorial Profile of Ambient Air Quality and Noise level Monitoring

Exhibit 4.14: Ambient Air Monitoring Location Map at Port Qasim for BQPS-III Power Project

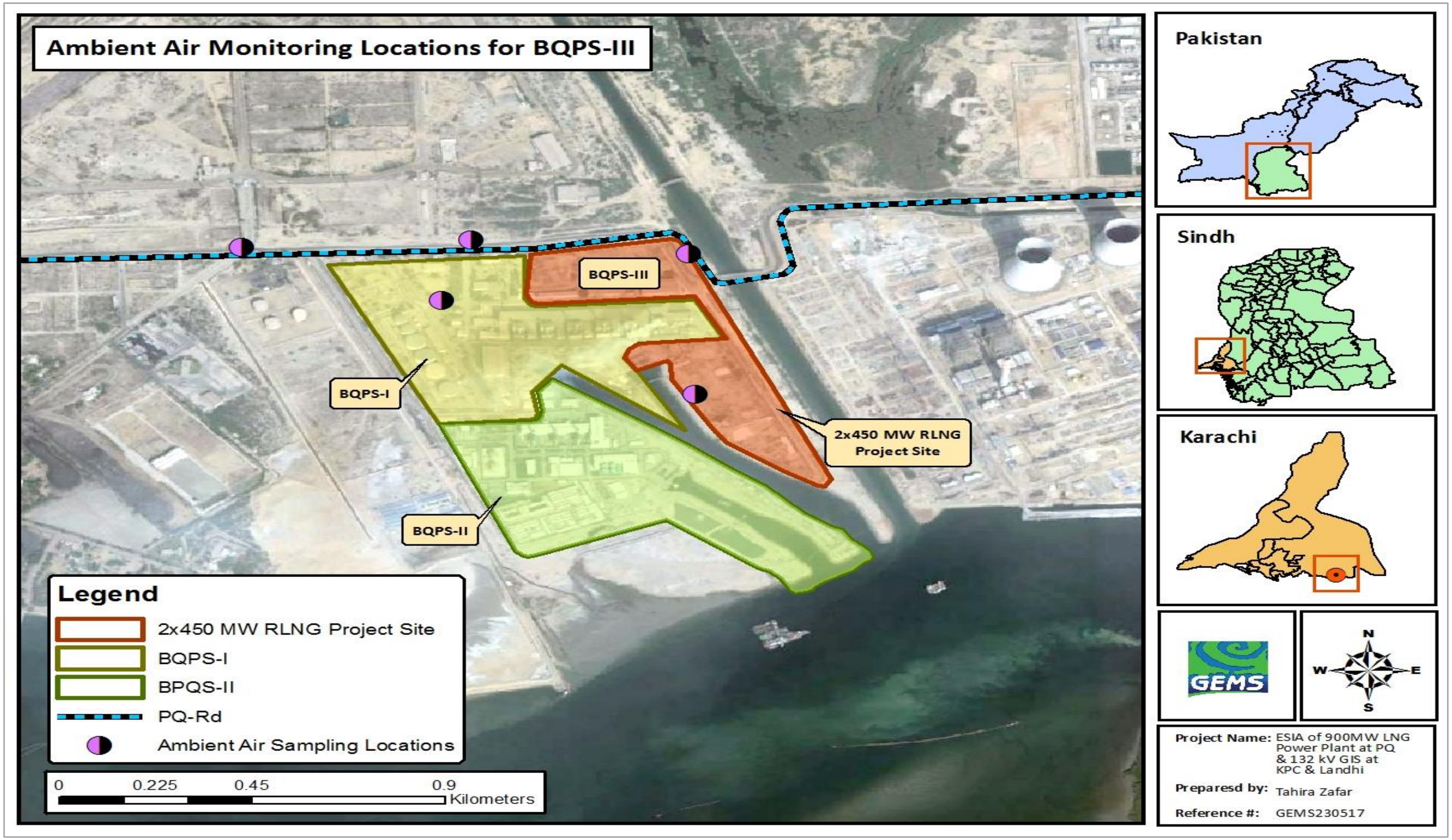


Exhibit 4.15: Ambient Air Monitoring Location Map at Korangi-KPC for BQPS-III Power Project

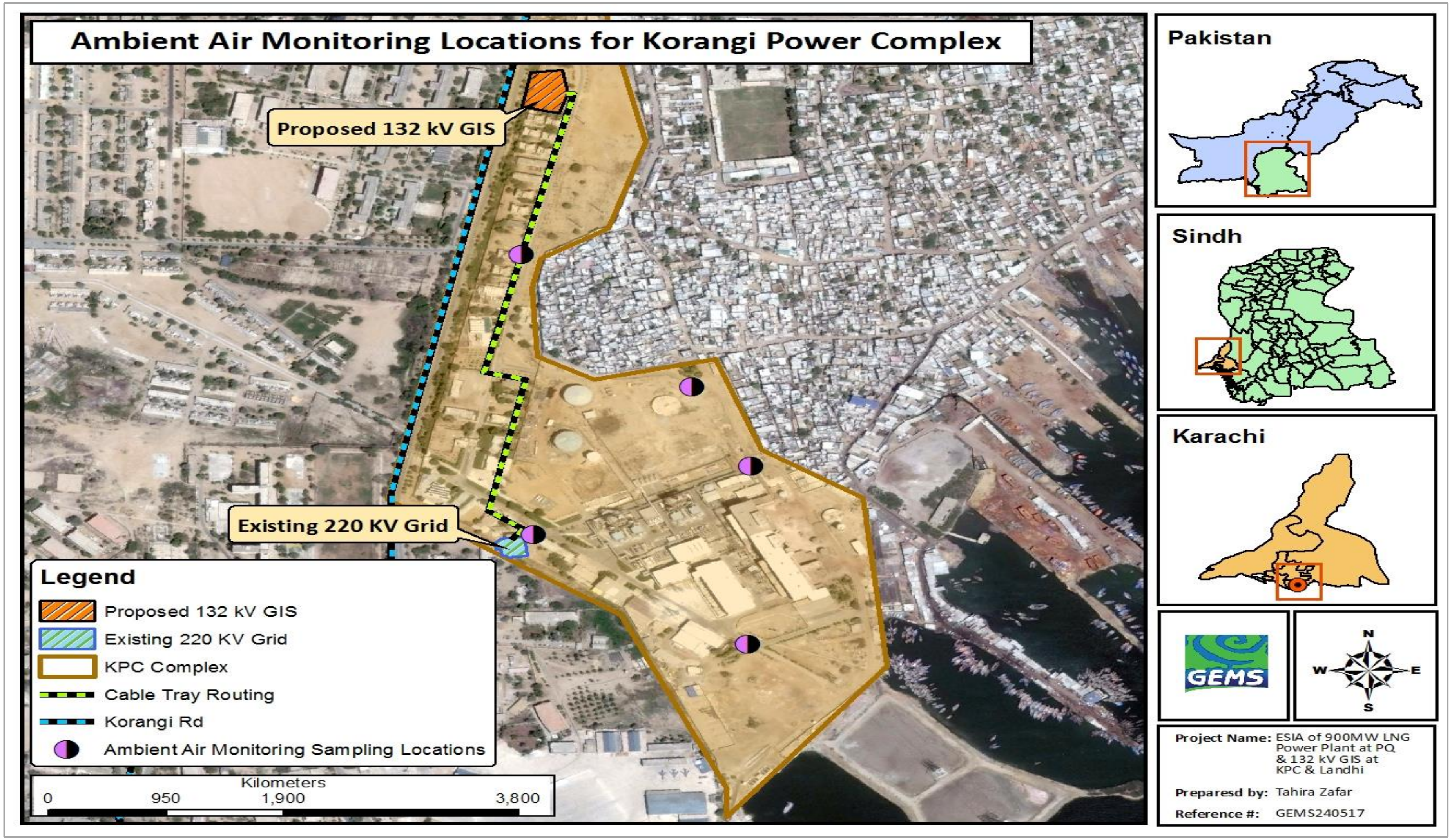


Exhibit 4.16: Ambient Air Monitoring Location Map at Landhi for BQPS-III Power Project

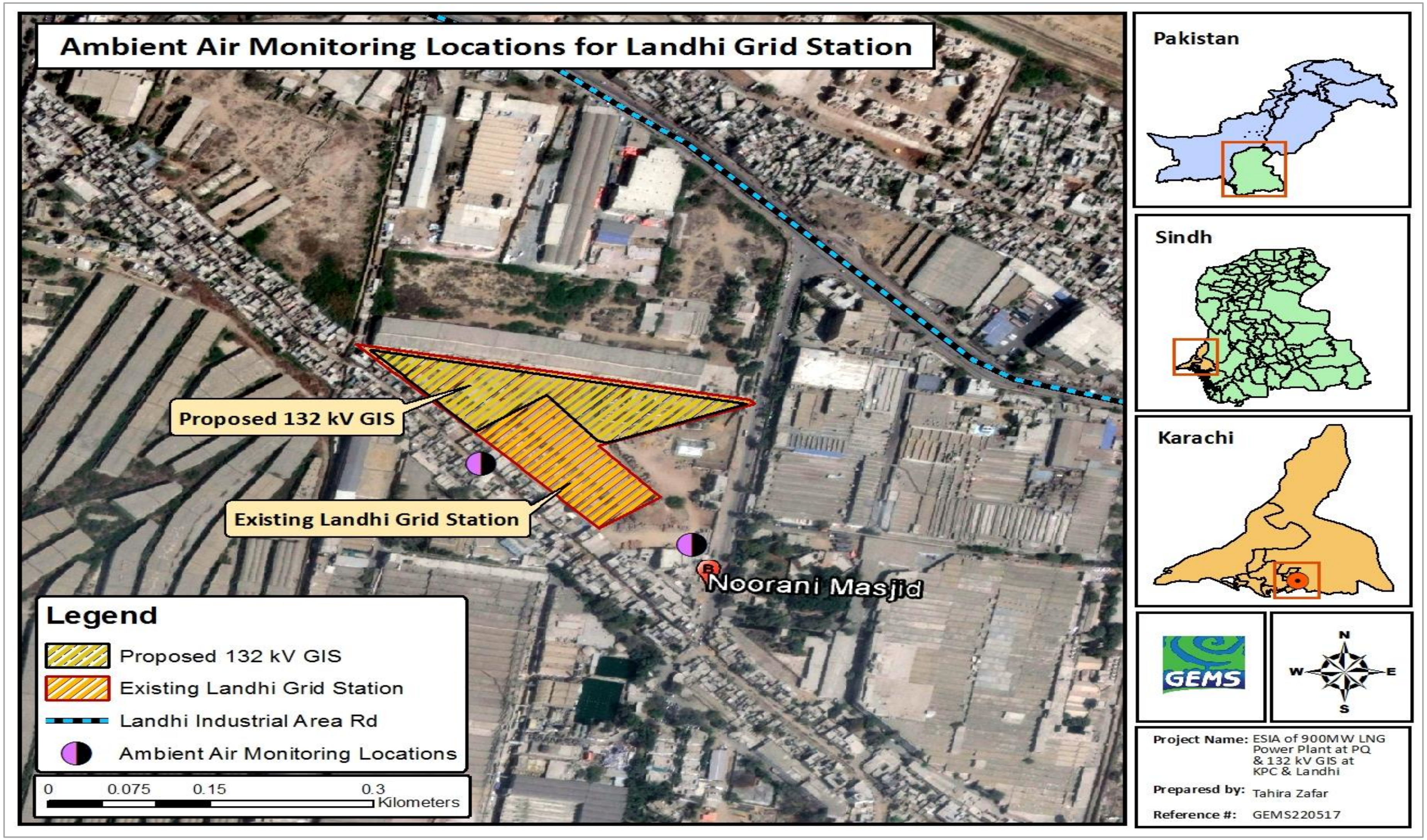


Exhibit 4.17: Ambient Air Monitoring Location Map at Korangi-Qayyumabad for BQPS-III Power Project

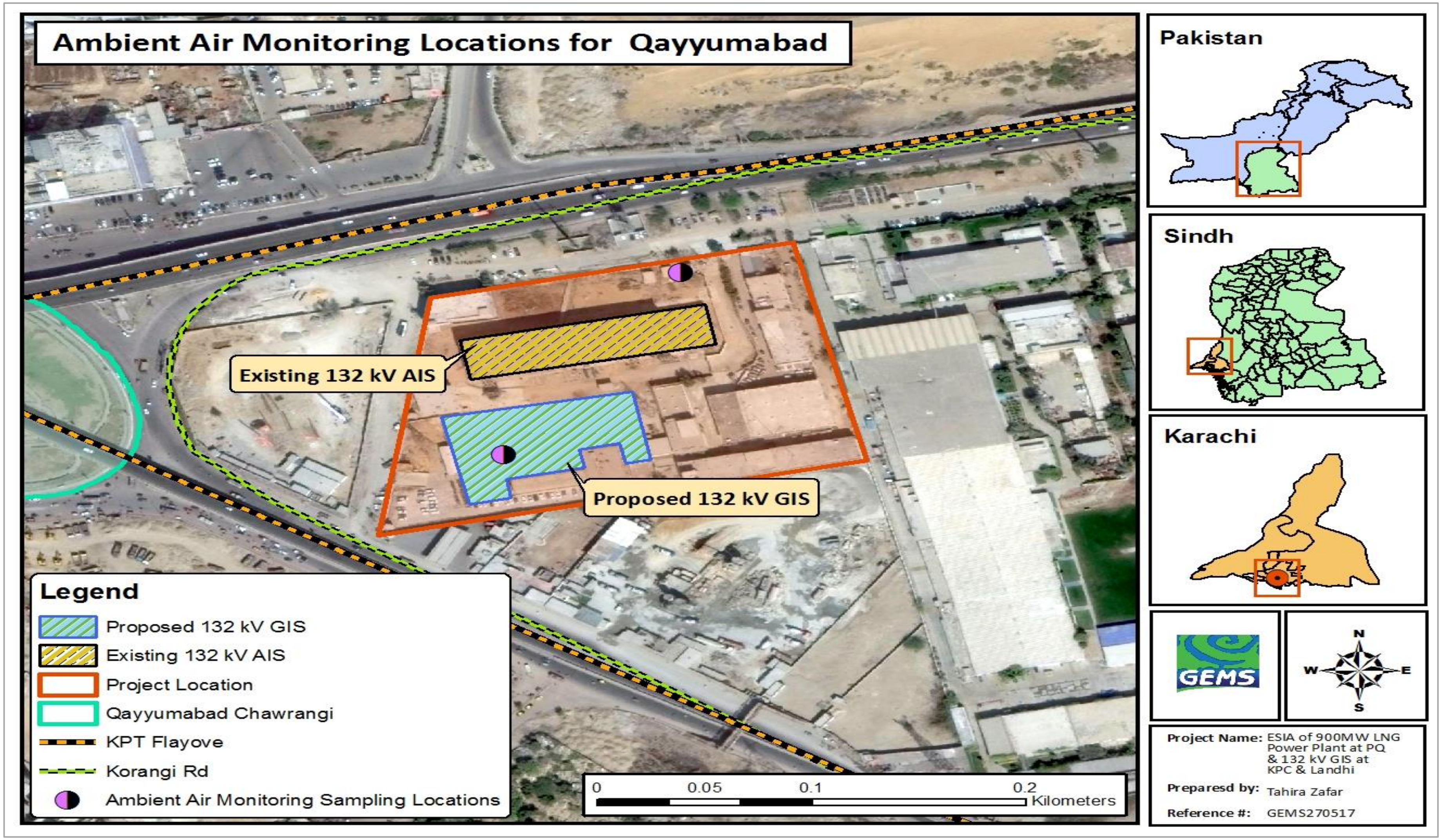


Exhibit 4.18: Ambient Air Quality and Noise Monitoring Results

S.no	Parameters	Units	SEQS Limits	Concentration at Port Qasim				
				Near Inside Corner of Eastern Boundary (L-1)	Near Inside Corner of Western Boundary (L-2)	At Front Boundary (L-3)	500m from boundary wall towards East (L-4)	500m from boundary wall towards West (L-1)
1	Carbon Dioxide (CO_2)	ppm	….	482	463	444	431	437
2	Oxides of Nitrogen (NOx)	ug/m^3	120	<1	<1	<1	<1	<1
3	Sulphur Dioxide (SO_2)	ug/m^3	120	<1	<1	<1	<1	<1
4	Particulate Matter PM_{10}	ug/m^3	150	141	147	133	121	113
5	Noise	dB	80	64.5	77	68	64	63.4
S.no	**Parameters**	**Units**	**SEQS Limits**	**Concentration at KPC**				
				Near Inside Corner of Southern Boundary (L-1)	**Near Inside Corner of Northern Boundary (L-2)**	**At Front Boundary (L-3)**	**250m from boundary wall towards Northeast (L-4)**	**500m from boundary wall towards North (L-5)**
1	Carbon Dioxide (CO_2)	ppm	….	484	476	466	471	457
2	Oxides of Nitrogen (NOx)	ug/m^3	120	<1	<1	<1	<1	<1
3	Sulphur Dioxide (SO_2)	ug/m^3	120	<1	<1	<1	<1	<1
4	Particulate Matter PM_{10}	ug/m^3	150	87	79	63	76	91
5	Noise	dB	80	63.5	65	61	62.7	62.3

S.no	Parameters	Units	SEQS Limits	Concentration at LGS	
				Near Noorani Masjid	Near Existing LAndhi Grid Station
1	Carbon Dioxide (CO_2)	ppm	….	452	467
2	Oxides of Nitrogen (NOx)	ug/m^3	120	<1	<1
3	Sulphur Dioxide (SO_2)	ug/m^3	120	<1	<1
4	Particulate Matter PM_{10}	ug/m^3	150	96	81
5	Noise	dB	80	64	69
S.no	**Parameters**	**Units**	**SEQS Limits**	**Concentration at KGS**	
				Proposed site for GIS	**At main Gate**
1	Carbon Dioxide (CO_2)	ppm	….	341	394
2	Oxides of Nitrogen (NOx)	ug/m^3	120	<1	<1
3	Sulphur Dioxide (SO_2)	ug/m^3	120	<1	<1
4	Particulate Matter PM_{10}	ug/m^3	150	86	71
5	Noise	dB	80	61	72

Key*

SEQS Sindh Environmental Quality Standards

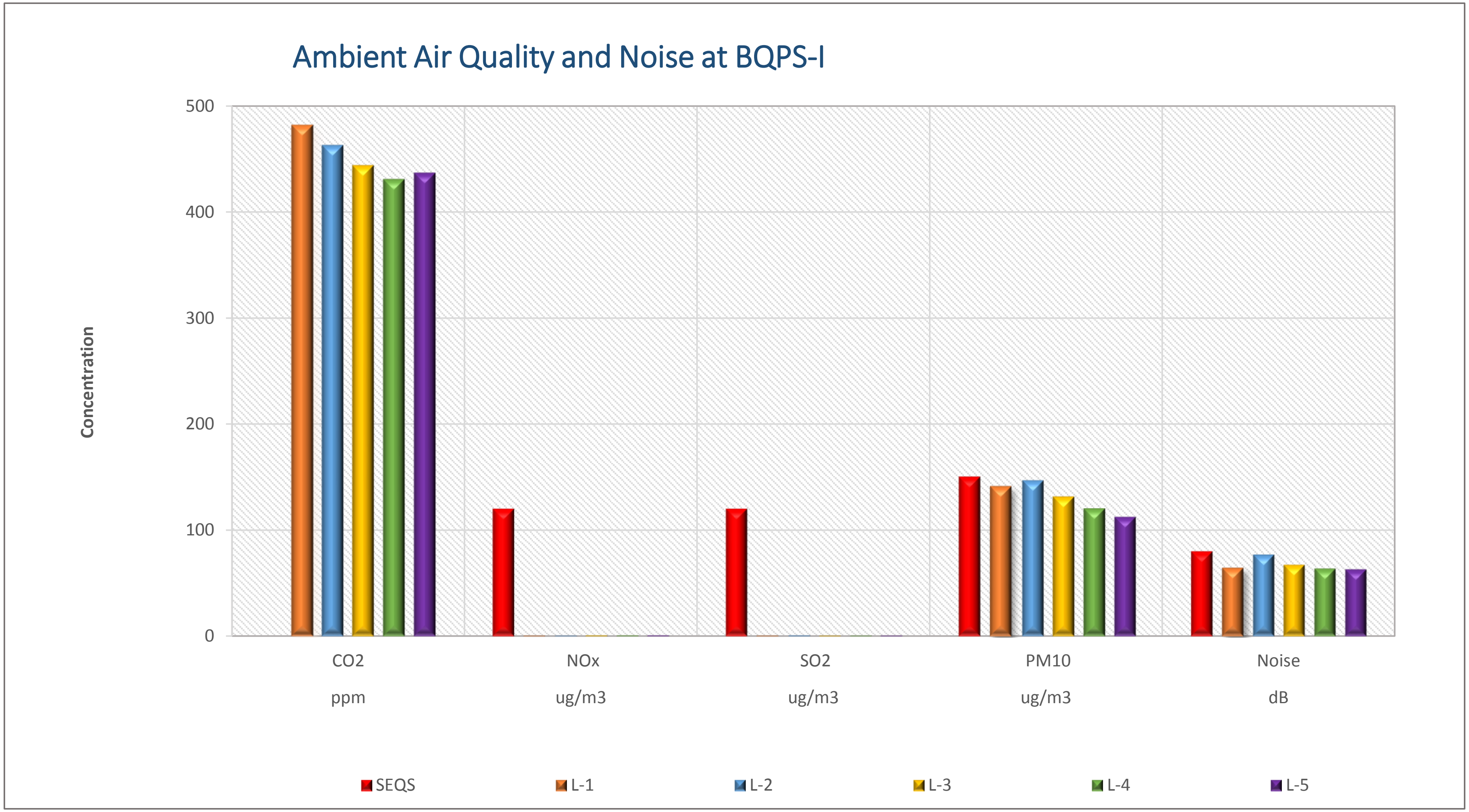
KGS Korangi Grid Station

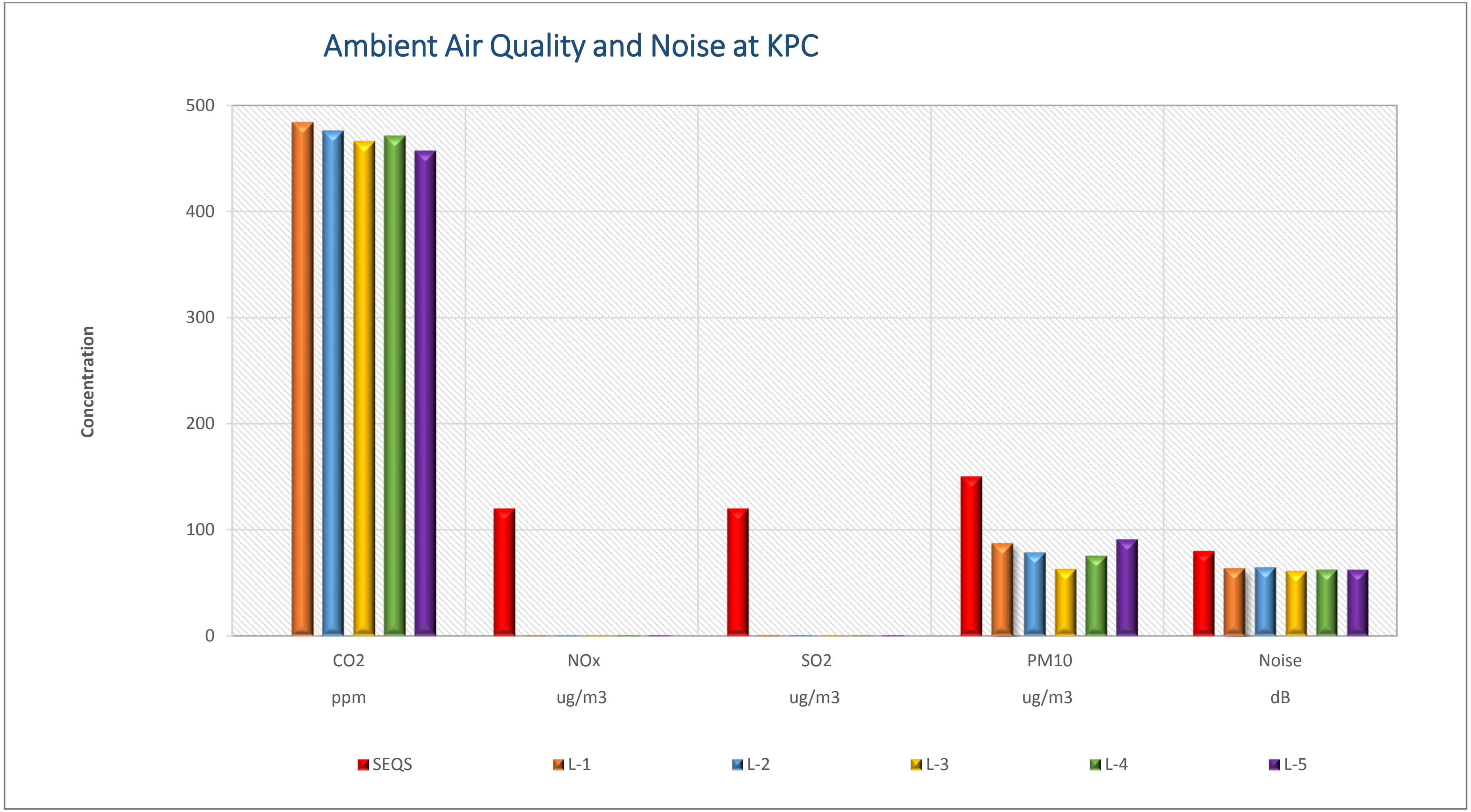
LGS Landhi Grid Station

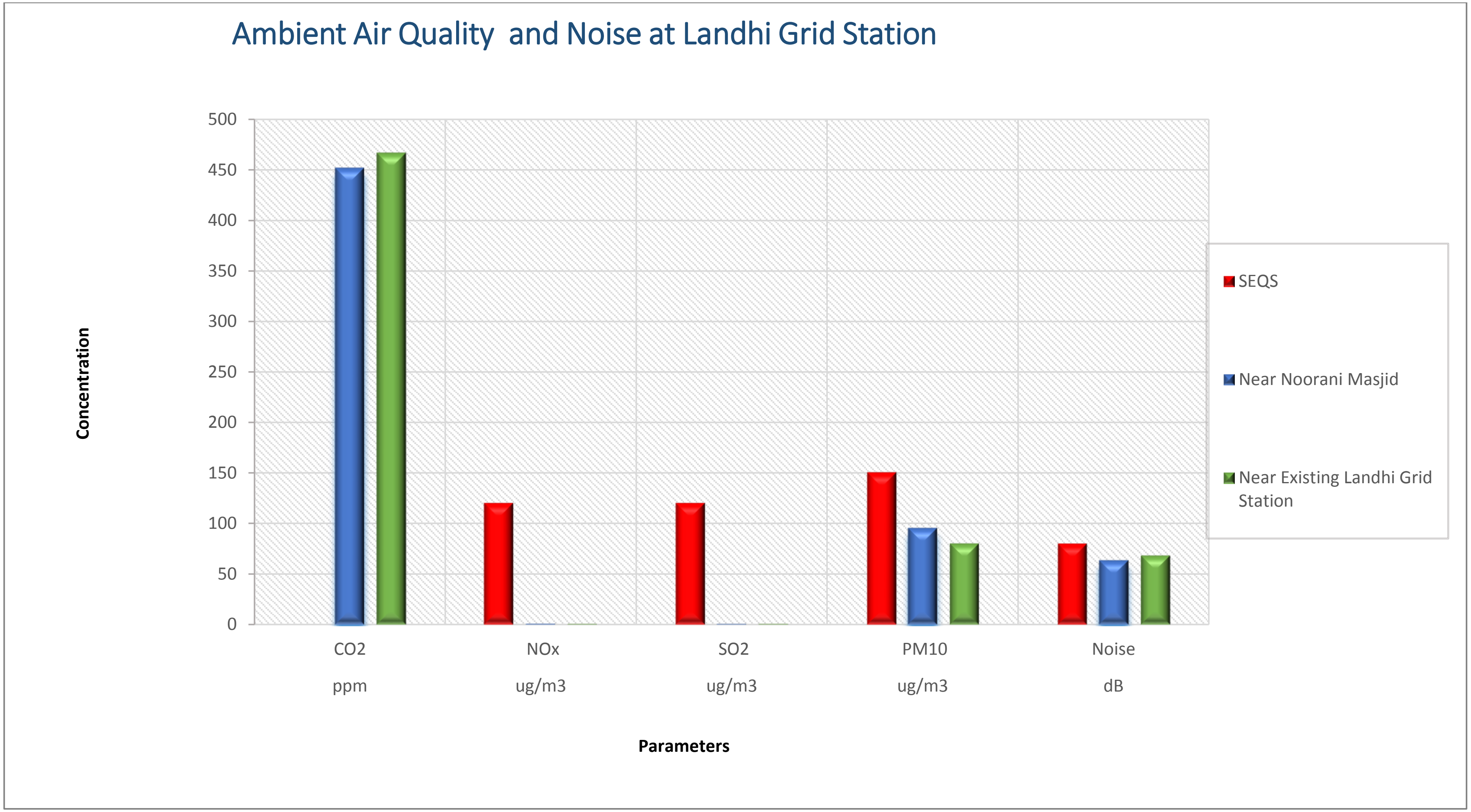
GIS Gas Insulated Switchgear

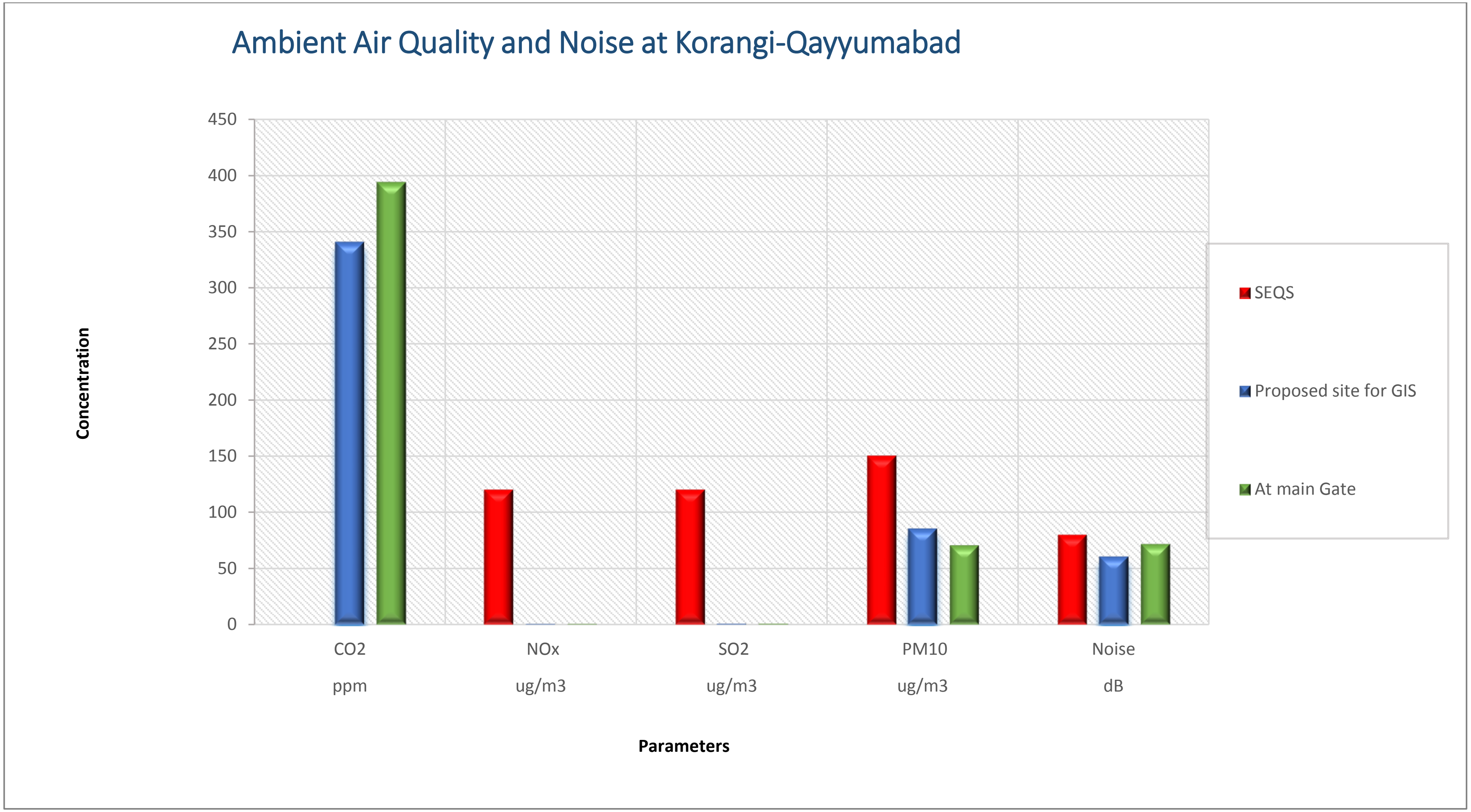
KPC Korangi Power Complex

Exhibit 4.19: Graphical representation of Ambient Air Quality and Noise Monitoring Results at all Monitoring Locations for BQPS-III Power Project




Ambient Air Quality and Noise at KPC
Concentration
500
400
300
200
100
0
CO2
ppm
NOx
ug/m3
SO2
ug/m3
PM10
ug/m3
Noise
dB
SEQS
L-1
L-2
L-3
L-4
L-5


Ambient Air Quality and Noise at Landhi Grid Station
Concentration
500
450
400
350
300
250
200
150
100
50
0
CO2
ppm
NOx
ug/m3
SO2
ug/m3
PM10
ug/m3
Noise
dB
Parameters
SEQS
Near Noorani Masjid
Near Existing Landhi Grid Station


Ambient Air Quality and Noise at Korangi-Qayyumabad
Concentration
450
400
350
300
250
200
150
100
50
0
CO2
ppm
NOx
ug/m3
SO2
ug/m3
PM10
ug/m3
Noise
dB
Parameters
SEQS
Proposed site for GIS
At main Gate

4.6.2 Key Observations on Ambient Air Quality

The key observations are as follows:

- All the ambient air quality parameters monitored at five different locations for BQPS-I were observed to be within the SEQS limits

- All the ambient air quality parameters monitored at Landhi, KPC and Qayyumabad grid stations were observed to be within the SEQS limits

- One of the reasons, of relatively clean air quality within the project surrounding is fresh sea breeze, which dilutes air pollution.

4.7 WATER RESOURCES

This section details the water resources of the proposed project area. Both, surface and ground water resources have been summarized in this section of the report. Data was compiled from secondary sources and through field observations and data collection (EIA field survey).

4.7.1 Surface Water Resources

There are no significant natural freshwater sources in the proposed project area. The Indus River is about 85 km to the east of Karachi city and the Hub River lies at a distance of 60 km to the north west of Karachi. A perennial stream that originates from Balochistan and marks the boundary between Karachi Division and Balochistan are the sources of fresh water in Karachi.

The Lyari and Malir River that passes through the city do not have any natural flow, except during the monsoons. The Lyari River falls in Kemari and Malir River falls in Gizri Creek. Malir River is ephemeral and is constituted from two major tributaries i.e. Mol and Khadeji as well as some minor tributaries. Khadeji is a perennial stream that originates at Khadeji falls and gains flow as it travels across the Malir Basin.

Port Qasim lies on the inactive and western extent of the Indus delta which is largely arid and swampy; the deltaic coastline associated with Indus Delta is dissected by 17 major creeks and numerous minor creeks. The major creeks of the Indus Delta within the study area include the Phitti, Khuddi and Khai Creeks. Minor creeks, within the study area close to Port Qasim includes Korangi, Gizri, Kadiro, Issaro, Gharo, Chann Waddo and Rakhal creek.

The Indus River had a river-dominated estuary* but due to the increasing demand of fresh water and increasing number of dams and reservoirs the discharge of fresh water to the deltaic region became low which is critically affecting the growth of mangroves and the aquatic flora and fauna. However, the flow of fresh water increases during summer southwest monsoon season. In between 1940s and 1950s embankments were constructed on Haleji and Keenjhar lakes to divert freshwater from Indus River into these lakes and to feed the dry Gharo River. The diverted water again re-enters the intertidal delta within the study area at a distance of 17 kilometers. The water from the Keenjhar Lake is also used for canal-fed irrigation within the eastern side of study area.

The main source of freshwater into the intertidal deltaic creeks of the study area is rain and associated runoff during the summer monsoon. The rainwater drains the land in the north of the study area and joins the intertidal deltaic creeks along the Gharo River, Malir River, ephemeral drains such as Badalnullah, Ghaggarnullah, Latnullah, and Mahyonullah, as well as wastewater drains, particularly into Korangi Creek.

4.7.1.1 Drinking Water Resources

Since the key component of the proposed project lies in Port Qasim, therefore the drinking water samples were collected from BQPS-I facility and subjected to microbial and chemical analysis in the Global Environmental Lab (GEL) Pvt. Ltd. The laboratory results of drinking water are presented below in **Exhibit 4.20** and **Exhibit 4.21.**

Exhibit 4.20: Chemical analysis results of Drinking Water

S. No.	Parameters	Units	SSDWQ	Concentration	Method
1	pH	_	6.5-8.5	7.61	pH meter
2	Total Dissolved Solids	mg/l	1000	536	APHA 2540 C
3	Total Suspended Solids	mg/l	_	<5	Hach Method 8006
4	Chloride	mg/l	250	87.90	APHA 4500 Cl C
5	Total Hardness*	mg/l	<500	203.57	APHA 2340 C
6	Fluoride*	mg/l	≤1.5	0.62	Hach Method 8029
7	Nitrate	mg/l	<50	0.90	Hach Method 8039
8	Nitrite	mg/l	<3	0.044	Hach Method 8507
9	Sulphate*	mg/l	250	68	Hach Method 8051
10	Bicarbonate	mg/l	_	115.15	APHA 2320 B
11	Residual Chlorine	mg/l	0.5	0.06	Hach Method 8021

Exhibit 4.21: Microbial Analysis Results of Drinking Water

S. No.	Parameters	Recommended Value	Results
1	Total Colony Count	<500 cfu / ml	450 cfu / ml
2	Total Coliform	0 cfu / 100 ml	0 cfu / 100 ml
3	Faecal Coliform	0 cfu / 100 ml	0 cfu / 100 ml
4	Faecal Streptococci	0 cfu / 100 ml	0 cfu / 100 ml

**Recommended Values as per WHO guidelines for Drinking Water*

4.7.2 Key Observations on Drinking Water Quality

Drinking water quality at BQPS-I is fit for human consumption.

4.7.2.1 Sea Water

Two seawater samples were subjected to environmental monitoring and testing and both the samples were collected from BQPS-I intake and outfall channel, since the BQPS-III Power Project will fulfill its cooling water needs from the existing sea water channel. Sea water sampling location map has been presented as **Exhibit 4.23** after pictorial representation of seawater collection which has been presented in **Exhibit 4.22,** while the sweater analysis results in **Exhibit 4.24** and its graphical representation in **Exhibit 4.25.**

Exhibit 4.22: Pictorial Representation for Sea Water Sampling

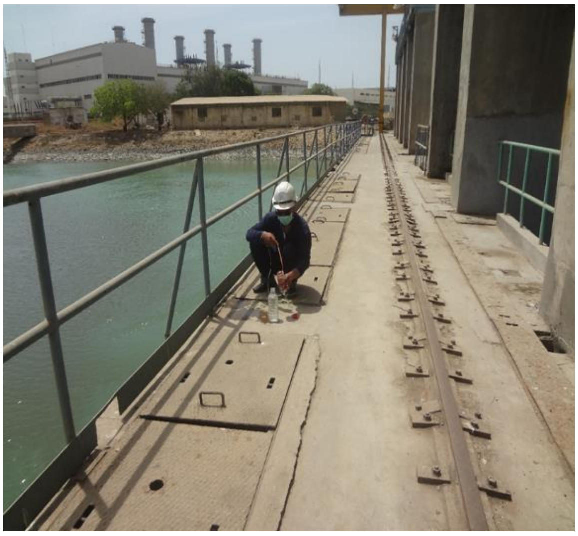
	
Water Sampling from Intake Channel	Water Sampling from Outfall Channel

Exhibit 4.23: Seawater Sampling Points at Port Qasim, for BQPS-III Power Project

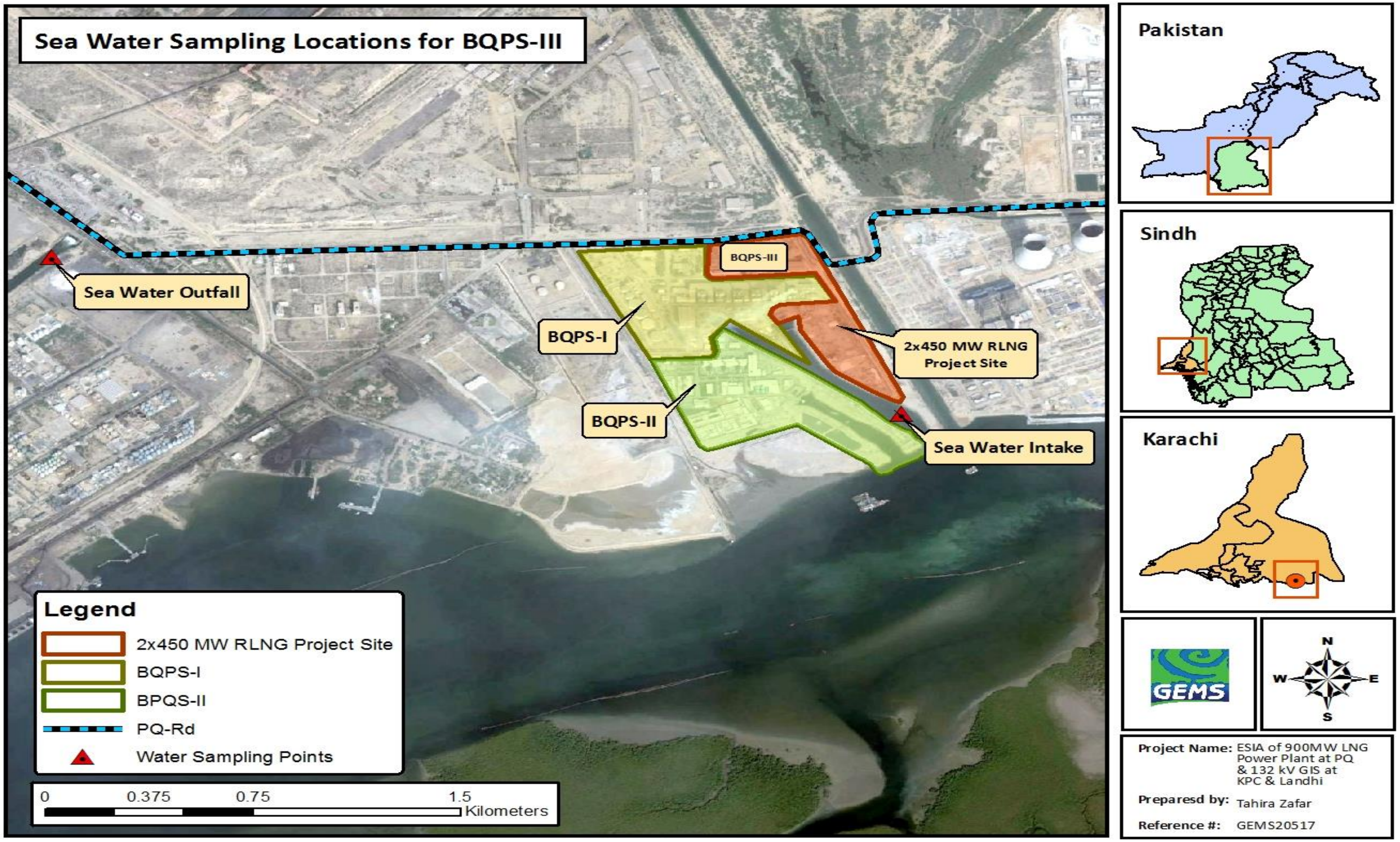
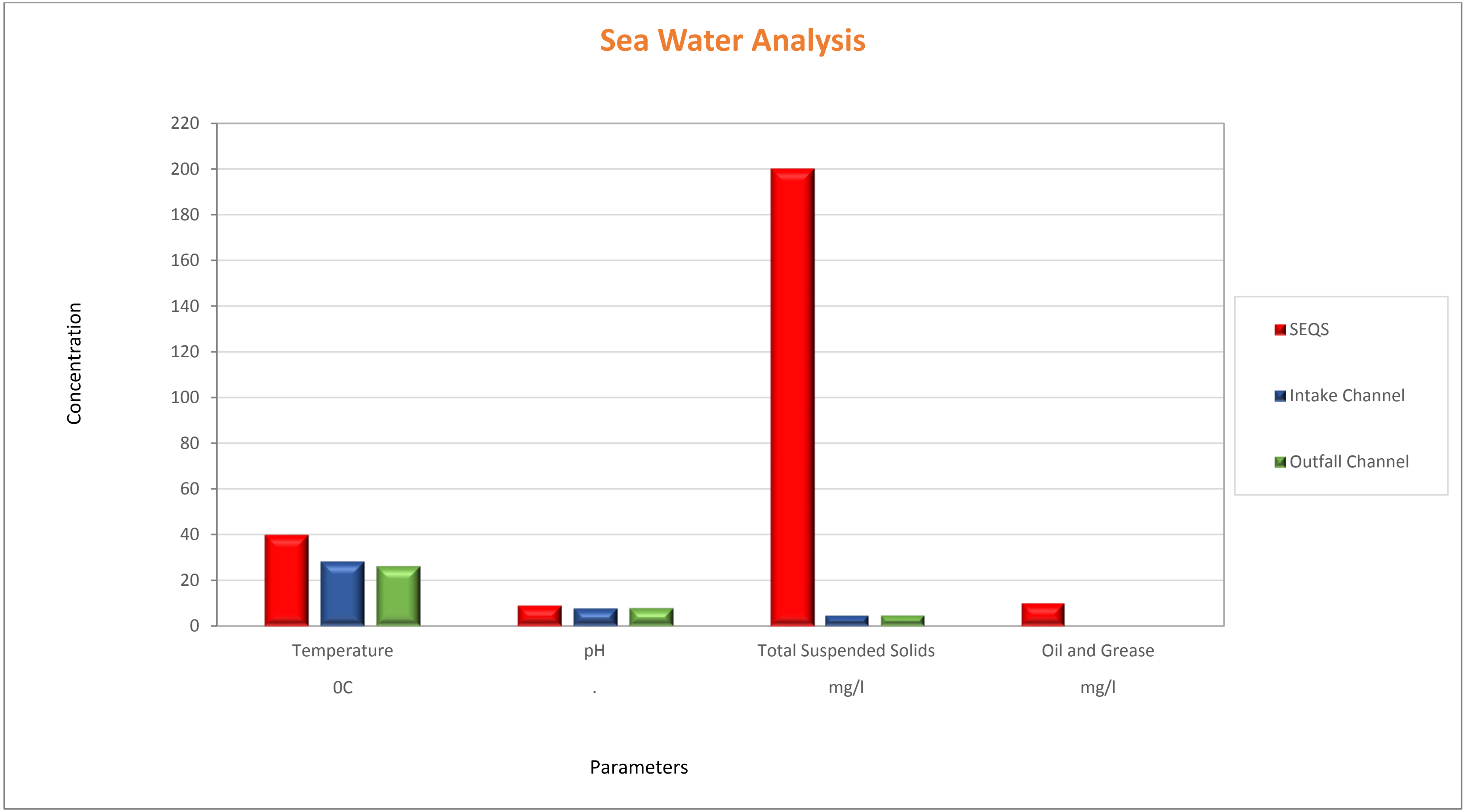


Exhibit 4.24: Sea Water Analysis Results of samples collected from Intake and Outfall Channel

S. No.	Parameters	SEQS	Unit	Concentration	
				Sea Water (intake)	Sea Water (outfall)
1	Temperature	40^0C (≤ 3 ^0C)	^0C	28	31
2	pH	6-9	….	7.62	7.73
3	Oil and Grease	10	mg/l	ND	ND
4	Total Suspended Solids	200	mg/l	<5	<5

Exhibit 4.25: Graphical Representation of Average Concentrations of Sea Water Analysis



4.7.2.2 Key Observations on Seawater Quality

Following are the key observations on seawater quality within the project surrounding

- Seawater is used for cooling the power generation units, therefore the discharge from outfall channel usually demonstrates about + 3 to 5^{o} C variation in seawater at the time of discharge, however total length of the discharge channel also plays a significant role in temperature reduction at final discharge.

- Another factor behind elevated levels of seawater temperature is that the temperature in the Arabian Sea is strongly influenced by the monsoons.

- The highest temperature occurs around May, shortly before the southwest monsoon sets in. Temperature drops in mid-summer because at this time cold water from the deeper sea circulates near the coast

- However it is important to note at present all the parameters are within the SEQS limits, which shows that the existing power generation units have well developed systems and protocols for SEQS compliance.

4.7.2.2.1 Waves

Karachi lies on the northern end of the Arabian Sea that extends southwards into the Indian Ocean for thousands of kilometers. The coast is exposed to waves from the south, southwest and west. The wave regime on the coastal belt of Karachi varies with season. It has been observed that the during the winter season, when winds are around 5 m/s, the coastal waters are almost calm and during the southwest monsoon the wave height is less than 1 m, the winds are around 13 m/s and the waves on the coast are more than 3 m high. Deep sea wave data, for the southwest Monsoon months (May to September) applicable to Pakistan coast is given in the **Exhibit 4.26.**

Exhibit 4.26: Deep Sea Wave Data, For the Southwest Monsoon Months (May to September) Applicable To Pakistan Coast

Resultant Wave Height (m)	*0-3*	*W 4-5*	*ave Period (Seconds) for*	*6-7*	*8-9 10-11*	*Higher of Sea/Swell Height 12-13*	*14-15*	*16-17 18*		*Total*
0 to 0.5	2.6%	4.1%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%
0.6 to 1.0	1.1%	5.3%	1.8%	0.4%	0.1%	0.0%	0.0%	0.0%		8.9%
1.1 to 1.5	1.2%	6.7%	6.3%	2.2%	0.6%	0.1%	0.1%	0.0%	0.0%	17.3%
1.6 to 2.0	**0.1%**	**3.8%**	**4.9%**	**2.9%**	**0.9%**	**0.2%**	**0.1%**	**0.0%**	**0.0%**	12.8%

4.7.2.2.2 Tides

> **Tides***
>
> Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces excreted by the moon and sun and the rotation of the earth.

Tides* along Karachi Coast are semi-diurnal but diurnal inequality is also present. The effect of this shows up in daily tidal cycle as there are two High Waters and two Low Waters which also vary considerably from each other in tidal heights. These are classified as HHW, LHW, LLW and HLW. The tides move from west to east i.e. the tide at the Hub River Coast arrives about 20 minutes earlier than Karachi. Similarly the tides at Karachi Harbour arrive at about 10 minutes earlier than entrance of Port Qasim. When tides progress up the Phitti Creek its magnitude increases and there is time lag. The tides reach Port Bin Qasim after 22 minute which is about 20 miles from Karachi and is located about 15 miles up to creek from the sea. At Gharo Creek tides fall down rapidly due to frictional effects and the gradual weakening of the tidal forces. At Gharo 35 miles from the Phitti Creek entrance the tides are almost half of the mean sea tides at the entrance. Lowest Astronomical Tide (L.A.T) is – 0.6 m. The highest Astronomical Tide (H.A.T) at PQA is + 3.7 m while the Mean Tidal Level (M.T.L) is recorded as + 1.76 m Exhibit.

4.7.2.2.3 Seawater Currents

The speed of the current is generally low, about ½ knots*. The speed increases up to 1 knot during SW monsoon. The direction of the set is directly related with the prevailing wind system. The set is generally easterly in the SW monsoon and westerly in the NE monsoon. The slight difference in direction in the Western and Eastern part of the Karachi Coast is due to circulatory pattern of the current around gyres* which are usually formed at the center of the sea. There is a clockwise gyre during SW monsoon and anti-clockwise gyre during NE monsoon *(Quraishee, 1988). Quraishee (1984, 1988)* has also observed the existence of warm core eddies in the offshore areas of Pakistan.

4.7.2.2.4 Seawater Salinities

The average salinity of the sea water is in between 35 to 37 % (parts per thousand) it remains constant throughout the year except in the months of monsoon. During the month of monsoon the average value of salinity decrease to 25-28 % for a few days. The salinity in most of the intertidal creeks of the Indus Delta remains between 37 and 41‰ for most of the year. It drops to about 30‰ in certain creeks during the period of August to October, due to the rain. The influx of floodwater from the Indus River lowers salinity in the creeks adjacent to the river[1].

4.7.3 Groundwater Resources

Groundwater resources in Karachi are limited. The aquifers close to the coastal belt are mostly saline and dry and this water cannot be used for drinking, domestic and agriculture purposes. Meanwhile

[1] *Cummulative Impact Assessment of Bin Qasim, Hagler Ballery Pakistan, 2016*

the aquifers which lies near the vicinity of the Hub River belt are well developed and are source of water for agriculture and other domestic purposes. Generally, the aquifers in the proposed project area are estimated to lie at depths of about 30ft to 40ft.

4.8 FAULTS, EARTHQUAKES AND SEISMIC HAZARD

Being located close to the collision boundary of the Indian and Eurasian plates, Pakistan lies in a seismically active zone. Pakistan is located in the Indus-Tsangpo Suture Zone, which is roughly 200 km north of the Himalaya Front and is defined by an exposed ophiolite chain along its southern margin. This region has the highest rates of seismicity and largest earthquakes in the Himalaya region, caused mainly by movement on thrust faults. Seismic zone mapping of Pakistan has divided the country into four seismic zones ranging in term of major, moderate, minor and negligible zones with respect to ground acceleration values. Under this zoning Karachi Division has been identified on the edge of moderate to high hazard zone. This zone has minor to moderate damaging affect. The proposed Project Site Port Qasim is located adjacent to an active tectonic setting, and is approximately 190 km east of the triple continental junction between the Arabian, Eurasian and Indian plates. The tectonic map of Pakistan is presented in **Exhibit 4.27** Tectonics Map Pakistan, while **Exhibit 4.28** represents tectonics of southern Pakistan and **Exhibit 4.29** represents earth quake density of Pakistan respectively.

Exhibit 4.27: Tectonics Map of Pakistan

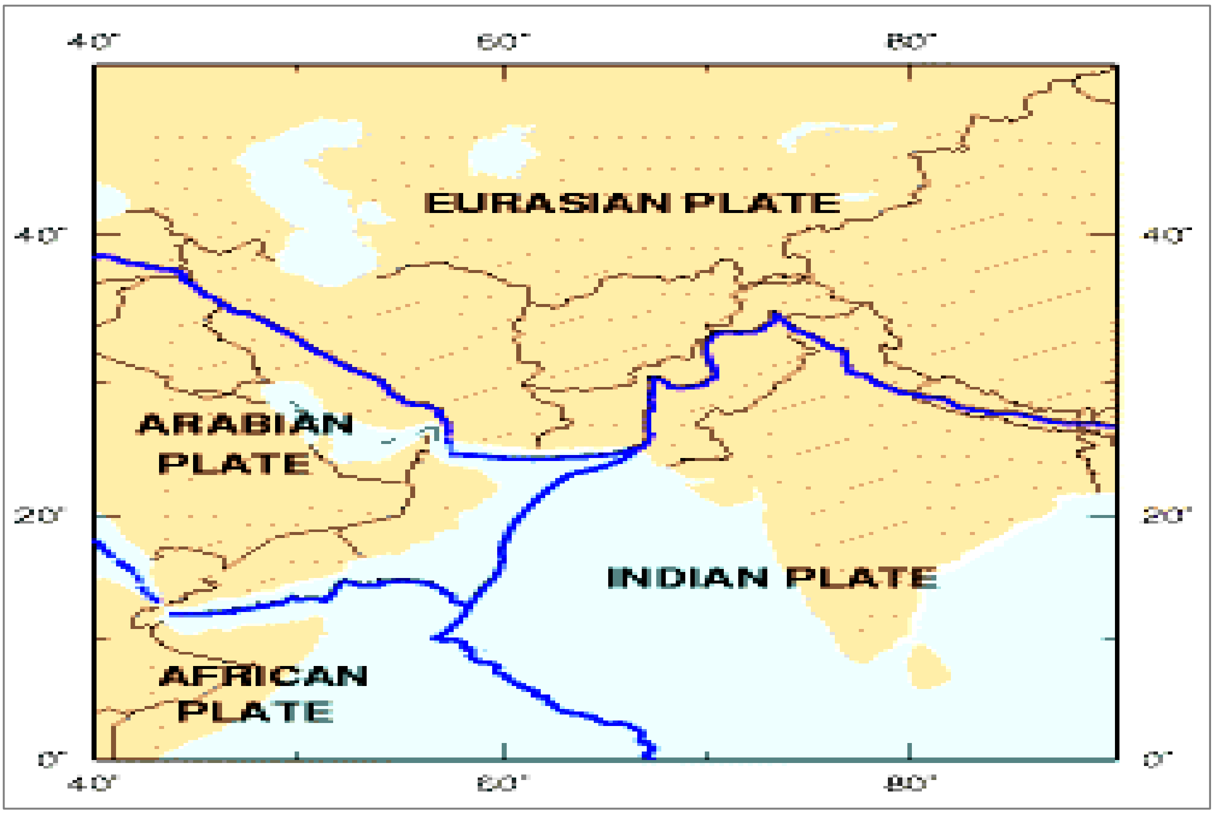
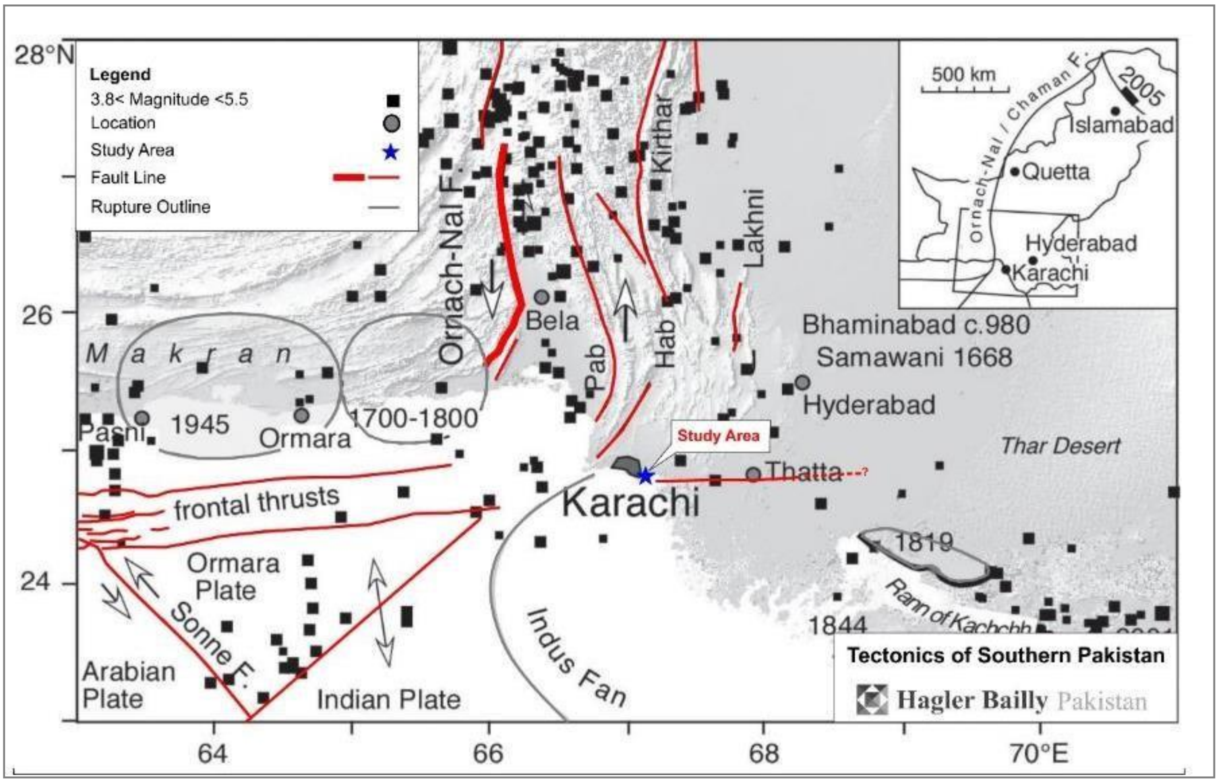
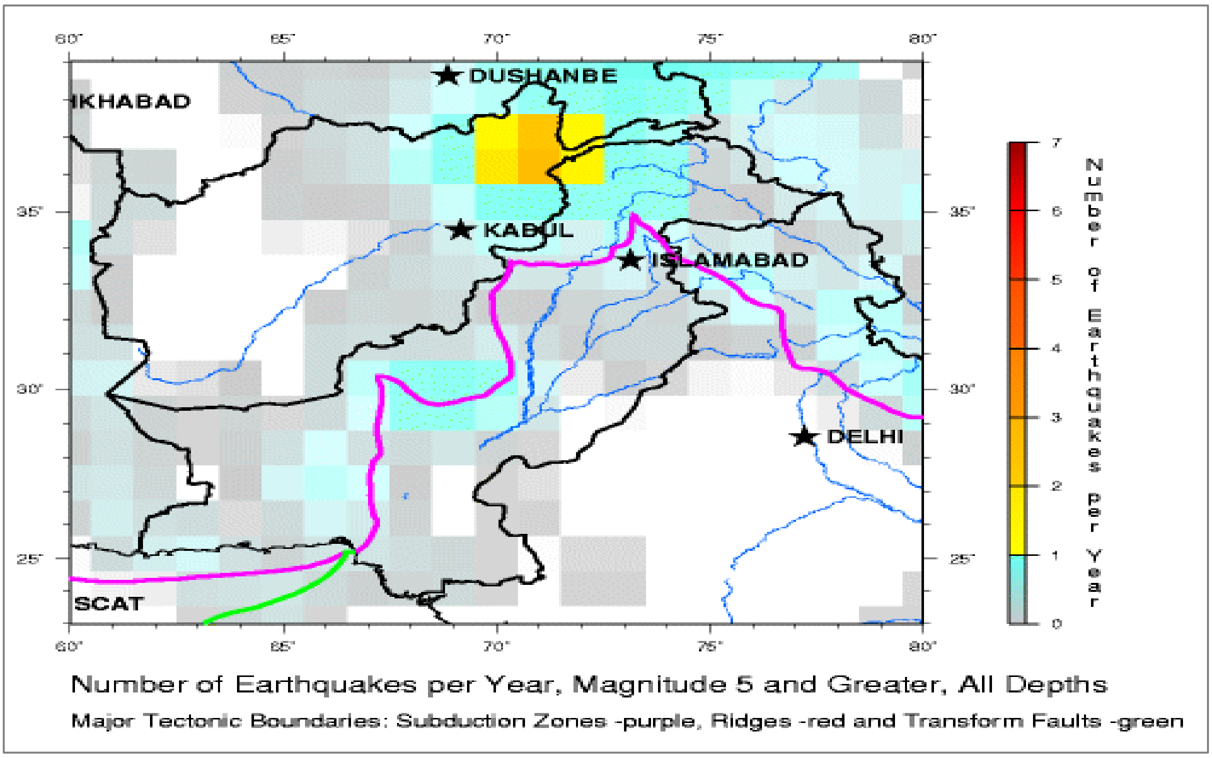


Exhibit 4.28: Tectonics of Southern Pakistan



Source: *Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Baley Pakistan, 2016*

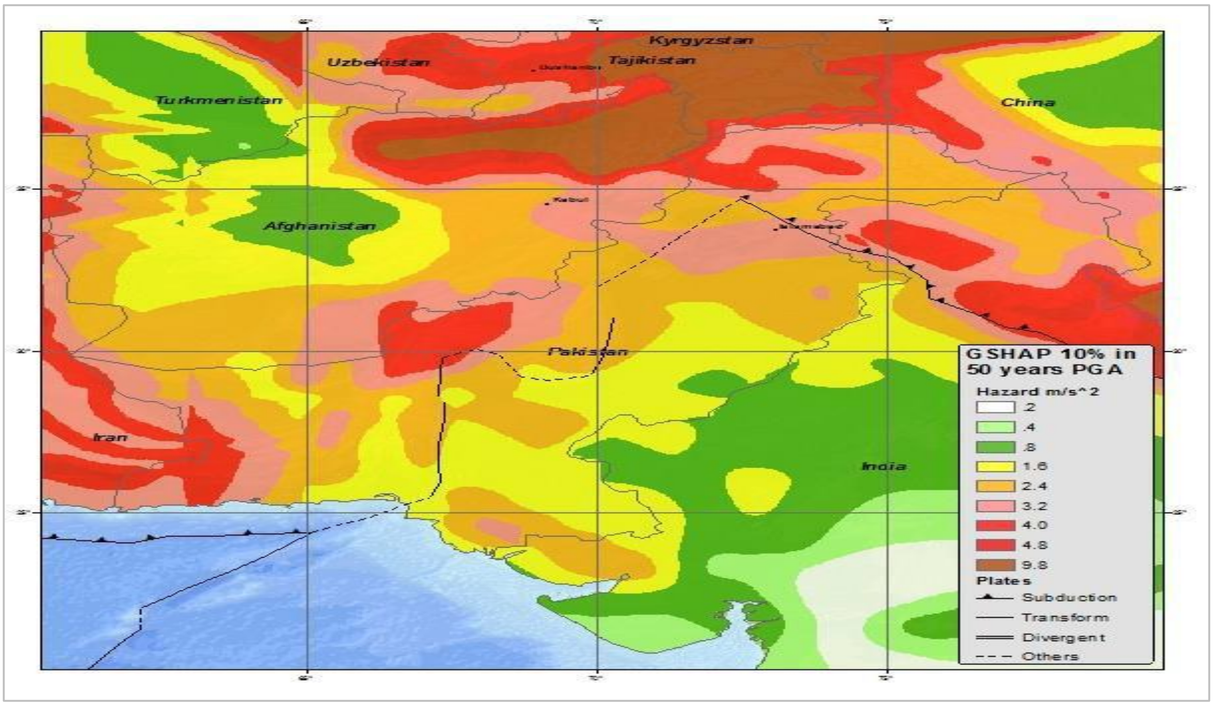
Exhibit 4.29: Earth quake Density of Pakistan



Source: *Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Baley Pakistan, 2016*

The study area experiences an earthquake density of less than 1 Richter Scale per year. Earthquake epicenters, for magnitudes between 3.8 and 5.5 ML, have been recorded along the Pab fault, Hab fault, Ornach-Nal fault, smaller micro faults east of Karachi and in the offshores areas southwest of Port Qasim. Based on the Global Seismic Hazard Map Project (GSHAP), the peak ground acceleration (PGA) of 10 % in 50 years is 1.6 m/s^2. **Exhibit 4.30** represents seismic hazard map of Pakistan.

Exhibit 4.30: Seismic Hazard Map of Pakistan

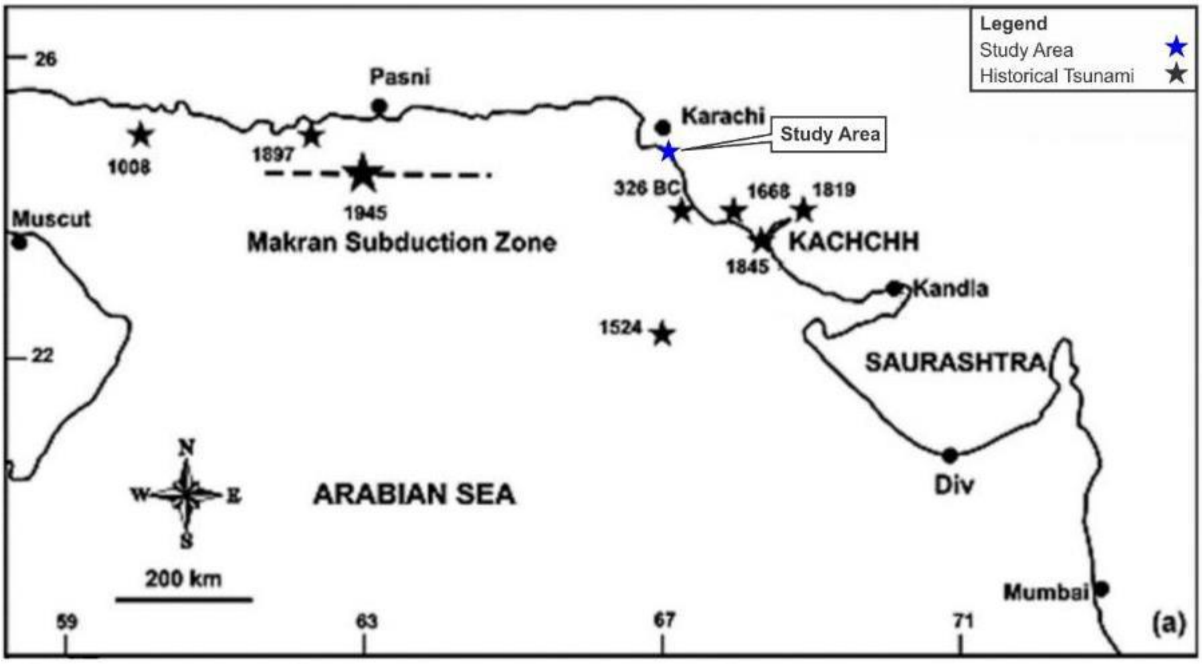


Source: *United States Geological Survey (USGS),"Seismic Hazard Map of Pakistan" (based on GSHAP), accessed15September2014,http://earthquake.usgs.gov/earthquakes/world/pakistan/density.php*

4.9 TSUNAMIS

The coastal belt of Pakistan is located in an area of potential tsunami. While large tsunami genetic earthquakes have been relatively rare but there is potential for a tsunami associated with the Makran Subduction Zone (MSZ) or smaller localized tsunamis associated with several smaller thrust faults around Karachi. A map of historical tsunamis that have been generated, some in close proximity to the Port Qasim Area, is shown **Exhibit 4.31**.

Exhibit 4.31: Historical Tsunamis Generated In the Region (Up To 1945)



Source: *Cumulative Impact Assessment for Industrial and Port Developments at Port Qasim, Hagler Baley Pakistan, 2016*

Coastal areas of Karachi might experience the effect of Tsunamis as the coast line of Pakistan has had already experienced this natural hazard in the recent past. An earthquake of magnitude 8.3 generated a destructive tsunami wave in the Northern Arabian Sea and the Indian Ocean on 28th November, 1945, producing 12 m to15 m high sea waves that killed at least 4,000 people in Pasni and adjoining areas. The tsunami hit as far as Mumbai in India. Karachi, about 450 km from the epicenter, experienced 2 m high sea waves which affected harbor facilities. Hence, the occurrence of tsunami cannot be ruled out in future. The city of Karachi lie close to potential epicenters for large earthquakes and it demands attention of the local government to enhance the capacity for managing disastrous situation, for minimizing disaster risk and response in order to reduce losses from tsunami or other climatic events. The coastal belt of Pakistan is also highly vulnerable to cyclones and associated storm surges. It has been recorded that Fourteen cyclones events had occurred between 1971 and 2001 (NDRMFP, 2007)

4.9.1 Storms and Cyclones

Tropical cyclones also occur periodically in the coastal areas. These cyclones have high intensities. A total of 14 cyclones have been observed which reached the coastal areas of Pakistan since1971 to 2001. The cyclone of 1999 in Thatta and Badin districts wiped out 73 settlements and killed 168 people and 11,000 cattle’s. Nearly 0.6 million people were affected. It destroyed 1800 small and big boats and partially damaged 642 boats, causing a loss of Rs.380 million. Losses to infrastructure were estimated to be Rs.750 million. Climate change may increase the frequency and intensity of storms and could cause changes in their tracks. Although the frequency of cyclones along Pakistan coast belt is low but it can cause a huge damage when it occurs. Hence the possible occurrence of a future cyclone with severe consequences is quite rare but cannot be ruled out (NDRMFP, 2007).

CHAPTER

5

ECOLOGICAL ENVIRONMENT

5.1 GENERAL OUTLINE AND SCOPE

This section gives the detailed description of the ecological environmental conditions of the study area. The proposed project area under review was assessed for its potential impact on biodiversity, and ecosystem in short and long term. The data collection techniques are combination of both primary and secondary. Primary means by field verifications, observations, sampling and monitoring within the close proximity of major project installations i.e. 2 X 450 RLNG based CCPGU that will be installed within the existing premises of BQPS-I and titled as BQPS-III at PQA.

KEY FEATURES OF ECOLOGICAL BASELINE

- ✓ General Habitation of Study Area under Focus
- ✓ Flora of The Study Area under Focus (Mangroves)
- ✓ Fauna of The Study Area under Focus (Macrofauna, MBI)

However ecological baseline of the areas which requires small scale modification such as grid installations and replacements at Qayyumabad, Korangi and Landhi were also made part of this baseline investigations supplemented by secondary means of verification, which included review of published literature and previous ESIA studies, conducted by GEMS Pvt. Ltd. in the surrounding areas where small scale modifications will be made for the proposed project.

Figure 2: Ecological Expert Observing the Floral Species

However key focus remained within the close vicinity of BQPS-III project site at PQA as the proposed project may contribute to the gaseous emissions, noise generation and heated effluent discharge during constructional and operational phase which may ultimately affect the ecology of the project surrounding at PQA, furthermore modifications associated with the proposed project in other areas are unlikely to bring about any changes within the ecological environment in its surrounding. The base line data defines and elaborates the present ecological environmental quality and features of the proposed project surrounding.

Figure 1: Macrofuana Sampling at Project Site

(Refer figure 1 and 2 to observe on-spot ecological baseline investigations and sampling pictures)

Experts in the field of terrestrial ecology were engaged in the area of interest from Global Environmental Management (GEMS). The floral and faunal diversity was also determined by random sampling in and around for the area under focus. The objective of the study was to establish terrestrial and marine ecological baseline of the proposed project site and its vicinity.

Sampling locations for the identification of flora and fauna, assemblages were carefully selected so that the maximum number of species can be observed and significant ecological baseline can be generated for the proposed project area. A hand-held GPS was used to document changes in the ecological assemblages.

5.2 GENERAL HABITATION OF AREA UNDER FOCUS

The proposed project site is located on the northwest edge of the Indus delta system, which is characterized by long and narrow creeks, mud flats and the mangroves forest ecosystems towards the south of the plant. The present delta covers an area of about 600,000 hectares and is characterized by 16 major creeks and innumerable minor creeks, dominated by mud flats, and fringing mangroves. The coastal morphology is characterized by a network of tidal creeks and a number of small islands with sparse mangrove vegetation, mud banks, swamps, and lagoons formed because of changes in river courses.

The Gharo Phitti Creek System consists of three creeks: Gharo Creek, Kadiro Creek and Phitti Creek. All three are connected in a series starting from Gharo Creek at the north-eastern end to the Phitti Creek at the south-western end and located at 22.3 km from Karachi. This creek system is about 28 km long and its width ranges from 250 to 2,500 m. The Korangi Creek, and Kadiro Creeks are connected with it at the north-eastern end while it acts as main waterway connected with the open sea at the south-western end. However the project area also sustains Mangroves forest within its vicinity immediately after the outfall channel, the forest inhibits diverse species habitats of Marine Benthic Invertebrates, reptiles, birds, and flora. However it is important to note that the proposed project does not involve clearance of cutting of the Mangroves species within its vicinity.

Furthermore the key area under focus for baseline establishment and other areas under modification and installation sustains a vegetation which is mostly dominated by shrubs. However variations in vegetation composition were observed with varying microhabitats. **Exhibit 5.1** represents the area under focus for ecological baseline establishment while **Exhibit 5.2** represents the flora and fauna sampling location map.

Exhibit 5.1: Biodiversity Study Area under Focus

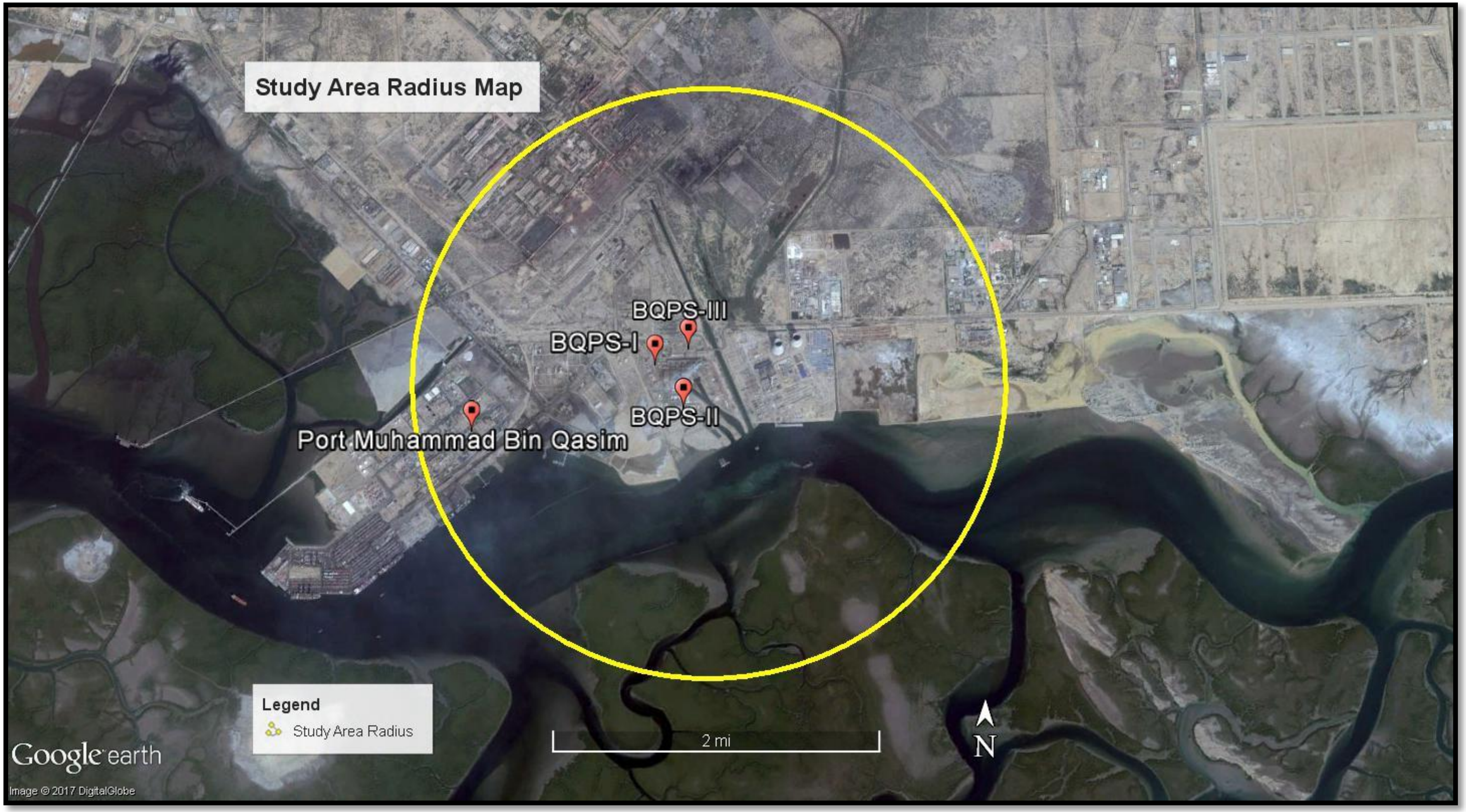
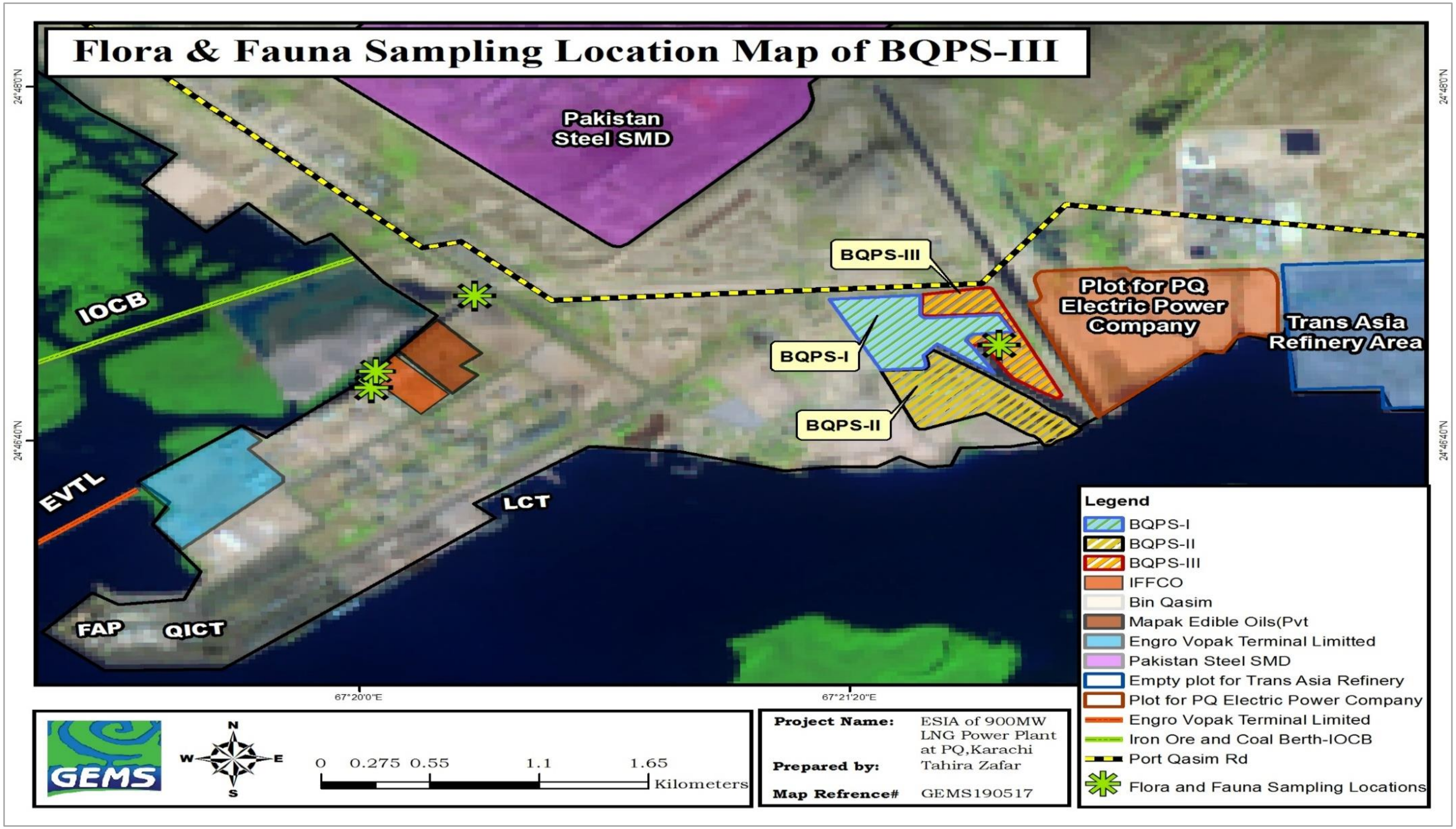


Exhibit 5.2: Floral and faunal sampling location map.



5.3 FLORA OF THE PROJECT AREAS

5.3.1 Survey/Sampling Methodology for Mangroves:

A generic survey was carried out during the establishment of the baseline, to assess the health of Mangroves within the proposed project vicinity. According to the Sindh Forest Department, the mangroves in the area are under the control of Sindh Forest Department and Port Qasim Authority and it is declared as **"Protected Forests".**

5.3.1.1 Brief Description

The PQA built area is located adjacent to the main land and has been surrounded by extensive networks of creeks system dominated by mangroves vegetation where few of the halophytic species were growing in association. The proposed project is located in Port Qasim which is part of the Indus Delta. The Indus Delta supports the seventh largest mangrove forest system in the world (WWF-P). In the Indus Delta mangrove ecosystem, eight species of mangroves have been reported out of 70 species known to occur in the tropical forests of the world. The *Avicenna marina* is the dominant species of the mangroves in the Indus Delta. Established natural or planted Mangrove habitats were not observed in immediate vicinity of the project site at both the intake and outfall channel area however, the outfall channel is lined with mangrove trees of Avicenna marina of >6 m in height. (Refer figure 3 & 4 to observe natual *Avicennia marina* mangroves at the outfall channel)

Figure 4: Natural *Avicennia marina* mangroves at the outfall channel.

Figure 3: *Avicennia marina*

5.3.2 Terrestrial Flora

5.3.2.1 Survey/Sampling Methodology for Terrestrial Flora

The area was surveyed by adopting a plot less methodology based on ocular observations was prepared for the proposed project area.

5.3.2.2 Brief Description

The proposed project installations at PQA, Korangi, Landhi and Qayyumabad are in the built up area.The vegetation is dominated mostly by shrubs; however variations in vegetation composition were observed with varying microhabitats. The associated life forms consisted halophytes belonging to family *Chenopodiaceae*. The other significantly represented members of the floristic list belonged to *Poaceae, Asteraceae* and *Zygophylliaceae.* The terrestrial habitat in the Study Area largely consists of arid and dry plain land. Plant species reported from the area include Mesquite *Prosopis juliflora*, Indian Milkweed *Calotropis procera* and Caper Bush Capparis deciduas the most abundant among these, Mesquite *Prosopis juliflorais* an alien invasive species which is harvested by the locals and sold in the local timber market for fuel wood and construction of local huts. Locals graze their camels on *Mesquite Prosopis juliflora.*

The general floristic list observed at PQA is presented as **Exhibit 5.3**, while on the other hand the general floristic list observed at Landhi, Korangi and Qayyumabad is presented as **Exhibit 5.4** accordingly

Exhibit 5.3: Floral Species Observed in Intertidal and Terrestrial Habitat of PQA

S. No	Taxon	Family
1.	*Blepharis sindica* Stocks ex T. And	Acanthaceae
2.	*Achyranthes aspera* L	Amaranthaceae
3.	*Pentatropis nivalis* (J.F.Gmel.) Field &J.R.I.Wood	Asclepiadaceae
4.	*Calotropis procera* (Aiton) W.T.Aiton	Apocynaceae
5.	*Conyza aegyptiaca* Ait	Asteraceae
6.	*Launaea procumbens* (Roxb.) Amin	Asteraceae
7.	*Sonchus asper* Fig.	Asteraceae
8.	*Avicennia marina* (Forssk.) Vierh	Avicenniaceae
9.	*Heliotopium ophioglossum* Boiss	Boraginaceae
10.	*Capparis decidua* (Forsk.) Edgew	Capparidaceae
11.	*Arthrocnemum macrostachyum* (Moric.) C.Koch	Chenopodiaceae
12.	*Arthrocnemum indicum (Willd.)* Moq	Chenopodiaceae
13.	*Atriplex stocksii* Boiss	Chenopodiaceae
14.	*Chenopodium album* L	Chenopodiaceae
15.	*Salsola imbricata* Forsk	Chenopodiaceae
16.	*Suaeda fruticosa* Forsk. ex J.F.Gmelin	Chenopodiaceae

S. No	Taxon	Family
17.	*Suaeda monoica* Forsk. ex J.F.Gmelin	Chenopodiaceae
18.	*Convolvulus arvensis* L	Convolvulaceae
19.	*Cressa cretica* L	Convolvulaceae
20.	*Cyperus bulbosus* Vahl	Cyperaceae
21.	*Euphorbia serpens* Kunth	Euphorbiaceae
22.	*Alhagi maurorum* Medic	Fabaceae
23.	*Acacia nilotica* Delile	Mimosaceae
24.	*Prosopis juliflora* Swartz	Mimosaceae
25.	*Commicarpus boissieri* (Heimerl) Cufod	Nyctaginaceae
26.	*Aeluropus lagopoides* (L.) Trin. ex Thw	Poaceae
27.	*Chloris barbata* Sw	Poaceae
28.	*Cynodon dactylon* (L.) Pers	Poaceae
29.	*Desmostachya bipinnata* (L.) Stapf	Poaceae
30.	*Paspalum vaginatum* Swartz..	Poaceae
31.	*Pennisetum purpureum* Schum	Poaceae
32.	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae
33.	*Sporobolus virginicus* (L.) Kunth	Poaceae
34.	*Rhizophora mucronata* Lam.	Rhizophoraceae
35.	*Salvadora persica* L	Salvadoraceae
36.	*Tamarix indica* Willd.	Tamaricaceae
37.	*Fagonia indica* Burm.f.	Zygophyllaceae
38.	*Zygophyllum simplex* L.	Zygophyllaceae

Exhibit 5.4: Floral species Observed at Landhi, Korangi and Qayyumabad

S. No.	Taxon	Family
1	*Blepharis sindica Stocks ex T. And*	Acanthaceae
2	*Cocos nucifera L.*	Aerecaceae
3	*Phoenix dactylifera L.*	Aerecaceae
4	*Launaea procumbens (Roxb.) Amin*	Asteraceae
5	*Avicennia marina (Forssk.) Vierh*	Avicenniaceae
6	*Heliotopium ophioglossum Boiss*	Boraginaceae
7	*Arthrocnemum macrostachyum (Moric.) C.Koch*	Chenopodiaceae
8	*Arthrocnemum indicum (Willd.) Moq*	Chenopodiaceae
9	*Atriplex stocksii Boiss*	Chenopodiaceae
10	*Suaeda fruticosa Forsk. ex J.F.Gmelin*	Chenopodiaceae
11	*Suaeda monoica Forsk. ex J.F.Gmelin*	Chenopodiaceae
12	*Cressa cretica L*	Convolvulaceae
13	*Prosopis juliflora Swartz*	Mimosaceae
14	*Aeluropus lagopoides (L.) Trin. ex Thw*	Poaceae
15	*Chloris barbata Sw*	Poaceae
16	*Cynodon dactylon (L.) Pers*	Poaceae
17	*Zygophyllum simplex L.*	Zygophyllaceae

Exhibit 5.5: Pictorial Profile of Common Floral species observed at PQA, Landhi, Korangi and Qayyumabad

Acacia senegal

Chorchorus depreses

Aerva javanica

Calotropis procera

Leucinea sp

Pentatropis nevalis

5.3.2.3 Conservation Status

Based on information available in the ESIAs for projects in Port Qasim, Korangi, Landhi aswell as Qayyumabad and literature review, no threatened or endemic terrestrial plant species has been reported from the Study Area, with an exception on mangroves at Port Qasim. The Mangrove species *Avicenna marina* found in the project area and Rhizophora mucronanta in the surroundings has been listed as least concern (LC), in IUCN red list of species, which endorsed its justification, as "This species is widespread and common throughout its range. It is a fast growing and fast regenerating, hardy species. It is threatened by the loss of mangrove habitat throughout its range, primarily due to extraction and coastal development, and there has been an estimated 21% decline in mangrove area within this species range since 1980. Mangrove species are more at risk from coastal development and extraction at the extremes of their distribution, and are likely to be contracting in these areas more than in other areas. It is also likely that changes in climate due to global warming will further affect these parts of the range. In addition to that according to the Sindh Forest Department, the area is under the control of Sindh Forest Department and Port Qasim Authority and declared as **"Protected Forests".**

5.4 FAUNA OF THE PROJECT AREA

5.4.1 Survey/Sampling Methodology for Coastal Invertebrate Fauna:

A field survey was undertaken by the marine environment experts on the during the month of April 2017 at project area during the onset of South West Monsoon Period. A Linear transects sampling methodology was followed using the hand-held GPS to identify the sampling station locations. A total of four sampling locations were selected to determine the baseline ecological conditions at the proposed project site. One sampling point was randomly selected at KE cooling water inlet and three sampling points at the outfall channel of the KE.

(Refer **Exhibit 5.2** to observe flora and fauna sampling points)

A digital camera was used to capture images of the marine habitats and fauna. The marine invertebrate specimens (Gastropods, Bivalves, Crustaceans, biofouling organisms etc.) encountered during the survey on exposed areas, were enumerated, documented and identified as taxonomic groups or to the genus level by referring to standard field guides.

Pictorial view of Intake Channel BQPS-I

Pictorial view of Combine outlet Channel of BQPS-I & II.

For benthic sampling (MBI), a spatula was used for sediment sampling top 10-20 cm of sediments was collected in 500 ml plastic jars. 10% neutralized Formalin was used to preserve the sediment samples for further analysis at the **CEMB research lab, Karachi University**. The macrofauna and meiofauna were separated through the 35 mm and 63 mm mesh size sieve from the sediments and preserved in 5% formalin mixed with Rose Bengal for staining of animals. The meiofauana was highly concentrated with sand particles and debris, therefore it was further diluted by making up 100 ml sample through tap water. From 100 ml sample, 10 ml sample was taken for meiofauna analysis. Samples were observed under the binocular stereo microscope and data sheet was prepared for the statistical analysis presented as **Exhibit 5.17**.

5.4.2 Brief Description and Findings

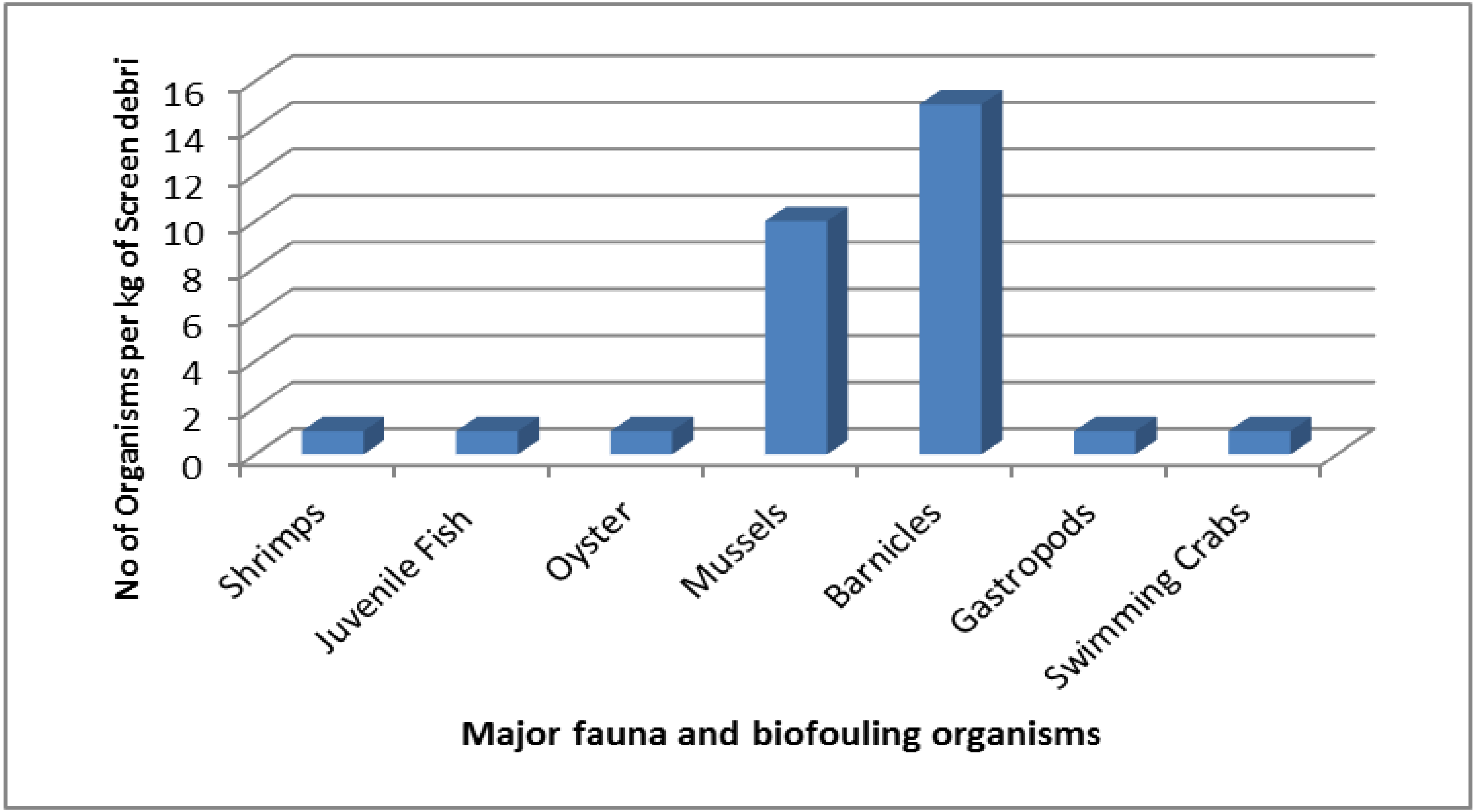
5.4.2.1. Epi pelagic Fauna

The marine invertebrates play an important role in mixing the organically enriched bottom sediments and are the key linkages in transferring the energy from lower trophic level to the next higher trophic level in the food chain.

5.4.2.1.1. Epi pelagic fauna intake channel

Approximately 230,000 m^3 per hour will be used as intake cooling water. The intake channel is productive in terms of benthic fauna and fish species primarily due to the fact it is a protected area and no fishing activity is allowed in the intake channel. The epi fauna observed at one sampling location of the intake channel includes juvenile fish, shrimps, swimming crabs, mussels, barnacles, oyster shells, gastropods. None of the taxonomic groups/species observed at the sampling locations are listed as endangered or near threatened or threatened under the red list published by IUCN 2014. Graph showing number of organisms at intake channel observed in per kg of screen debris is presented in **Exhibit 5.6.**

Exhibit 5.6: The numbers of organisms observed in per kg of screen debris at BQPS-I intake channel



5.4.2.1.2. Descriptive Statistics

The epi fauna trapped in the inlet channel screen was approximately 200 Kg of fish, bivalves, crustaceans and bio fouling organisms per week, display a diversified fauna. The descriptive statistics of the faunal community is given in **Exhibit 5.10** while the pictorial profile of fauna and biofouling organism collected from the BQPS-I intake cooling screen on a weekly basis consisted of juvenile fish, shrimps, swimming crabs, mussels, barnacles, oyster shells, gastropods etc. is represented in **Exhibit 5.7.**

Exhibit 5.7: Descriptive Statistics of faunal community at the sampled location

Station Location	Mean Ind	Variance	Std. Dev	Std Error	Total Ind	Total Spp	Min	Max	Mean Confidence Interval
Station I-1	4.286	33.571	5.794	2.19	30	7	1	15	24.87

Exhibit 5.8: Pictorial Profile of Epi-pelegic Fauna Observed in the Sampling Area.

Fish, bivalves, crustaceans and bio fouling organisms trapped in the screen of intake channel of KE

		
Shrimp (*Metapenaeus spp*)	Mussel (*adult)*	Juvenile fish spp
		
swimming crab *(Portunis peligicus)*	Barnacles	Oyster shell

5.4.2.2. Epi pelagic fauna outfall channel

The outfall channel was sampled at 3 locations at an approx. distance of 200 m from each sampling site. The epifaunal abundance observed at the outfall channel *Cerethium spp* was observed to be dominant at location # 1, the species number declined downstream at locations 2 & 3. Juvenile species of gastropods *Cerethium* were found in patches and a filamentous green microalgae was also observed. **Exhibit 5.9**: The Epifaunal Abundance Observed at the Outfall Channel of BQPS-I while on the other hand **Exhibit 5.10** represents the pictorial profile of epi pelagic fauna observed at the outfall channel.

Exhibit 5.9: The Epifaunal Abundance Observed at the Outfall Channel of BQPS-I

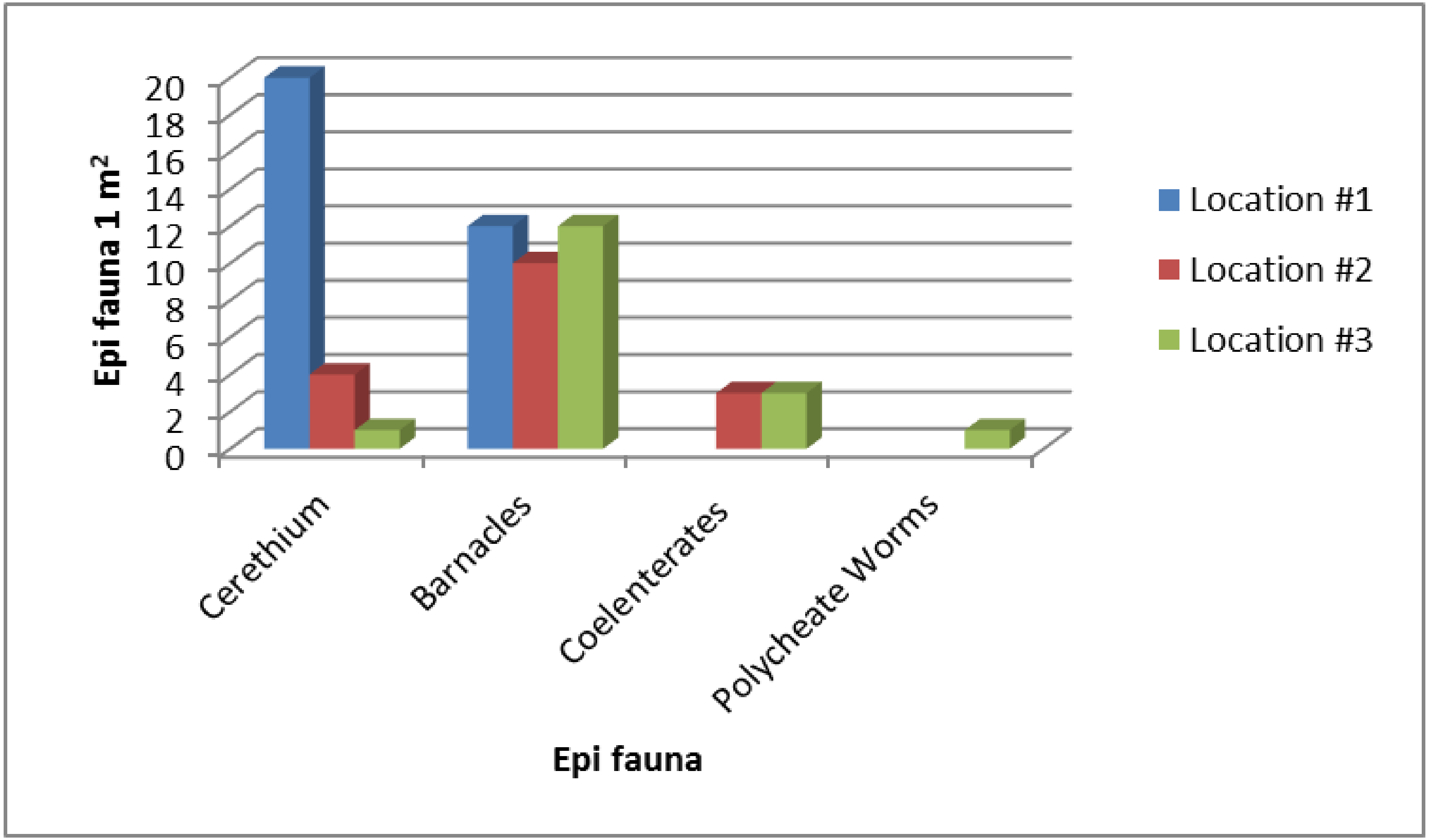


Exhibit 5.10: Pictorial Profile of Epi Pelagic Fauna Observed at the Outfall Channel

Juvenile of Gastropods *Cerethium*

Barnacles and Coelenterates

Filamentous Green Microalgae

5.4.2.2.1. Descriptive Statistics

About 2-4 species were observed from the 3 outfall locations in the channel of the BQPS-I & II power plant. Station O-1 had the highest number of individuals representing 2 species while Station O-2 and Station O-3 had 17 individuals represented by 3 and 4 species respectively. Statistical evaluation of individuals observed at 3 locations in the outfall channel can be seen in **Exhibit 5.11.**

Exhibit 5.11: Descriptive Statistics of individuals observed at 3 locations in the outfall channel

Station Location	Mean Ind	Variance	Std Dev	Std Error	Total Ind	Total Species	Min	Max	Mean Confidence Interval
Station O-1	8	96	9.798	4.899	32	2	0	20	94.08
Station O-2	4.25	17.583	4.193	2.097	17	3	0	10	17.231
Station O-3	4.25	27.583	5.252	2.626	17	4	1	12	27.031

5.4.2.2.2. Distribution Behavior

Coastal intertidal areas have a diverse range of communities that inhabit muddy/clay shores. The surface and burrowing marine invertebrates play an important role in mixing the organically enriched bottom sediments and are the key linkages in transferring the energy from lower trophic level to the next higher trophic level in the food chain. The marine invertebrate communities reported from the Study Area are characteristic of fine sediments from rocky to muddy/clayey. The Epifaunal species distribution (aggregate or random) is calculated for each of the species identified from the sampling stations is given in **Exhibit 5.12.**

The aggregate or random distribution is due to the mode of reproduction and bottom currents that may also be responsible for their distribution behavior. The Invertebrates epifaunal communities are restricted to top 10-15 cm of the bottom substrates. They have a relatively short regeneration (about 3-4 week) time and are quick to re-colonize. The epifaunal communities are good indictors of physical disturbance to bottom sediments or pollution related studies.

Exhibit 5.12: The Epi-faunal species distribution (aggregate or random)

Species	Variance	Mean	Chi-sq	d.f.	Aggregation
Cerethium	104.3333	8.3333	25.04	2	Aggregated
Barnacles	1.3333	11.3333	0.2353	2	Random
Coelenterates	3	2	3	2	Random
Polycheate Worms	0.3333	0.3333	2	2	Random

5.4.2.2.3. Shannon Weiner Diversity Index

Shannon Weiner diversity index is a tool for measuring the health of the ecosystem. The biodiversity values are relatively low at sample Station O-1 (0.62) at Station O-2 and Station O-3 the diversity values range from 0.959 and 0.885 respectively, (Diversity ranges from 0.1-3.0). The species Evenness (J') ranges from 0.639 to 0.954. The normal range for evenness (J') is from 0.1 to 1.0. The outfall channel is a relatively disturbed area, and therefore both species diversity and species richness are relatively low. The Shannon Weiner biodiversity Index for the outfall channel is shown in **Exhibit 5.13.**

Exhibit 5.13: Shannon Weiner biodiversity Index for the outfall channel

Index	Station O-1	Station O-2	Station O-3
Shannon H' Log Base 2.718	0.662	0.959	0.885
Shannon Hmax Log Base 2.718	0.693	1.099	1.386
Shannon J'	0.954	0.873	0.639

5.4.3. Benthic Invertebrate (MBI)

5.4.3.1. Sampling methodology for MBI

The benthic fauna (Macrofauna, Meiofauna and Microfauna) play an important role in biodegrading organic substances debris and dead material and in liberating nutrients within the sediments.

Exhibit 5.14: Descriptive Statistics of Benthic Fauna Observed In the Sampling Area

Outfall	Mean Ind.	Variance	Std. Dev.	Std. Error	Total Ind.	Total Species	Min.	Max.	Mean Confidence Interval
Sample 1	15.083	265.542	16.295	6.652	90.5	6	0.5	42.5	212.478

The sediment samples were greasy; there was presence of oil in the samples in the outfall drain. MBI were observed to be abundant in the benthic fauna. In macrofauna, oligochaetes (lemon color) were observed in highest number in the sample followed by Polycheate and nematodes presented below as **Exhibit 5.15**. Moreover, Copepods, Gastropods and Nereis were also present in small number in the sample which are presented in **Exhibit 5.16**. The meiofauna comprised of, nematode was observed in highest number in the sample followed by oligochaetes and forams.

Exhibit 5.15: Marine benthic Invertebrates observed at the outfall sampling location

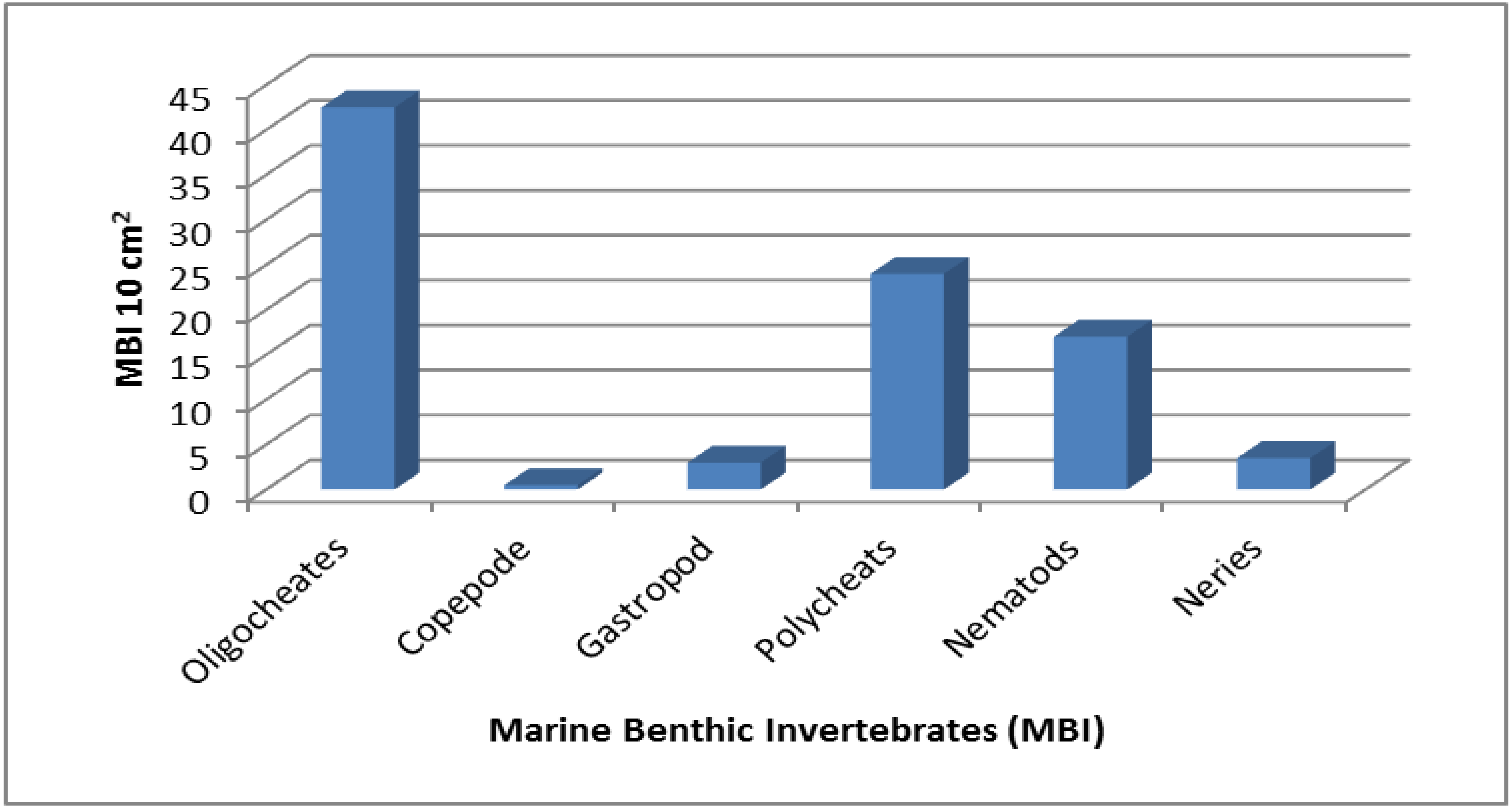
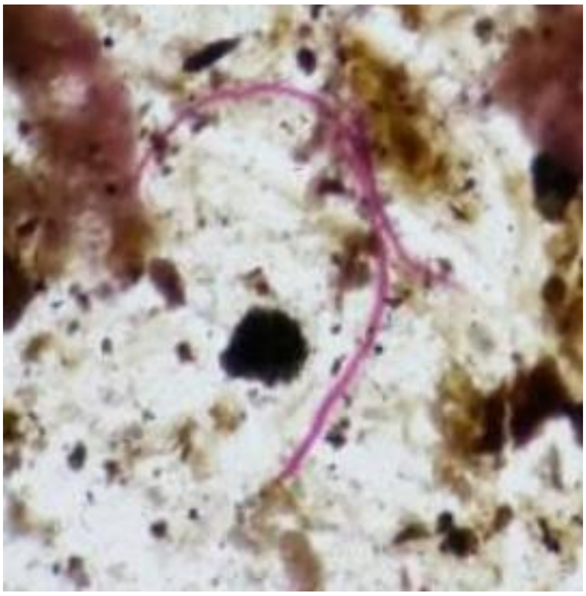
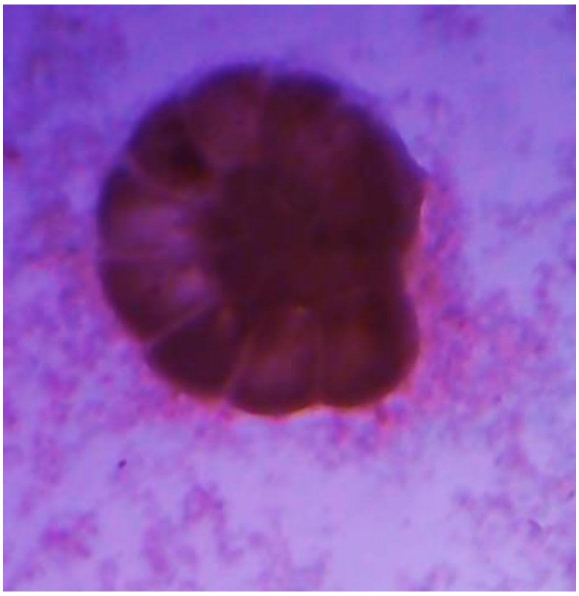


Exhibit 5.16: MBI observed in the outfall sampling location.

	
Oligochaetes	Oligochaetes
	
Nematode	Foraminifera

5.4.3.2. Conservation Status

The benthic fauna listed above are not listed as threatened, near threatened or as declining populations under the IUCN Red list of 2014.

5.4.4. Survey/Sampling Methodology for Endemic Birds:

To estimate avifaunal diversity of the proposed project area individual count technique was used by using binocular spotting technique during field surveys and the identified species were immediately recorded and reported accordingly.

5.4.4.1. General Description and Findings

The mangroves of the Indus Delta provide abundant food and shelter to a number of endemic species of birds Figure 16. The common birds are Oystercatcher *Haematopus ostralegus*, Lesser Sand Plover *Charadrius mongolus*, Greater Sand Plover *Charadrius leschenaultii,* Grey Plover *Pluvialis squatarola*, Golden Plover *Pluvialis apricaria*, Little Ringed Plover *Charadrius dubius*, Kentish Plover *Charadrius alexandrinus,* Sanderling *Calidris alba*, Dunlin *Calidris alpina*, Curlew *Numenius arquata* , Whimbrel Numenius phaeopus, Marsh Sandpiper *Tringa stagnatilis* and Common Sandpiper *Actitis hypoleucos*.

White Crane near Project Site

Flamingos in Flight at Proposed Project Area

Breeding activities of a number of endemic birds have been reported in the coastal wetlands of the Delta particularly Little Tern *Sterna albifrons*, Common Tern *Sterna hirundo, Gullbilled* Tern *Gelochelidon nilotica,* Yellow legged Gull *Larus michahellis*, Lesser Black backed Gull *Larus fuscus* and Great Black headed Gull *Ichthyaetus ichthyaetus*

5.4.4.2. Conservation Status

Among these birds, only Common Curlew *Numenius arquata* is listed as Near Threatened in IUCN Red List.

5.4.5. Cetaceans

Dolphins have been sighted in the PQA area of interest and in the In the Indus deltaic region. The survey team did not observe any dolphins in the area during the boat survey. There is no published information available about the number of Cetaceans that visit the area. Similarly, the team did not find any turtles in the area nor any turtle tracks were found on the muddy shores. No turtle nest was observed. It is unlikely that the turtles would nest in muddy substrate, they prefer sandy substrates instead.

5.5. CONCLUSION

Marine benthic invertebrates are essential for the energy transfer within the coastal ecosystem. However, they have a short reproductive life cycle, especially the marine benthic meiofauna (0.5 mm) that can quickly re–colonize a new site within a short span of about 2 – 3 weeks. None of the MBI species reported or observed in the vicinity are included in the IUCN Red List. Even though individuals are liable to be killed, the habitat loss associated with any construction activity is not likely to have a significant long–term impact on the MBI species due to their ability to re–colonize quickly.

CHAPTER 6

SOCIO-ECONOMICS & CULTURAL ENVIRONMENT

6.1 GENERAL OUTLINE AND SCOPE

A team of experts comprising of a sociologist and an environmental assessment specialist carried out a comprehensive study of socio-economic and cultural environment of the proposed project surrounding. The approach and methodology was a combination of primary and secondary data gathering techniques much of the secondary data was extracted from previous ESIA studies conducted in the project surrounding. This section of the report represents the assessment of the socio-economic baseline of the proposed project surrounding based on social surveys. The assessment also includes a focus on the gender aspects.

KEY FEATURES OF SOCIO ECONOMIC ASSESSMENT

Administrative Setup
Demographic
Amenities
Health
Education
Livelihood
Law and Order (Security)
Economics

The socio-economic assessment is focused on evaluation of population, languages, literacy rate, educational facilities, health facilities, diseases, available utilities, access to social amenities, road access, availability and medium of transport, occupational statistics, water resources and basic needs of the people living in the area. However key focus remained within the close vicinity of BQPS-III project site at PQA as the proposed project may contribute to the gaseous emissions, noise generation and heated effluent discharge during constructional and operational phase which may ultimately affect the socioeconomics of the project surrounding at PQA, furthermore modifications associated with the proposed project at Korangi, Landhi and Qayyumabad are unlikely to bring about any significant changes within the socioeconomic environment in its surrounding. The information gained, helped in the measurement and determination of the impacts (positive and negative) on social services, livelihood and cultural pattern of the population under study.

6.2 PROJECT LOCATION AND ADMINISTRATIVE SETUP

The proposed project lies in the jurisdiction of Port Qasim Authority (PQA). PQA was established on June 29, 1973 and it is the second deep-sea industrial commercial port operating in Karachi. This Port is situated in Indus delta region at a distance of about 28 nautical miles in the south-east of Karachi. Port Qasim is geographically located on the trade route of Arabian Gulf. The port currently caters for more than 40% of seaborne trade requirements of the country. The port is engaged in providing shore-based facilities and services to international shipping lines[1].

HUMAN SETTLEMENT SPECIFICATIONS

PQA employees residential 10 km from the proposed project site.

Pakistan Steel Mills Employees Township about 12 km from proposed project site.

Gulshan-e-Hadeed about 12 km from proposed project site of BQPS-III.

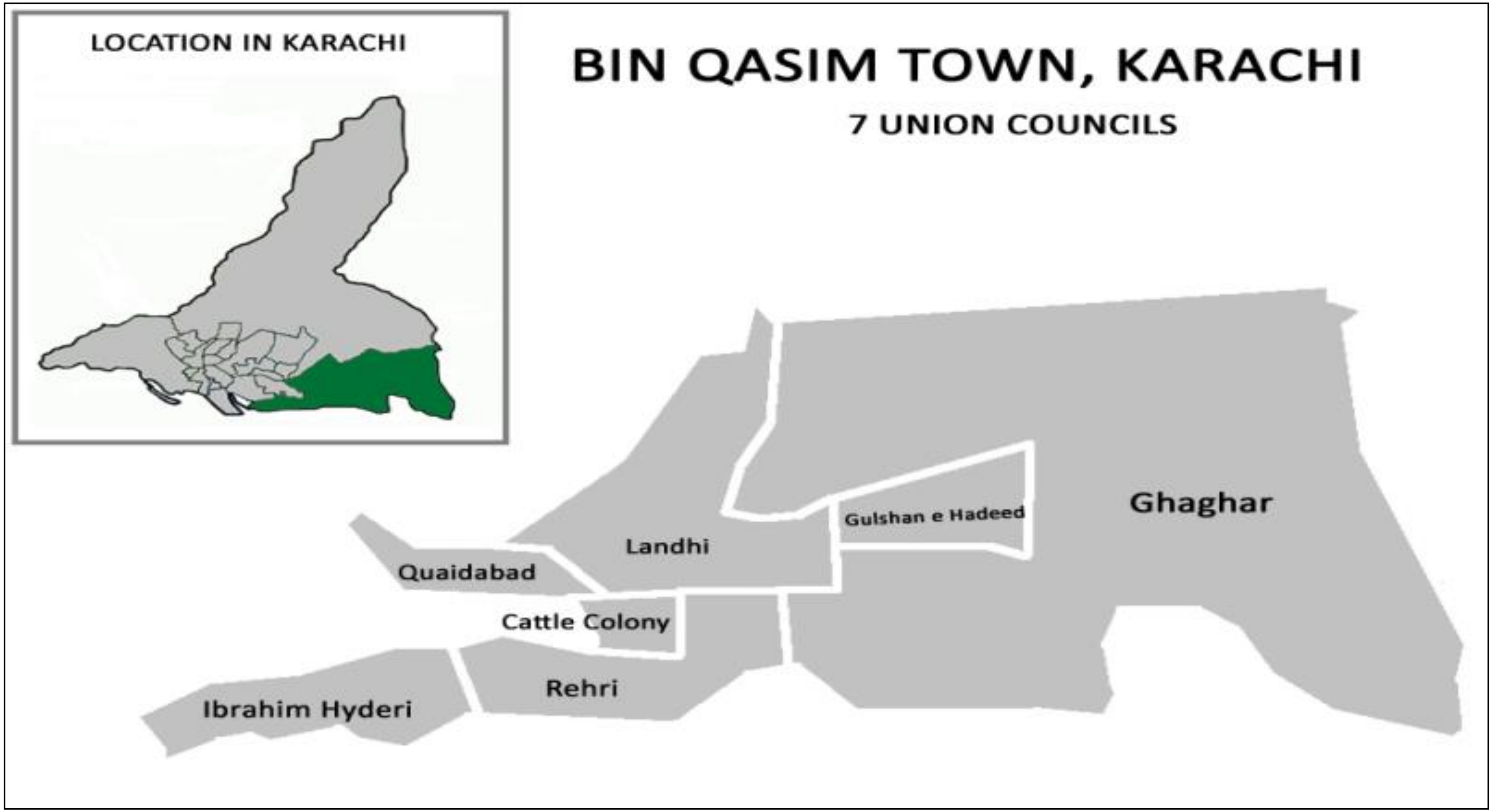
Ibrahim Haidery about 14 km from proposed project site of BQPS-III.

Rehri Goth about 8 km from proposed project site of BQPS-III.

Major industrial areas in close proximity of the proposed project includes southwestern and North Western Industrial zone of PQA which houses a sizeable number of industries in its surrounding. Port Qasim Authority is the main administrative body of the town comprising of 7 UCs (Union Councils). **Exhibit 6.1** represents the administrative setup of the project surroundings.

[1] http://pqa.gov.pk/introduction.php

Exhibit 6.1: Administrative Setup of the Proposed Project Area



6.3 TRAFFIC INLETS AND OUTLETS

The proposed project surrounding is less populated but it is rapidly growing as administrative towns of Karachi city. The local administration is working on the development and maintenance of roads and infrastructures and has led to the development of link roads and traffic networks in the city.

Considerable Major Access Routes to The Proposed Project Area		
Identification	Total Length	Status
National Highway N5	About 1819 km	Operational
Port Qasim Road	About 23.5 km	Operational

6.4 DEMOGRAPHICS

Karachi is reported to be the largest city of Pakistan and it is world's 5th largest city, spread over an area of 3,530 square kilometers. The city credits its growth to the mixed populations of economic and political migrants and refugees from different national, provincial, linguistic and religious origins that settle here permanently along with their families.

UNION COUNCILS IN BIN QASIM TOWN

Cattle Colony
Gaghar
Gulshan-e-Hadeed
Ibrahim Hyderi
Landhi Colony
Quaidabad
Rehri

The population of Bin Qasim Town is approximately 1,260,000 *(Pakistan Economic Survey 2013-2014)*[2]. However, the population of the city is exponentially increasing with the passage of time due to the rapid developmental activities such as new residential towns are being developed to reduce the burden of overpopulation on the central city. Both upper and middle class population of the city is living near port Qasim. Gulshan-e-Hadeed and Steel Town are two main residential areas of the vicinity of the project area. Cattle colony is the center of cattle and meat trade in Karachi. Cattle Colony is the dairy products supply hub for Karachi. Small Goths such as Rehri Goth and Lath Basti sustains a major chunk of lower middle and lower class fishing communities. These communities are located about 10 to 12 km away from proposed project site on the North Western Zone of PQA, layout of (NWZ) is presented as **Exhibit 6.2**. Prominent industries like, Pakistan International Bulk Terminal Industries (PIBT) Engro Vopak Terminal Limited (EVTL), Pakistan International Bulk Terminal (PIBT), Fauji Oil Terminal Company (FOTCO) and Multi-Purpose Berths etc. are located on the South Western Zone of Port Qasim as presented in **Exhibit 6.3**. However industries such as, Trans Asia Refinery Limited, 1320 MW Coal Power Plant of Port Qasim Electric Supply

[2] *http://www.finance.gov.pk/survey/chapters_15/Highlights.pdf*

Company (PQEPC), Engro Polymers, Engro Zarkhez, Tuwairqi Steel Mills Limited, KE Bin Qasim Power Station-I & II (BQPS) and Lotte Chemicals Pakistan Limited, etc. located near the project area comes under the Eastern Industrial Zone of PQA as shown in **Exhibit 6.4**. No human settlements are observed in the immediate vicinity of the proposed project as demonstrated in **Exhibit 6.5** accordingly

Exhibit 6.2: North Western Zone Layout of PQA

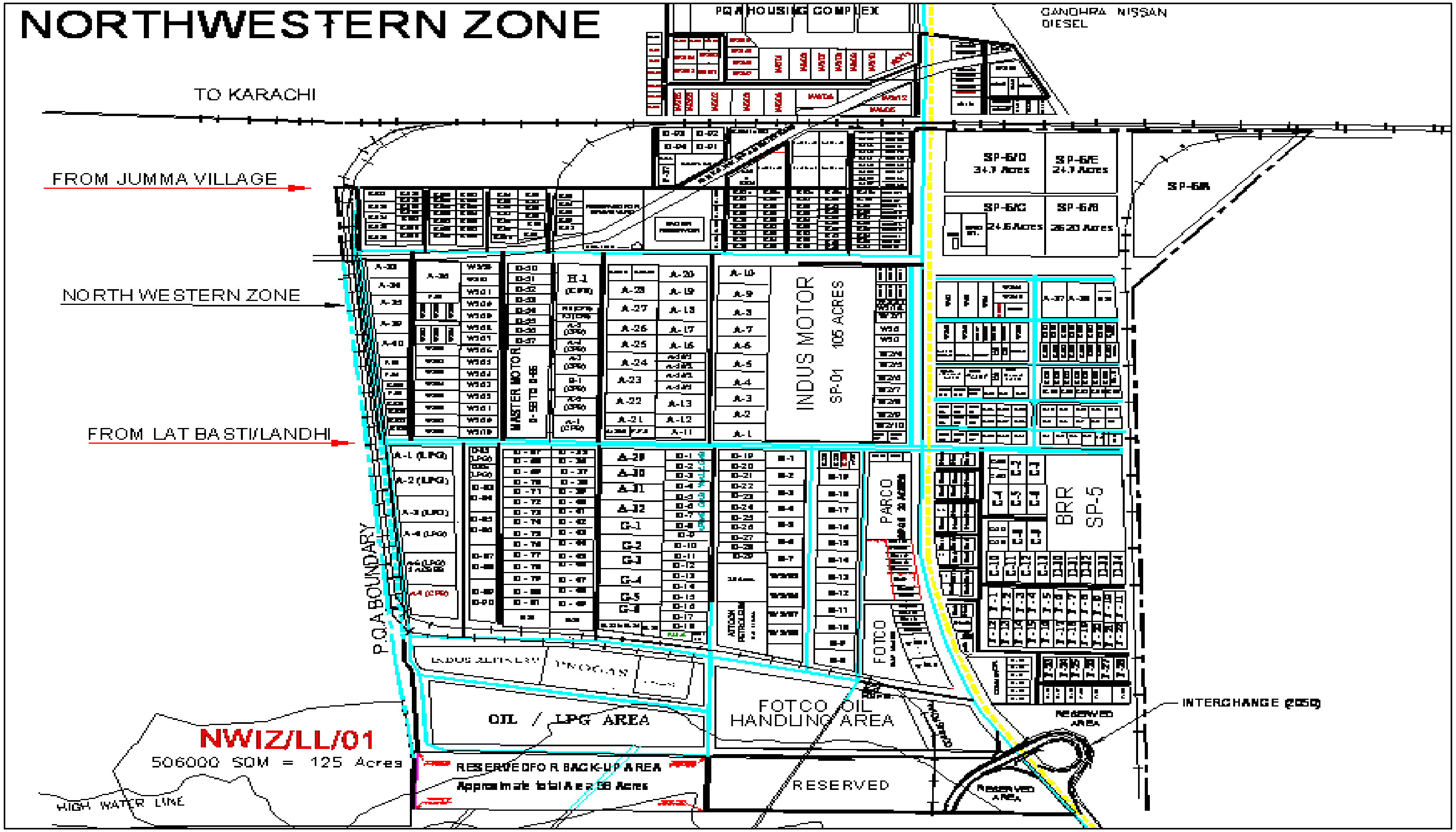
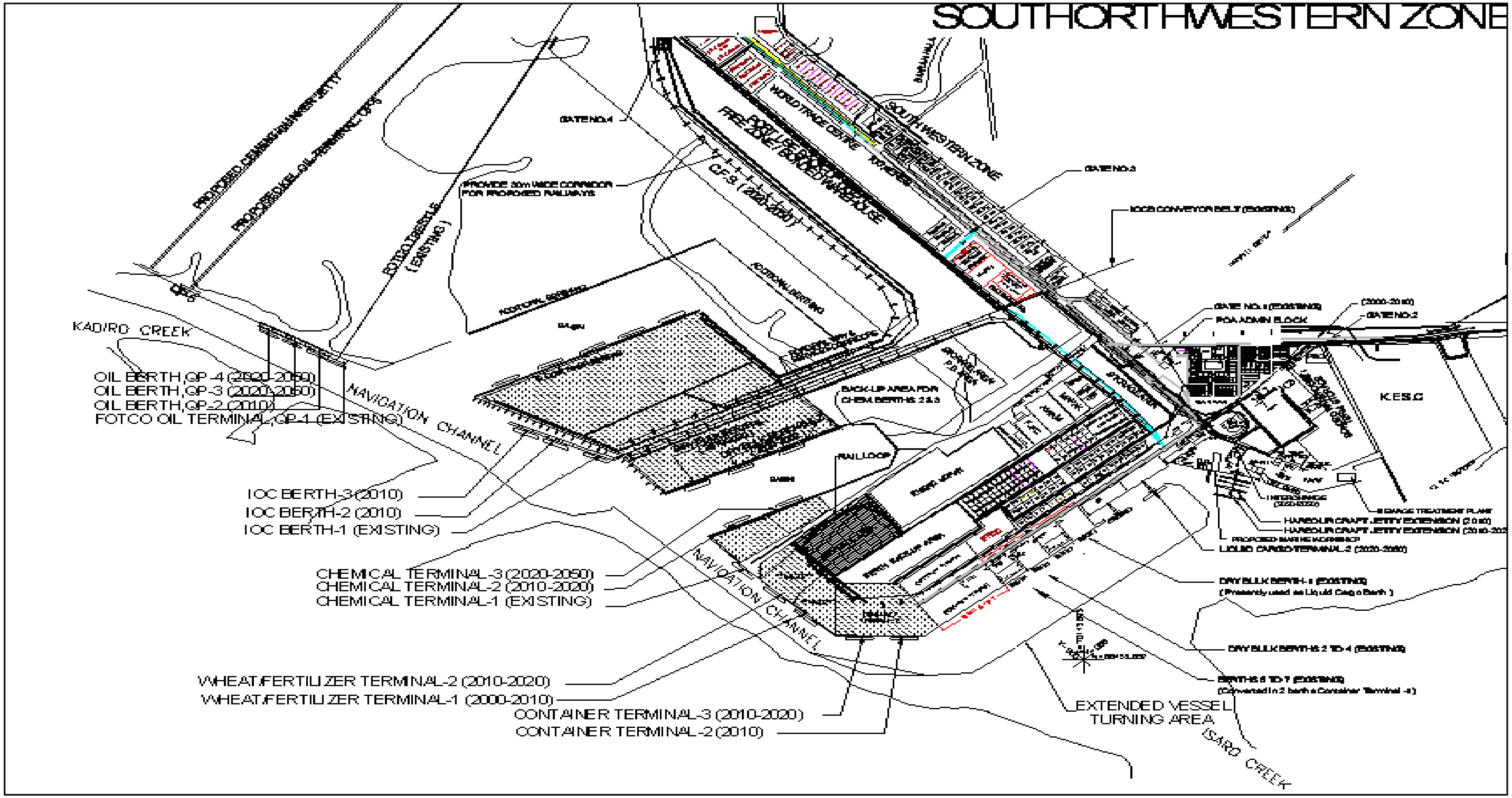


Exhibit 6.3: Southwestern Zone of PQA



Source: *http://pqa.gov.pk/uploads/image/northen-zone.gif*

Exhibit 6.4: Eastern Industrial Zone of PQA

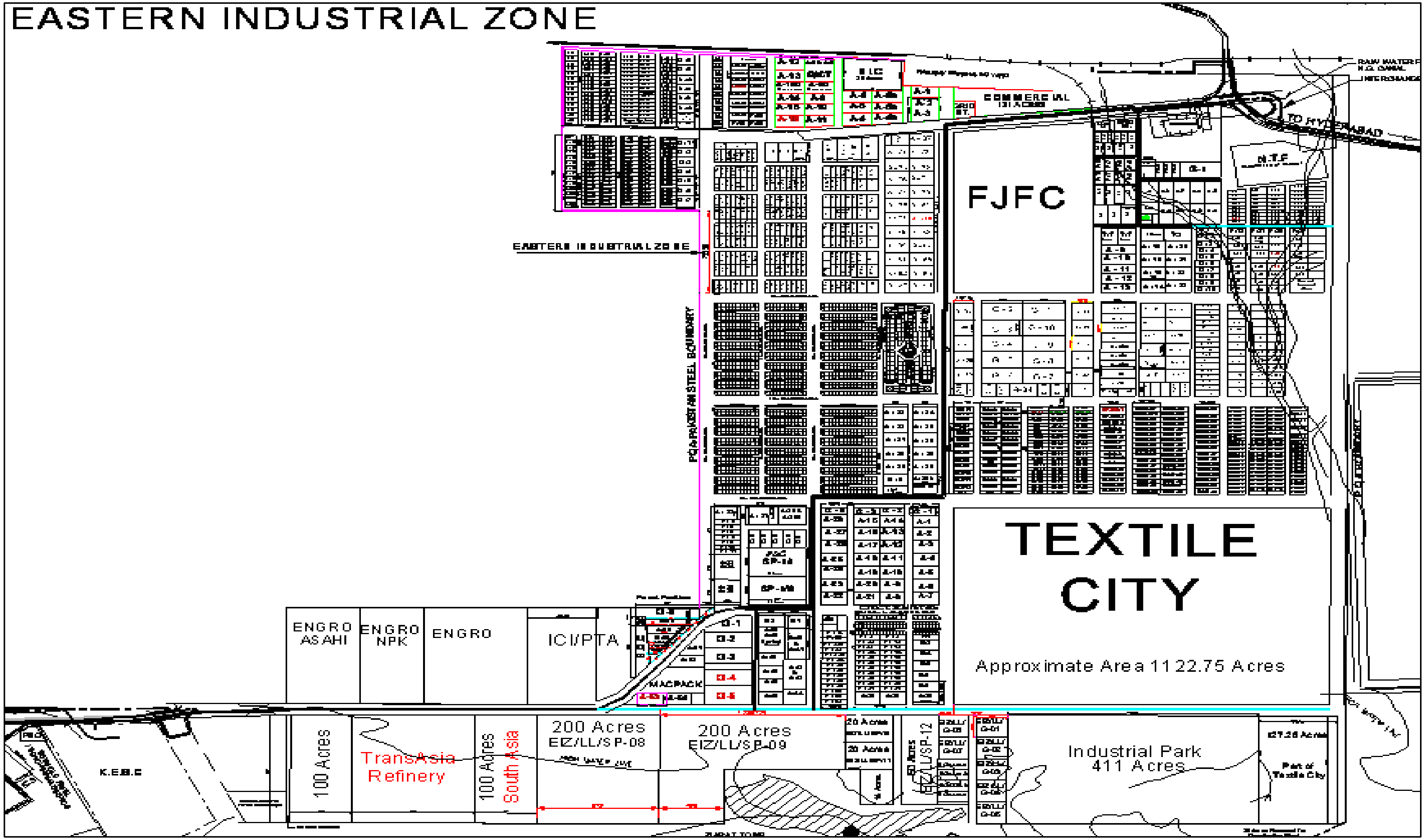
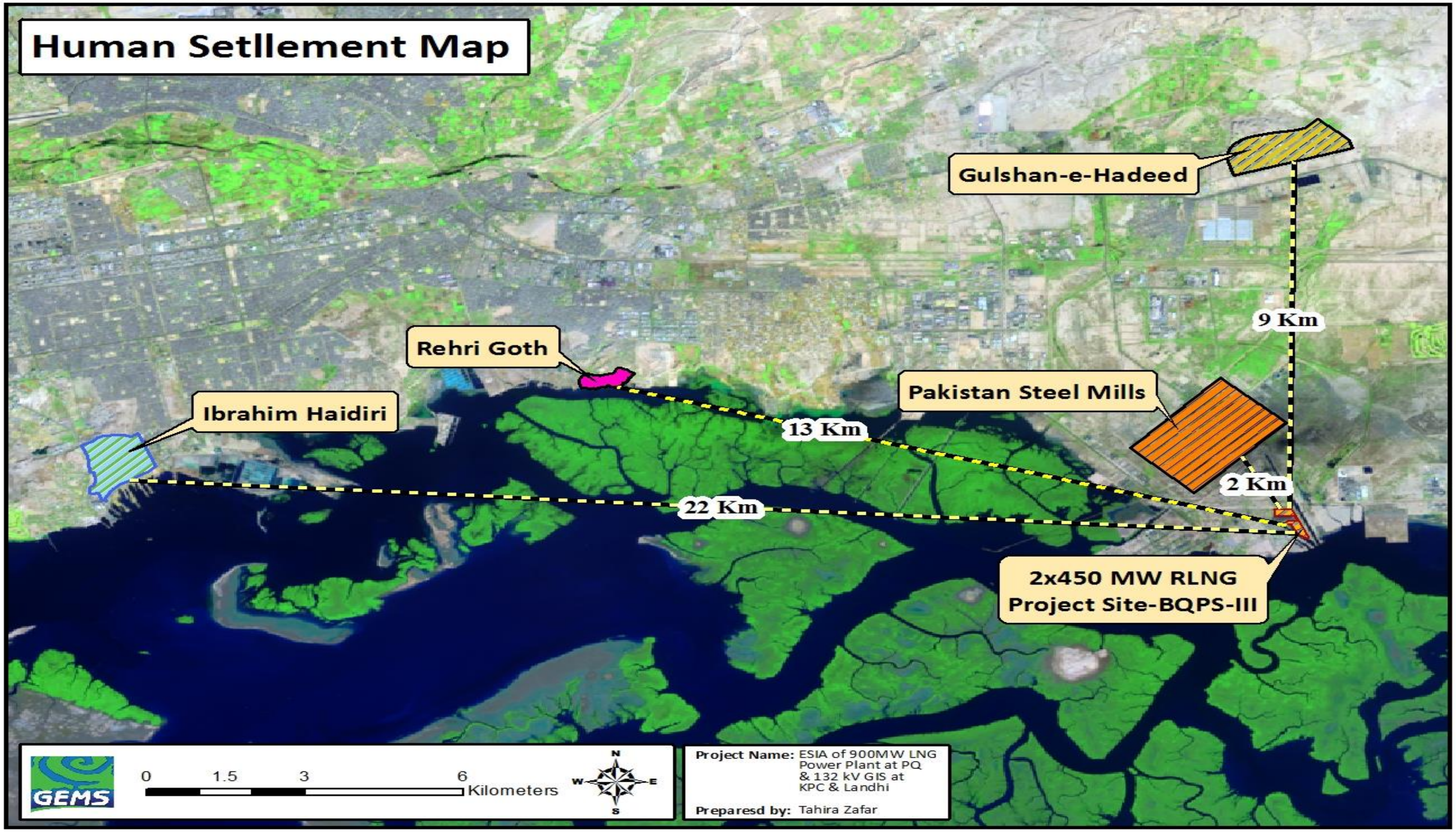


Exhibit 6.5: Human Settlement in Project Vicinity



6.5 NETWORKING AND BUSINESS ACTIVITIES

PRINCIPLE EXPORTS AND IMPORTS AT PQA

Wheat	Imports & Exports
Chemicals	Imports Only
Coal	Imports Only
Containers	Imports and Exports
Crude oil	Imports Only
Furnace oil	Imports Only
Edible oil	Imports Only
Iron ore	Imports Only
Rice	Export Only
General Cargo	Imports & Exports
Cement	Export
Sugar	Import

Key portion of the project surrounding comprises of developed infrastructure on land. Pakistan Steel Mills is one of the significant landmarks of the area, which exist at a distance of about 8 Km from the proposed project site. Apart from that PQA has launched multi-faceted strategy i.e. increase port parameters to accommodate larger vessels to benefit from economy of scales, strengthen the port with requisite crafts and build additional berths/terminal for capacity enhancement. Some of the development projects include: Deepening of navigation channel, acquisition of tugs, Establishment of 2nd Container Terminal, Grain & Fertilizer Terminal, LPG Terminal, Coal & Clinker/cement Terminal, World Trade Centre and Development of Waterfronts etc. To facilitate industrial and commercial establishment at its industrial estate, PQA is also undertaking development of roads, provision of water facilities, sewerage, and storm water drainage in Eastern Industrial zone at a cost of Rs. 8.8 billion[3]. Moreover, it has been observed that Government of Pakistan is also pursuing to enhance gas production in order to meet the increasing need of energy in the country. Power sector has been given priority in terms of allocation of gas for power generation. Such kind of developments will not only promote networking and business activities in the project surrounding but will bring about a positive change in country's economy and the Cleaner Production techniques will be adopted by industry to minimize the air pollution[4] as the oil based power plant releases the noxious gases in environment as well as it is not the cost effective technology for the production of electricity. With concrete and sincere efforts of the government, almost 12 percent growth has been observed in real value addition of electricity generation & distribution and Gas distribution during FY 2015 and FY 2016 which in turn helped the real GDP growth of 4.7 percent during FY 2016.

6.6 LIVELIHOOD

The proposed project area sustains variety of livelihood opportunities for the residents of the vicinity as well as other parts of the city. The livelihood opportunities in the project area can be broadly classified as; the fishing and non-fishing communities.

[3] *http://pqa.gov.pk/port_qasim_at_a_glance.php*
[4] *http://www.irispunjab.gov.pk/Economic%20Surveys-New/Economic%20Survey%202015-16.pdf*

6.6.1 The Fishing Communities of the Project Area

ESTIMATED POPULATION OF FISHING COMMUNITIES

Village Name	Population
Rehri Goth	4450
Lat Basti	3000
Ibrahim Hyderi	150,000

Source: EIA, Global Energy Holding, 2012

Fishing communities are those who are engaged in fishing as a major source of their livelihood, these communities are located on the northwestern side of the port Qasim at distance of about 10 km away from the proposed project site. These communities are a group of diverse community who resides on the seashore of Rehri Goth, Korangi creek and Ibrahim Haidiri, most of them belong to the Baloch khaskhali tribe, and they totally rely on the mangroves forest for hunting of fish, crabs and shrimps. Ibrahim Haidiri and Rehri Goth are the two biggest fishing communities of the proposed project site almost 90% of the fishing communities are directly or indirectly attached with fishing business in the form of net forming, boats and ships building, fisheries, selling fishes in the local as well as in international markets. The fishing communities are also engaged with ecotourism as many local tourists visit the creeks for recreational activities as well as for fishing, these sites are playing an important role for the nature explorer to explore the beauty of mangroves and other aquatic flora and fauna. The mangroves and migratory birds of the creeks provide fun to the visitors and nature lovers. **Exhibit 6.6** is pictorial presentation of fishing community at residence and on field while fishing.

Exhibit 6.6: Pictorial Presentation of Fishing Community at Rehri Goath and on Field While Fishing

Local Fisherman from Rehri Goth on Field for Fishing

Fishing Community of Rehri Goth at OtaakaAK (Local Residence)

6.6.2 The Non Fishing Communities of the Project Area

The communities located near the proposed project area were categorized as 'Non-Fishing Communities and belong to lower income class as their livelihood mainly depends on daily wages and labor in the industries located in PQA industrial and commercial zones, towns of Gharo, Dhabeji, and

Karachi city. On the other side, most of the people living in Steel Town belong to higher and middle income class. These people are engaged with Pakistan Steel Mills while some of the people living near the proposed project area are working on the port, the rest of the population is working in different industrial units of North-western, south-western and eastern part of Port Qasim. Livelihood of the people living in these areas is different from the residents of central city. The residents of Gulshan-e-Hadeed and other developed towns of the proposed project area are usually engaged in private and government jobs within and outside the city. The Higher Income class of the proposed project area is mostly engaged with businesses and working in private and public sectors.

6.7 LEADERSHIP DYNAMICS

The proposed project surrounding sustains a variety of industrial units and all the administrative matters are undertaken by PQA within the project surrounding. As mentioned earlier the proposed project surrounding sustains a number of industrial units, therefore a fully functional association referred to as Bin Qasim Association of trade and Industry (BQATI) looks after general industrial matters and affairs. This association came into existence under section 42 of companies ordinance 1984 dated February 3, 2006 with clear objectives to promote industrial activities in the area in sustainable way and to contribute positively to the economic well-being, industrial production and to advance, develop, protect, safeguard, and to promote the rights, interest and privileges of the industrialist, traders and service providers having their office and / or industries / facilities in the Bin Qasim Town, Karachi. The proposed project surrounding is less populated, hence no political or religious leadership was observed.

6.8 EDUCATION

There are only few renowned educational facilities available within the project surrounding; these educational facilities are not enough to facilitate the communities of these areas. Most of the students within the project area seek higher education from central part of city.

Few renowned educational institutions in Bin Qasim Town are listed below:

- Textile Institute of Pakistan (Main Campus)
- Fast Institute (National University)
- Islamic Public School
- Askari Public School
- The Educators (Gulshan-e-Hadeed Campus)
- TCF School (Near Rehri Goth)

The educational facilities of the proposed project vicinity are shown in **Exhibit 6.7.**

Exhibit 6.7: Educational Facilities of the Proposed Project Area

	
TCF School Near Rehri Goth	Textile Institute of Pakistan (Main Campus)

Note* *None of the educational facility is in close proximity of the proposed project site*

6.9 HEALTH

Only few hospitals and health care facilities are available within the proposed project area. In addition only one hospital is well equipped within the Bin Qasim Town namely Pakistan Steel Hospital. This hospital has a capacity of about 100 beds. This hospital can only accommodate approximately one Hundred serious patients at a time which is comparatively low as compared to the existing population of Bin Qasim Town. The hospital is located on National Highway near Steel Town, which was established to facilitate the local community. The residents of nearby Goths of the proposed project sites have only one public health facility namely Benazir Bhutto Shaheed Dispensary, which is a public facility. Other health facilities in the surrounding towns include Al-Hadeed Medical Centre, Child and Mother Clinic and Family Health Care Hospitals. Major contagious diseases in the area were observed to be GIT "Gastro Intestinal Tract Infections" and respiratory tract diseases due to the unavailability of clean drinking water and emissions of industries at Port Qasim and Pakistan Steel Mill.

Respiratory tract related infectious diseases are the major contagious disease reported in the proposed project area, this type of diseases are directly linked with the emissions from the industrial units. The people of Rehri Goth reported that they are having the epidemics of water borne, water washed and water related diseases, and these diseases are linked with the inadequate supply of fresh water in the area. **Exhibit 6.8** shows the health care facilities of the proposed project area.

Exhibit 6.8: Health Care Facilities of the Proposed Project Area

100-Bed Pakistan Steel Hospital

A Child Health Care Centre in Memon Goth.

6.10 CULTURE, ETHNICITY AND RELIGION

Various cultural and ethnical groups such as Baloch, Pakhthuns, Sindhi and Punjabies are living in the project surroundings, some of the them are permanent residents of Gulshan-e-Hadeed and steel town while a major portion of the population are residing in the project vicinity due to employment opportunities. The people of the project area have adopted a mix lifestyle. Both the urban and rural establishments of the area have miscellaneous ethnic communities and multiple languages are spoken such as Sindhi, Punjabi, Pashtu and Balochi. The residents of Rehri Goth which near the proposed project site are mostly Balochi belonging to Khaskhali tribe and they speak Balochi Language.

The developing areas and Goths of Bin Qasim Town are facilitated with basic amenities especially the residents of bin Qasim and Gulshan-e-Hadeed. People of the project area have however established small communities according to their livelihood. The people of Steel Town and Gulshan-e-Hadeed represent urban life style and their way of life reflects the developed environment while on the other side, the inhabitants of Lutt Basti and Rehri Goth are urban villages and their daily routine practices resemble the Sindhi rural environment. There is a Jama masjid located by a distance of 7 km at Pakistan Steel namely Jamiya Masjid Bait ul Mukram and a famous shrine of Hazrat Hassan Shah Bukhari at Russian point Additionally it is important to note that variety of mosques and madaris are available in each society and Goths.

6.11 RECREATIONAL AREAS

Bin Qasim Town has a few recreational areas. Quaid e Azam Park is the only noted public recreational park of the town and this park was built in recent years adjacent to Steel Town. A large number of local people and residents from different part of Karachi visits this park and it has been noticed that on weekends the number of visitors increases. Another famous recreational point is the Arabian Sea Country Club situated in the centre of Bin Qasim Industrial Zone. This recreational place is basically a golf club and a resort situated away from the residential areas. There are many playgrounds, small parks and gardens available within towns of the area especially Gulshan-e-Hadeed and Steel Town.

Exhibit 6.9: Socioeconomic Features of the Bin Qasim Town

Well Being Indicator	***Name of Town / Area***
	Bin Qasim Town
GPS Coordinates	**25º50’05.29’’N** **67º21’22.67’’E**
Major Communities	Urdu-speaking, Punjabi, Sindhi, Pakhtoon, Balochi
No. of Houses	105000 approx.
Livelihood	Labor, business, shops, transporters, Public and private jobs
Electricity	Available
Fueling Source	Available
Major Educational Institutions	National University (Fast Institute) Textile Institute of Pakistan (Main Campus)
Literacy Rate	Low

Drinking Water	Tankers system, groundwater, KWSB
Major Health Problems	Malaria, Skin Diseases, Respiratory Tract Diseases
Health Facilities	Not Satisfactory
Major Hospitals	Pakistan Steel Hospital (100 beds)
Major Needs	Govt. hospitals. Modern Schools, Security, Drinking Water, Continuous Electricity
Major Markets	Small Markets and Shops
Transport	Public Transport, Motorcycle, cars, buses

CHAPTER

7 STAKEHOLDER CONSULTATION

7.1 GENERAL OVERVIEW AND SCOPE

> KEY FEATURES OF STAKEHOLDER CONSULTATION
>
> Key outcomes were derived from following sources:
>
> ✓ Key informant interviews (KII)
>
> ✓ Scoping meeting/ stakeholder Consultative Workshop

The main objective of public consultation and scoping meetings is to disseminate information about the project and its expected impact on the primary and secondary stakeholders. The public consultation and participation serves as an effective tool for social interaction. This tool helps to develop the significant confidence between the stakeholders and the proposed project developer to minimize the anticipated environmental and social impacts of the project. Additionally, it is important to note that the word primary stakeholder is usually referred to those, which may be directly affected by the proposed project's activities while on the other hand secondary stakeholders refers to those who are usually affected indirectly or they have power to make decisions at governmental or institutional level. Based on the ESIA assessment procedures, a detailed scoping meeting/stakeholder consultative workshop was carried out on 26th April, 2017. The scoping meetings usually define the scope of environmental impact, which was later supplemented, by KIIs with different stakeholders. The most important objective of these consultation meetings was to determine the extent of the impact of different proposed project activities and suggest appropriate mitigation measures accordingly.

7.2 SCOPING MEETING & STAKEHOLDER CONSULTATION OUTCOMES

As discussed earlier this section of ESIA clearly describes the issues raised by the stakeholders during different consultation meetings conducted specifically for this assignment, informal and focused group discussions with the primary and secondary stakeholders were carried out which was primarily focused on determining the perceptions of the following key stakeholders:

- Governmental departments
- NGOs
- Associations
- Industries

The overall objectives of the process were identified as follows:

- To inform and acquire feedback from primary and secondary stakeholders on proposed project activities
- To gain the consent of all the primary and secondary stakeholders for carrying out proposed project activities;
- To identify potential issues and mitigation measures;
- To incorporate stakeholders concerns in the project documents
- To identify the negative impacts due to the project execution

List of stakeholders consulted during the scoping meeting and KIIs is presented as **Exhibit 7.1**.

Exhibit 7.1: List of Participants of Stakeholder Consultation Workshop

List of Participants of Scoping Meeting Conducted on 26th April, 2017

S. No	Name	Designation	Organization
1.	Dr. Sami uz Zaman	Chairman	Global Environmental Management Services (GEMS) Pvt. Ltd.
2.	Dr Shahid Amjad	Marine Biodiversity Expert	Institute of Business Management (IOBM)
3.	Mr. Rafi Ul Haq	Consultant Ecologist	Coastal Restoration Alliance for Biodiversity (CRAB)
4.	Mr. Imran Sabir	Deputy Director Technical	Sindh Environmental Protection Agency (SEPA)
5.	Mr. Saleem uz Zaman	Chief Executive	Global Environmental Management Services (GEMS) Pvt. Ltd.
6.	Mr. Chandar Parkash	General Manager – HSE G&T	K-Electric (KE)
7.	Mr. Fattah Moin Jah	Manager Strategic Planning & Business Development Department	K-Electric (KE)
8.	Mr. Jibran Khalid Kidwai	Sr. Environmental Specialist & Project Coordinator	Global Environmental Management Services (GEMS) Pvt. Ltd.

S. No	Name	Designation	Organization
9.	Muhammad Zeeshan Siddiqui	Deputy General Manager Strategic Planning & Business Development Department	K-Electric (KE)
10.	Mr. Mansoor Akram	Deputy Director	K-Electric (KE)
11.	Mr. Muhammad Tahir Qureshi	Senior Advisor	International Union for Conservation of Nature (IUCN) Pakistan
12.	Engr Kashif Noor	Sr. Environmental Engineer	Global Environmental Management Services (GEMS) Pvt. Ltd.
13.	Ms. Sharmeen Shafique	Information Officer	National Forum for Environment & Health (NFEH)
14.	Mr. Shoaib Abdul Razzak	Conservation officer	World Wildlife Fund (WWF) PAK
15.	Ms. Ayesha Sufyan	Conservation officer	World Wildlife Fund (WWF) PAK
16.	Dr. Nuzhat Khan	Principle Scientific Officer	National Institute of Oceanography (NIO)
17.	Mr. Anwar Ali Memon	Legal Officer	Shehri, Citizen for Better Environment (CBE)
18.	Mr. Ali Rasheed	Executive Member	Shehri, Citizen for Better Environment (CBE)
19.	Dr. M Mansha	Director Earth Sciences	SUPARCO
20.	Mr. Tayyab Shafique	Environmental & Social Expert	Global Environmental Management Services (GEMS) Pvt. Ltd.
21.	Ms. Kanwal Khatri	ESIA Technical Writer	Global Environmental Management Services (GEMS) Pvt. Ltd.
22.	Ms. Maria Kausar	ESIA Technical Writer	Global Environmental Management Services (GEMS) Pvt. Ltd.

S. No	Name	Designation	Organization
23.	Ms. Tahira Zafar	GIS Specialists	Global Environmental Management Services (GEMS) Pvt. Ltd.
24.	Engr. Musawir Munsif	Environmental Engineer	Global Environmental Management Services (GEMS) Pvt. Ltd.
List of Participants of KIIs during March, April 2017			
1.	Dr. Zafar Iqbal Shams	Professor	Institute of Environmental Studies, University of Karachi (IES, UoK)
2.	Dr. Hashim Zuberi	Head of Department, Professor	Department of Environmental Science, Sindh Madresat ul Islam University (SMIU)
3.	Mr. Shabbir Anwar Kazi	Director General Technical	Port Qasim Authority (PQA)
4.	Mr. Chen Shujian	Chief Commercial and Technical Depart	Port Qasim Electric Power Supply Company PQEPC

7.3 STAKEHOLDER CONSULTATION OUTCOMES

As discussed above stakeholder consultations were carried out with both primary and secondary stakeholders through scoping meeting and key informant interviews (KII), these are questionnaires and an effective tool for the process. The outcomes and findings of the consultation workshop have been presented below under separate headings, accordingly

(Refer to **Exhibit 7.2** for pictorial presentation of scoping meetings and **Exhibit 7.3** for KIIs)

7.3.1 Outcomes, Concerns and Recommendations of Scoping Meeting Participants

Outcome of concerns and recommendations given by various stakeholders during the meeting are summarized as follows:

- The participants of the scoping meeting revealed optimistic views regarding the proposed project as 2 x 450 MW RLNG based power generation units will exhibit less environmental pressure in terms of air pollution and thermal plume dispersion as compared to the existing power generation units of BQPS-I operating on Heavy Furnace Oil (HFO).
- Majority of the participants suggested that the air dispersion and thermal plume modeling for the proposed project should be considered and made part of this ESIA study, not only this but it was

also suggested by the participants that the impacts on aquatic ecology should also be studied and incase adverse impacts are envisaged a proper mitigation plan should be devised and implemented throughout the life cycle of the propose project.

- The participants also identified that Pakistan as a country is moving towards industrialization therefore at this stage environmental compliance should be treated as priority to reduce the chances of environmental deterioration in future.
- A unique suggestion was also proposed by the participants that, K-Electric may work with NEPRA or other regulatory bodies to gain approvals for producing water from power generation units which can significantly contribute in reducing the water crises of the country.
- Participants appreciated KE's effort for producing electricity while reducing the environmental pressure. However, they stressed upon K-Electric to ensure regular monitoring and compliance with the SEPA regulations.

Exhibit 7.2: Pictorial Presentation of Scoping Meeting

	
Chief Executive (GEMS) Pvt. Ltd. while opening the scoping meeting	Manager Strategic Planning & Business Development Department K-Electric while briefing proposed project features.
	
A view of Scoping Meeting Participants.	Representative from Shehri CBE While Raising Concern Regarding The Proposed Project

	
Senior Advisor IUCN Pakistan while raising concerns about thermal pollution effects on aquatic life & plume modeling	Principle Scientific Officer NIO while raising concerns & suggesting K-Electric to produce water from power generation
	
General Manager – HSE G&T K-Electric while Observing Participants Concerns	Conservation Officer WWF raising concerns regarding the proposed project
	
Director Earth Sciences SUPARCO While Briefing The Participants Regarding The Thermal Plume & Air Dispersion Modeling	Deputy Director Technical SEPA Emphasizing The Environmental Monitoring & Compliance

Scoping Meeting Particpants

7.3.2 Outcomes, Concerns and Recommendations of Stakeholder during KIIs

Outcomes of suggestions, concerns and recommendations made by different stakeholders during KIIs are summarized as follows:

(Refer **Exhibit 7.3** for pictorial presentation of KIIs)

7.3.2.1 Director General Technical PQA

- The proposed project, seems to be relatively clean and it is expected that the proposed project will reduce the environmental burden within PQA vicinity by replacing old HFO based power generation units by adding 2 X 450 MW RLNG based power generation units.
- Since the proposed project is being developed within the already built up area of BQPS-I therefore the project developer does not need to acquire any approvals from PQA.
- The project developer must ensure compliance of all the relevant provincial, national and international applicable standards during the entire life cycle of the propose project.

7.3.2.2 Chief of Commercial and Technical PQEPC

- PQEPC employees are already facing health complications in terms of upper respiratory disorders, as the HFO based power generation unit’s pollution is dispersed within the existing boundaries of PQEPC. Therefore it is suggested that the project developer should replace all the power generation units by RLNG or natural gas power generation units, which will reduce the chances of health degradation of human resource within the close proximity of BQPS-I.

- LNG is relatively a clean fuel and since the project developer is replacing old HFO based power generation units by 2 X 450 MW RLNG based power generation units within the close vicinity of PQEPC, therefore it is expected that the level of air pollution may reduce significantly within the proposed project area surrounding.

- Moreover it also suggested that a detailed air dispersion and thermal plume modeling should be made part of this ESIA assignment and air pollution concentrations along with thermal plume dispersion should be properly documented, reported and project developer to ensure strict compliance with all the recommended mitigation measures suggested by the environmental consultants for the proposed development.

- Project developer must ensure environmental compliance during the entire life cycle of the propose project, and maintain good liaison with its neighboring industries.

7.3.2.3 Assistant Professor, IES, UOK.

- The proposed project seems to be an environmental friendly initiative from the project developer since the power generation units based on natural gas and RLNG does not contribute in SO_X and Particulate matter emissions during its operations, however still the project developer must ensure pollution abatement technologies installation for the proposed power generation units to reduce the probability of pollution.

- Usually one of the serious concern regarding the environmental pollution associated with power plant projects is air pollution and thermal plume dispersion within its close proximity, however RLNG based power generation units usually results in less air pollution mainly due to use of cleaner fuel and thermal plume dispersion due to reduced cooling water requirements.

- A detailed air dispersion and thermal plume modeling reports must be generated for the proposed project, and project developer must ensure strict compliance of SEQS during the entire life cycle of the proposed project, not only this but all the recommended mitigations measures suggested in ESIA study should be given due consideration and to be implemented in true spirit.

- Since Karachi is the industrial hub of country and number of industrial units along with human population is increasing on day to day basis therefore its electricity demand is also increasing which at present is not up to the mark, therefore the project developer should ensure continuous and smooth supply of electricity while reducing the electricity demand and supply gap.

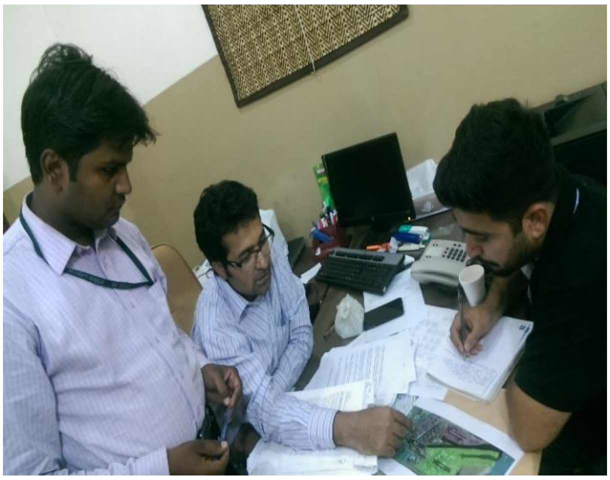
7.3.2.4 Head of Department, Department of Environmental Sciences SMIU, Karachi.

- The current situation demonstrates that the current electricity demand of the city is not being catered properly, therefore the project developer must ensure continuous and smooth electricity throughout the city while reducing the demand and supply gap.

- Since the world is already moving towards sustainable development, therefore considering RLNG and Natural Gas as a fuel for the proposed power generation units is a sustainable step from the project developer.

- However it is strongly recommended that the project developer should execute the plantation plan within the project surrounding which will significantly reduce the level of air pollution, as mature trees serves as carbon sinks.

Exhibit 7.3: Pictorial Presentation of KIIs

	
KII at SMI University	KII at IES, UoK
	
KII at SEPCO	KII at PQA

CHAPTER 8

ANALYSIS OF ALTERNATIVES

8.1 GENERAL OUTLINE AND SCOPE

As discussed previously in this report, the proposed project mainly deals with construction and operations of 02 X 450 MW RLNG Based Combined Cycle Power Generation Units (CCPGU), which will includes few modifications and installations of Gas Insulated Switchgears (GIS) at different locations.

Analysis of alternatives is an integral part of the ESIA process to select the best option among all the possible project options such as:

- Analysis of Project Refusal
- Analysis of Site Alternatives
- Analysis of Alternate technology/design

KEY FEATURES OF PROJECT ALTERNATIVES

Analysis of alternatives is mainly based on following key aspects:

- ✓ Project Refusal
- ✓ Site Alternatives
- ✓ Technology Alternatives

The assessments and recommendations made by the ESIA team are presented below:

8.2 ANALYSIS OF PROJECT REFUSAL

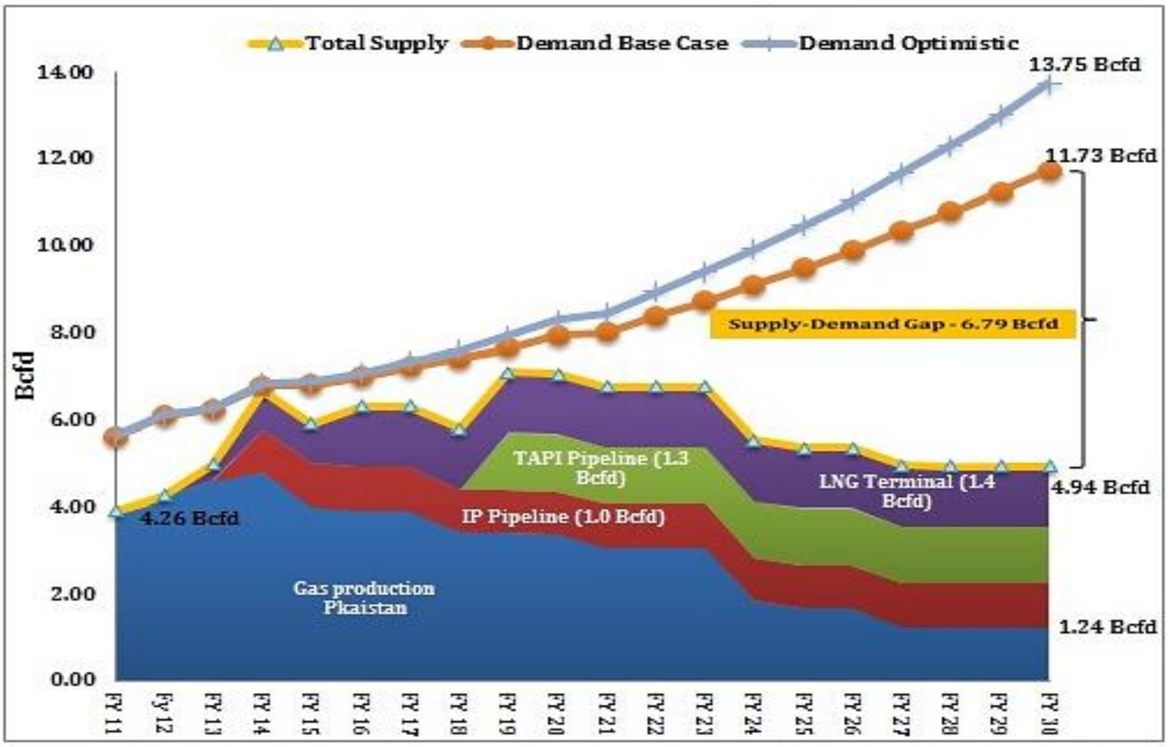
8.2.1 Overview

The "Project Refusal" means not proceeding with the proposed LNG based CCPGU and bringing no change to the baseline scenario and alternate technology option that is using HFO instead of Liquefied Natural Gas.

8.2.2 Key Observations

Pakistan is in the midst of a severe energy crisis that largely stemmed from mismanagement of natural resources in the country. Weak regulatory and pricing mechanisms in the natural gas sector have led to huge disparities between demand and supply. Pakistan has a large demand for natural gas and a well-established gas market and distribution system. At present, demand of natural gas is estimated at around 8 Billion Cubic Feet (BCF) against a total supply of 4 BCF, creating a shortfall of 4 BCF[1] As per Pakistan Gas Supply-Demand Study conducted in 2012 by ILF BeratendeIngenieure GmbH, over the next 17 years gas demand is projected to stand at 11.73 BCFD, while domestic supplies are expected to reach the level of 4.94 BCFD resulting in a huge shortfall of about 6.79 BCFD by FY 2030. The analysis was done considering the existing and planned capacity. Below given Exhibit shows the yearly natural gas supply-demand project. A base case scenario is considered based on existing scenario i.e. business as usual.

Exhibit 8.1: Natural Gas Demand Projections



Source: *ILF Report on Gas/ Supply Demand Analysis and Base Gas Demand 2012*

In order to meet the future energy challenges, to sustain and support economic growth, to mitigate the impact of widening shortfall, the Government has encouraged private investment LNG sector to establish an LNG Import projects under the LNG Policy 2002, 2006 & 2011.

Pakistan is going through an acute power shortage and the proposed project has the potential to increase electrical power production capacity, which is an urgent need of today's energy deficient economy. Based on the above stated facts and figures KE being one of the prudent organization has also decided to place their reliance on imported LNG and initially replace their existing 2 x 210 MW NG and HFO based power generation units of BQPS-I by adding 2 X 450 MW RLNG based power generation units within the existing premises of BQPS-I.

The proposed project aims to improve Pakistan's energy balance and decrease the gap between its growing energy requirements and available energy supplies in the country by utilizing environmental

[1] Total Gas Demand on System, 2013. Internal Documents of Ministry of Petroleum and Natural Resources. Islamabad, Pakistan

friendly RLNG fuel instead of more expensive, diesel and furnace oil, and the more environmentally detrimental coal, to generate electricity.

8.2.3 Rationale for Project Approval

Based on the environmental expert's judgment and analysis which is supplemented by aforementioned facts and figures it can be interpreted that project refusal would mean loss 2 X 450 MW RLNG Electric Power Generating Units, thus ultimately resulting in bottleneck for smooth, continuous and uninterrupted electric supply to the city, while minimizing the industrial outputs and ultimately resulting in socioeconomic loss.

8.3 ANALYSIS OF SITE ALTERNATIVES

8.3.1 Overview

The basic purpose of "Analysis of Site Alternatives" is selecting the best possible site in terms of less environmental degradation while minimizing the environmental, social and monetary cost.

8.3.2 Key Observations

As discussed previously in this ESIA document, the proposed 2 X 450 MW RLNG based power generation units will be installed within the already built up area of BQPS-I, as far as other project components are concerned such as grid installation and its modifications it will also be done within the already built up boundaries of KPC (Korangi Power Complex), Landhi Grid Station and Qayyumabad Grid Station.

The following criteria for installation of 2 X 450 MW RLNG based power generation units have been considered for the selection of the site for the proposed project:

- Availability of LNG import terminals.
- Ease of access to SSGC LNG tie in point.
- Availability of seawater for cooling;
- Availability of land;
- Low site preparation costs;
- Availability of access roads;

8.3.3 Rationale for Site Selection

Based on the key observations as discussed above, the best possible site for installation of 2 X 450 MW RLNG based CCPGU at Port Qasim and Grid Modifications and Installations at KPC (Korangi Power Complex), Landhi and Qayyumabad will result in following key benefits:

- The sites selected for installation of proposed 2 x 450 MW RLNG based CCPGU and Grid Stations, is expected to exhibit insignificant impact and disturbance onto the existing land use patterns at Port Qasim, Korangi and Landhi since all the project components are proposed within the already built up area.

- The proposed power plant will be located at Port Qasim, nearby upcoming LNG Import Terminals and SSGC LNG tie in point, which will make RLNG transmission more viable and economical, and less environmental damaging.

- Sea water channels are present and the capacity is sufficient to fulfill the needs of the new proposed power generation units, therefore this site will not prove to be a new introduction to the sea system.

8.4 ANALYSIS OF ALTERNATE TECHNOLOGY/DESIGN

8.4.1 Overview

The basic purpose of “Analysis of Alternate technology/design” is selecting the best possible technology, design or arrangements to minimize the environmental degradation by promoting sustainable development.

8.4.2 Combined Cycle Technology

8.4.2.1 Key Observations

Power Generation Plants are designed according to available fuels and feasibility of operation in existing environmental setups of the area. Coal, Petroleum, Gas and renewable energy sources are utilized for power generation around the world. In the proposed project, considerations were taken for available fuels (i.e. Liquefied Natural Gas and Natural Gas) and the durability of the proposed power plant.

The power plant is designed to generate electricity by utilizing the maximum available resources. Gas Turbines are selected to ensure continuous power generation from Liquefied Natural gas as well in case of shortage of Liquefied Natural Gas, Natural gas fuel is to be used. HRSGs are selected to recover heat and utilize the heat as energy source in Steam Turbine, this shall enhance power generation capacity as well as prove as effective resource utilization.

Not only this but project modifications and installations at Korangi, Landhi and Qayyumabad includes replacement of old AIS (Air Insulated Switchgear) by GIS (Gas Insulated Substation) which is relatively an advanced technology.

8.4.2.2 Rationale for technology/design selection

At present among fossil fuels, the options currently available for power generation includes:

Heavy Furnace Oil (HFO)

Diesel

Coal and Natural Gas

All the available options exerts pressure onto the existing environment in terms of pollution not only this but power plants operating on aforementioned fuels also require a significant amount of financial resources to install sophisticated pollution abatement technologies to reduce the pollution levels.

However power RLNG, used in power generation emits about 50 per cent fewer greenhouse gases than coal and far fewer smog-causing air pollutants.[2]

Moreover the proposed GIS technology is used as a compatible grid station option and it needs less space and is cost-effective in terms of maintenance. The area available will suffice for the installation of GIS.

[2] http://blog.transcanada.com/bcs-lng-projects-will-reduce-global-ghg-emissions-and-air-pollution-experts-say/

CHAPTER 9

ENVIRONMENTAL IMPACTS AND MITIGATIONS

9.1 GENERAL OUTLINE AND SCOPE

As discussed previously in chapter 2; project description of this ESIA document, the key project component is installation of 2 X 450 RLNG based power generation units within the existing boundaries of BQPS-I at PQA and including modifications at Korangi, Landhi as well as Qayyumabad as sub components of the proposed project, therefore the key focus during the impact assessment remained on the aforementioned component. Moreover after a thorough review and assessment of the existing environmental and socio-economic conditions and review of technical data, a team of environmental professionals analyzed the significant environmental impacts and suggested the necessary measures for mitigating the impacts. This chapter presents the environmental impact assessment of the proposed project as a whole including all the components.

This section discusses the potential environmental and social impacts of the proposed activities associated with construction and operational phase of the proposed project additionally this section of the report predicts the magnitude of the impact, assess its significance, recommends mitigation measures to minimize adverse impacts, and identifies the residual impacts of the proposed project.

The discussion starts with a description of the methodology used for the impact assessment. The impacts on the environment from various activities of the proposed project can be categorized as follows:

Impact on Physical Resources

- Topography and Land use pattern

Impact on Environmental Resources

- Air Quality
- Noise Levels
- Surface and Ground Water Quality
- Soil Quality

Impact on Ecological Resources

- Terrestrial Ecology
- Aquatic Ecology

Impact on Human Environment

- Health and Safety

Socio-economics

- Road Safety & Traffic
- Livelihood & Economy

Waste Disposal

- Liquid and Solid waste disposal

9.2 IMPACT ASSESSMENT METHODOLOGY

Potential impacts from the proposed project activities were identified by thorough review of the project activities, study of surrounding environment, review of literature, review of previous similar studies and expert's judgment.

The identification and assessment of environmental impacts is based on the local and international guidelines as discussed previously in chapter 3; legislative requirements of this ESIA document which was supplemented by review of project activities, expert's judgement study of surrounding environment, review of literature and review of previous similar studies. The assessment procedure includes following steps:

a. Prediction of the potential environmental and social impacts

This step refers to the description, quantitatively (where possible) or qualitatively impacts of the proposed project. This may be achieved through comparison with other similar activities.

b. Definition of the Criteria for Determining Significance

The consequence of the proposed activity is evaluated by comparing it against a recognized Significance Criteria. The criteria are of the following types:

- Institutional recognition laws, standards, government policies, or plans;
- Technical recognition guidelines, scientific or technical knowledge, or judgment of recognized resource persons;
- Public recognition social or cultural values or opinion of a segment of the public, especially the community directly affected by the proposed project;
- Professional interpretation of the evaluator.

c. Identification of the mitigation measures

If it is determined that the predicted impact is significant then the suitable mitigation measures are identified. There is a range of mitigation measures that can be applied to reduce impacts. Broadly, these measures can be classified into four categories:

- Avoiding the impact altogether by not taking certain proposed activity or parts of an activity, for example, using CFC-free equipment to avoid impact on ozone layer;
- Minimizing impacts by limiting the degree or magnitude of the activity, for example, minimizing dust emission by reducing vehicle speed;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Compensating for the impact by replacing or providing substitute resources or environments.

The project developer plays a key role in implementing the mitigation plan and assessing the feasibility of proposed measures.

d. Evaluation of the residual impacts

Incorporation of the suggested mitigation measures reduces the adverse impact of the proposed project and brings it within the acceptable limit. This step refers to the identification of the anticipated remaining impacts after mitigation measures have been applied.

e. Identification of the monitoring requirements

The last step in the assessment process is the identification of the minimum monitoring requirements. The scope and frequency of the monitoring depends on the residual impacts, and its details are later addressed in Chapter 10; Environmental Management and Monitoring Plan (EMMP) of this ESIA document. The purpose of monitoring is to confirm that the impact is within the predicted limits and to provide timely information if unacceptable impact is taking place.

9.3 IMPACT ASSESSMENT (CONSTRUCTION PHASE)

9.3.1 Impact on Physical Resources

9.3.1.1 Topography and Land use

The activities associated with construction phase, may result in changes in topography however no major impacts onto the existing land use pattern is envisaged at all project locations.

a. Potential Impact

The activities expected to exhibit impacts onto the surface topography at all project locations may include excavation activities, site leveling and grading etc. Further, the grading and leveling of the site are likely to result in modified surface topographical regime at proposed BQPS-III project site at Port Qasim, while small scale excavation and site leveling activities are envisaged at other project modification sites including Korangi, Landhi and Qayyumabad, these sites may also be impacted by loss of top soil and soil erosion though the impact on the topography at project modification sites is expected to be insignificant.

b. Criteria for Determining the Significance

An adverse impact will be interpreted if surface topography is modified and the proposed project site at PQA is flooded during rainy season, meanwhile an adverse impact onto the surface topography of project modification sites will be interpreted if the fact is established that the topographic elevation of project sites is modified and prominent heaps are observed.

c. Mitigations

- Proper site leveling should be ensured, in order to minimize the probability of topographic changes at and project site flooding during rainy season at all project locations.
- Ensure that construction material such as cement and or ready mix is handled properly and no residual material is left unattended so as to avoid the probability of formation of heaps and uneven structures

d. Residual Impacts

- If the suggested mitigation measures are implemented, disturbance to the surface topography will be minimized.

e. Monitoring Requirements

- Surface topography, to be monitored during construction by an Independent Environmental Monitoring Consultant.

9.3.2 Impact on Environmental Resources

9.3.2.1 Ambient Air Quality

a. Potential Impact

It is anticipated that all project components i.e. 2 x 450 MW RLNG based CCPGU installation and grid installations or modifications may require small scale excavation, site leveling and demolition of old structures which may result in elevated levels of Dust and Particulate Matter dispersion at proposed project locations. Not only this but un-tuned construction equipment, vehicles and machineries may result in elevated levels of SOx, NOx, PM_{10} and CO, thereby affecting the air quality of the proposed project surrounding which will be transitory in nature. Not only this but release of welding fumes and VOC from welding / metal fabrication works, surface cleaning and painting; is also anticipated, the fumes generated during welding and metal cutting activities and hazardous air pollutants released during spray-painting can cause health hazard to workers.

b. Criteria for Determining the Significance

An adverse impact will be interpreted if the ambient air quality at all the proposed project locations exceeds the prescribed SEQS limits.

(Refer chapter 2 to observe project locations)

c. Mitigations

- Use of standard construction equipment and vehicles;
- Scheduled maintenance of equipment and vehicles including engine tuning, filter cleaning, etc.;
- Water spraying will be done to reduce dust emissions;
- Enclosed painting booths and dedicated fabrication areas in favor of wind direction so the fumes may divert away from the site;
- The vehicle speeds on graded roads will be limited in order to minimize dust emissions.

d. Residual Impacts

- Dust and Particulate matter dispersion will occur but will be transitory in nature. Fumes from painting and fabrication works will be controlled to minimized levels.

e. Monitoring Requirements

- Ambient air quality monitoring including critical pollutants such as SOx, NOx, PM10 and CO to be conducted by engaging Independent Environmental Monitoring Consultant. The monitoring reports to be submitted quarterly to SEPA, providing compliance status with applicable regulations.

9.3.2.2 Noise

a. Potential Impact

It is anticipated that the heavy equipment used for the construction work, fabrication activities, earthwork such as grading and excavation, and the vehicles used for transportation of men and materials to site may result in elevated levels of noise which may serve as nuisance to the workers working in close proximity of the construction sites, however it is important to note that the major construction activity is expected to be carried out during the daytime and all the proposed project sites at Port Qasim, Korangi and Landhi are far away from densely populated areas, only few residential plots were observed during the surveys although these plots are far away from the proposed project sites.

b. Criteria for Determining the Significance

An adverse impact will be interpreted if, the noise levels at within the close proximity of the proposed project construction sites exceeds the SEQS limits.

c. Mitigation Measures

- Noise levels as per SEQS will be maintained at the fence lines of the construction sites;
- Project construction zone to be barricaded and proper signs boards to be displayed at all construction sites.
- Unauthorized personnel will not be allowed to access construction zone;
- Onsite workers associated with construction activities will be provided with adequate 'personal protective equipment' (PPE) to reduce their probability of high noise exposure;
- Construction equipment/machineries will be provided with suitable noise dampening systems such as mufflers, silencers, etc. as feasible, to minimize noise at source;
- Also, the construction activities will be scheduled / planned in such a way as to prevent high noise activities during night times and simultaneous operation of multiple high noise equipment will be avoided to the extent feasible.

d. Residual Impact

- Strict implementation of the proposed mitigation measures is not likely to leave any long-term residual impact, however the minimal level of noise is still expected from proposed project activities.

e. Monitoring Requirements

- During construction phase periodic noise level monitoring will be carried out as prescribed in SEQS, by an IEMC. The ambient noise levels and noise emission from equipment and machineries will also be monitored.

9.3.2.3 Surface and Groundwater Quality

a. Potential Impact

Since the proposed 2 X 450 MW RLNG based CCPGU will be installed within the existing premises of BQPS-I (Bin Qasim Power Station) and will replace existing unit 3 and 4, therefore there is no need to develop new discharge channels as the discharge channels for existing unit 3 and 4 will be used for newly proposed power generation units, therefore the impact associated with development of discharge channel is not foreseen for the proposed project. However construction residue and debris if not handled and stored properly may result in seawater contamination, while on the other hand it is important to note that the proposed power plant will be installed near the coastline at Port Qasim and there is no significant groundwater resource within the vicinity of power plant installation therefore no impact on groundwater quality is envisaged.

As far as project modification sites at Korangi, Landhi and Qayyumabad is concerned there is no significant surface water source nearby these modification sites, and it is anticipated that the impact on groundwater quality is insignificant since the proposed project modification sites does not involve heavy duty construction works.

b. Criteria for Determining the Significance

A significant impact on the surface water quality will be interpreted if improper discharge of construction material onsite causes nuisance and may result in disturbed surface water visual aesthetics.

Mitigation measures

– Ensure that the all liquid raw material such as oil, lubricants and chemical at all proposed project sites are stored within the storage yard with impermeable floors and roof top, the storage yard should be protected with secondary containment facility with appropriate labeling, this will significantly reduce the chances of liquid waste or material discharge into the sea during the accidental spill or rain water runoff, not only this but the but such kind of storage will also reduce the chances of ground water contamination by impermeable flooring.

c. Residual Impacts

Residual impacts are foreseen to be negligible / low in this case if recommended mitigation measures are adhered with.

d. Monitoring Requirements

Visual inspection and chemical testing of surface water quality to be done by an Independent Environmental Monitoring Consultants. The parameters to be monitored includes:

- TSS
- pH
- Temperature
- Oil and grease

9.3.2.4 Soil Quality

a. Potential Impact

Since the proposed project will be developed within the existing boundaries of already built up area of BQPS-I and modifications associated with the proposed project will also be made within the built up areas at Korangi, Landhi and Qayyumabad, hence small scale excavation will be required, which may result in soil erosion, not only this but leakage and spillage of construction material and or leakages from construction machineries may also result in soil contamination.

b. Criteria for Determining the Significance

The adverse impact onto the site soil will be interpreted in case if it is contaminated by spillage of construction material.

c. Mitigation Measures

- Careful use of heavy machineries and equipment should be ensured in order to prevent leakages which may result in release of contaminants directly onto the soil.
- Ensure that malfunctioning machineries should be kept away from exposed soil area and should be repaired on immediate basis at designated workshops having impermeable floors.
- A spill prevention response team will be available throughout the construction phase.

d. Residual Impacts

Residual impacts are foreseen to be negligible / low in this case if recommended mitigation measures are adhered with.

e. Monitoring Requirement

Visual inspections will be carried out by an Independent Environmental Monitoring Consultant to ensure that the soil within the project surrounding is not being contaminated during the project activities.

9.3.3 Impact on Ecological Resources

9.3.3.1 Terrestrial Ecology

a. Potential Impact

The impact on terrestrial ecology is envisaged to be insignificant as none of the Species within or around the project sites that are classified as rare, threatened, endangered or of significant conservation value. However small scale impact onto the terrestrial ecology is envisaged largely due to site clearing and leveling activities. Further, disturbance to ecology in the area will also result from increase in noise during construction activities and vehicle movements, which can be easily mitigated by adopting best and safe industrial practices.

Avifauna in the area are very common and are highly adaptable or can easily re-colonized vacant habitats whenever necessary. In general, the BQPS-III project is foreseen to have a very minimal or insignificant impact to the flora and fauna in the area. The development will cause a very minimal mortality to plant life and to some extent loss of foraging area for avifauna. In addition, the fauna, which is largely composed of birds, at the site are mostly omnivores (generalist feeders) that can easily shift from one diet to another. This ecological trait will permit them to move from other vegetated areas especially the tree communities surrounding project site.

9.3.3.2 Aquatic Ecology

a. Potential Impact

The impact on aquatic ecology is envisaged to be insignificant as the proposed project does not require construction of new discharge channels, the aquatic species have already adopted to the existing baseline conditions of the proposed project area and no additional burden or pressure will be added to these species. However the possible release or leakage of any construction material containing toxic waste may result in short term adverse impact on to the aquatic ecology which can be mitigated by implementation of standard construction practices and implementation of spill prevention and containment plan.

9.3.4 Impact on Human Environment

9.3.4.1 Health and Safety

a. Potential Impact

Construction phase activities may result in severe health and safety hazards and health conditions. It is important to note that the untrained workers may cause harm to themselves as well as others due to lack of awareness and skills.

b. Criteria for Determining the Significance

A significant impact will be interpreted if a large number of frequent accidents, incidents, injuries and hazards occurs at proposed project sites.

c. Mitigation Measures

The contractor will ensure that activities at the site will not cause damage to lives and properties by implementing the following measures to ensure the health and safety of workers and the public.

- Only skilled workers will be allowed to work at the construction sites;
- Provision of first aid facilities for workers at site for meeting the emergency needs of workers;
- Emergency response training should be given to employees and evacuation drills should be scheduled and conducted
- Ensure that hazards associated with manual lifting are controlled by proper lifting techniques, work rotation system will reduce the chances of being exposed to work related stress associated with construction activities.

- Unauthorized personnel will not be allowed to access the proposed project site without permission and safety permits.
- Arrangement of proper first aid unit and emergency vehicle to take affected personnel to the nearest medical facility.
- Workers should be facilitated by providing appropriate work specific PPE's;
- Construction area will be fenced to avoid accidents and will be properly drained to avoid ponding of water that could harbor mosquitoes and other disease vectors;
- Accidents records will be maintained;
- Use of signage must be implemented.
- The project developer must ensure implementation of proper HSEQ policy at all project locations so as to reduce the chances of occurrence of frequent hazards

  (Refer **Annexure-IV** for KE HSEQ Policy)

d. Residual Impacts

Residual impacts are foreseen to be negligible / low in this case if recommended mitigation measures are implemented

e. Monitoring Requirements

Risk assessment to be carried out on weekly basis by engaging Independent Environmental Monitoring Consultants

9.3.5 Socio-Economics

9.3.5.1 Road Safety and Traffic Management

a. Potential Impact

Since the proposed project developments, installations and modifications will be undertaken within the existing boundaries of already built up area of BQPS-I, KPC, Landhi and Qayyumabad therefore the construction equipment and material carrying vehicles will be parked in designated areas within the premises of aforementioned project sites therefore the impact on road safety and traffic management is anticipated to be insignificant. However it is strongly recommended that the drivers of construction equipment and material carrying vehicles should have valid licenses and must obey all the relevant road safety standards, protocols and traffic rules. A proper traffic management plan for incoming and outgoing project specific vehicles is attached as **Annexure V**.

9.3.5.2 Impact on Livelihood & Economy

a. Potential Impact

Since the proposed project will use the existing facilities such as intake and outfall, hence no further conflict or loss of sea access for the local fishermen due to this project is envisaged, and accordingly the impact on livelihood is assessed to have negligible/ minor significance. However, construction activities will require significant number of local skilled and unskilled workers therefore a positive impact on the local livelihood during the construction phase through creating new job opportunity is envisaged. In addition, local hotels (Dhabas) in project vicinity will also be benefited in terms of increased routine sales. Considering the above, beneficial impacts are envisaged from the proposed project on the local employment and economy. Therefore, it can be concluded that the proposed project will set positive impact on local livelihood option.

9.3.6 Waste Disposal

9.3.6.1 Solid waste:

a. Potential Impact

The construction phase of the proposed project is expected to generate wastes including; packing waste; scrap, excess construction materials and debris, empty containers and drums, used lubricating oils and chemicals etc. Besides being an eyesore, the waste can also pose a health hazard; pollute soil, surface and ground water if disposed of improperly. Majority of the construction material to be used and waste generated as a result of construction activity will be inherently less reactive and chemically inert under normal conditions however, its handling and storage may pose adverse impacts of minor nature which could easily be controlled by employing the recommended mitigation measures in this report.

b. Criteria for Determining The Significance

A significant impact will be interpreted the construction waste is scattered and dispersed at project sites and its surroundings.

c. Mitigations Measures

A waste management plan will be developed by the contractor after approval of K-Electric before the start of the construction activities. Key elements of the waste management system will be the following:

- Separate bins will be placed for different type of wastes - plastic, paper, metal, glass, wood, and cotton;
- Recyclable material will be separated at source. The recyclable waste will be sold to waste contractors for recycling;

- No waste will be dumped at any location outside the proposed site boundary;
- All hazardous waste will be separated from other wastes. Hazardous wastes will be stored in designated areas with restricted access and proper marking. Hazardous wastes will be disposed of through approved waste contractors;
- Surplus construction materials including partially filled chemical and paint containers will be returned to suppliers. Inert construction wastes will be sold as scrap to contractors;
- Record all waste generated during the construction period will be maintained. Quantities of waste disposed, recycled, or reused will be logged on a Waste Tracking Register;
- Training will be provided to personnel for identification, segregation, and management of waste.

d. Residual Impacts

Proper implementation of the mitigation measures will ensure that the residual impact from waste is minimal.

e. Monitoring Requirements

An IEMC will carry out monthly visual inspections to ensure good solid waste management practices at proposed project site.

9.4 IMPACT ASSESSMENT (OPERATIONAL PHASE)

9.4.1 Impact on Physical Resources

9.4.1.1 Topography and Land use

Since all the developments and installations will be executed during the construction phase, hence no impact on to the topography and land use pattern is envisaged during the operational phase of the proposed project.

9.4.2 Impact on Environmental Resources

9.4.2.1 Air Quality

a. Potential impact

Quantitative techniques are used to assess the impacts of air emissions during the operation phase, for which computer simulation models are used. AERMOD software was used for conducting air dispersion modeling, which demonstrated air dispersion comparison scenario for existing HFO based unit 3 & 4 and proposed 2 X 450 MW RLNG based CCPGU.

This modeling addressed emissions from stationary point sources. The emissions from existing HFO based power generation unit 3 & 4, were calculated separately and were found to be significantly high as compared to the emissions from newly proposed 2 X 450 MW RLNG based CCPGU which were also calculated separately and were found to be insignificant, therefore the air dispersion modeling concluded that the air pollution concentrations will reduce significantly not only this but the intensity of the impact on air quality due to emissions from the proposed project is expected to decrease with increasing distance from the project-site

Detailed findings of Air Dispersion modeling is attached as **Annexure VI**. It is to be noted that maximum air dispersion will occur when the proposed power plant will run on complete load. However, on mean calculations of pollutant emissions, they were all found to be within SEQS.

b. Criteria for Determining the Significance

An adverse impact will be interpreted if the newly proposed 2 X 450 MW RLGN base d CCPGU exceeds the maximum permissible SEQS limits.

c. Mitigation Measures

- Ensure Fuel to Air Ratios are maintained;
- Ensure power plant maintenance;
- Ensure Fuel quality is excellent for utilization even after fuel treatment.

d. Residual Impacts

Strict implementation of the proposed mitigation measures is unlikely to leave any long-term residual impact.

e. Monitoring Requirements

Periodic air quality monitoring will be carried out as prescribed in SEQS, by an IEMC. The parameters to be monitored includes:

- NOx
- CO

9.4.2.2 Noise

a. **Potential Impact**

The proposed project will include a number of noise sources, which will have potential adverse impacts on the workplace and ambient noise levels. Most of the sources are continuous which include the engines / generators, steam turbines and pumps.

The continuous exposure to the elevated levels of noise may result in; headaches, hearing problems and even loss in severe conditions, anxiety, and accumulation of stress hormones and hypertension.

All these health conditions may affect the overall health of the exposed workers and laborers associated with the proposed project.

b. Criteria for Determining the Significance

An adverse impact will be interpreted if the noise level exceeds the prescribed SEQS limits.

c. Mitigations Measures

- Proper maintenance of all the equipments to be utilized during operational phase will be maintained throughout the entire life cycle of the proposed project to reduce the chances of elevated noise levels.
- High noise areas, will be identified and proper safety signs indicating noise hazards will be displayed, KE Employees accessing high noise area will always wear PPE's like ear protection muffs or ear plugs;
- Unauthorized personnel will not be allowed to access high noise areas.

b. Residual Impacts

- Nuisance or health effects caused by high noise will be reduced

c. Monitoring Requirements

- During operational phase periodic noise level monitoring will be carried out as prescribed in SEQS, by an IEMC. The ambient noise levels and noise emission from equipment and machineries will also be monitored.

9.4.3 Impact on Ecological Resources

9.4.3.1 Terrestrial Ecology

a. Potential Impact

It is important to note that the proposed project area is already under PQA industrial zone therefore, the terrestrial species observed have already adapted to such environment. Although some of them may still be under the phase of adaptation and their migratory paths and or habitats may be affected due to maintenance activities resulting in noise and vibration however the anticipated impact will be transitory and insignificant in nature.

9.4.3.2 Aquatic environment.

a. Potential Impact

As mentioned earlier, the proposed power plant is the replacement of existing HFO based power generation unit 3 & 4 at BQPS-1 in Port Qasim and proposed 2 X 450 MW RLNG based CCPGU is designed with efficient technologies which would utilizes less amount of water than existing two units. Moreover it is important to note that a detailed thermal plume modeling has been conducted for the propose project and it has been predicted that during the its operations and by abandoning existing HFO based unit 3 & 4 of BQPS-I there would be reduced discharge flow rate and velocity therefore, it is expected that impact on the marine ecology with Regulatory Mixing Zone of 100 m due to this project would be minimized and would result in lesser area to be affected due to reduced discharge from 144,780 m^3/hr to 69, 622 m^3/hr and flow velocity which would also result in plume dispersion with shorter distance in downstream i.e. 8.86 m.

Moreover it is important to note that the potential impact from the discharge of effluents is tempered by the following factors: the total volume of brine being released; the constituents of the discharge; and the amount of dilution prior to release. Further, it may be noted that the treated effluents will be combined with return cooling water prior to discharge, which will result in significant dilution of the effluents and in turn will reduce the concentration of various constituents. Furthermore, the combined effluents from the plant will be discharged to sea through existing common marine outfall, which will result in further dilution prior to discharging to the marine environment.

b. Criteria for determining the significance

Temperature difference in water will be caused due to heat exchange in plant. To assess the impact Thermal Plume modeling is conducted. CORMIX is used for assessing thermal plume variance. The mixing zone will completely neutralize the temperature difference. The Thermal Plume modeling is attached as **Annexure-VII**. However the significant impact will be interpreted if temperature of the effluent discharge exceeds 3 °C of ambient seawater temperature at the edge of a scientifically established mixing zone.

c. Mitigations Measures

- Retain effluent prior to final discharge for treatment unless the quality remains within SEQS;
- The treated water can be reutilized for green belt areas.

Residual Impacts

- Residual impacts are foreseen to be negligible / low in this case if recommended mitigation measures are strictly implemented

Monitoring Requirements

- Quarterly benthic faunal sampling at the proposed project site will be carried out by an Independent Environmental Monitoring Consultant to check the biodiversity status of the project area.

9.4.4 Impact on Human Environment

9.4.4.1 Health and safety

a. **Potential Impact**

Operational activities which may result in health and safety hazards such as, slipping, tripping, falling from height, electrocution, fires, explosions and suffocation in confined space etc. One of the major potential issue related to the health and safety of the workers working in close proximity of the proposed project area includes accidental LNG release, fire hazards and other health and safety hazards.

b. Criteria for determining the significance

A significant impact will be interpreted if a large number of fire, explosions, frequent accidents, incidents, injuries and hazards occurs at proposed project sites.

c. Mitigation Measures

- Ensure that all the safety and security procedures are in place and implemented in true spirit.
- Ensure proper maintenance of firefighting systems during the entire life cycle of the proposed project.
- All the workers involved in, operational activities will be provided with proper PPEs according to their job description including; safety belts, footwear, helmets, goggles, eye-shields, and coverall to workers depending on their nature of work.
- Necessary training regarding safety aspects to the personnel working at the proposed project site will be given.
- Material Safety Data Sheet (MSDS) for chemicals, if any, will accompany the consignment.
- The project developer must ensure implementation of proper HSE policy at all project locations so as to reduce the chances of occurrence of frequent hazards.

d. Residual Impacts

- Residual impacts are foreseen to be negligible / low in this case if recommended mitigation measures are adhered with.

e. Monitoring Requirements

- HSE Inspections and detailed risk assessments will be carried out on monthly basis by engaging IEMC at proposed project site to evaluate the health and safety practices at the project site.

9.4.5 Socio-Economics

9.4.5.1 Road Safety & Traffic

a. Potential Impact

Since the proposed project will operate in an already built up area of BQPS-I within industrial zone of PQA, therefore vehicular movement for employs mobilization is already a routine activity within the given area and a sufficient road infrastructure is also available. However probability of road accidents and traffic congestions always remains therefore all the workers moving from different parts of the city towards project site will have valid driving licenses and will obey traffic rules at all times.

9.4.5.2 Livelihood & Economy

a. Potential Impacts

Since the proposed project will use the existing facilities such as intake and outfall, hence no further conflict or loss of sea access for the local fishermen due to this project is envisaged, and accordingly the impact on livelihood is assessed to have negligible/ minor significance. However, project operations will require significant number of skilled and unskilled workers therefore a positive impact on the local livelihood during the project operations is expected by creating new job opportunity. In addition, local hotels (Dhabas) in project vicinity will also be benefited in terms of increased routine sales. Not only this but adding 2 X 450 MW RLNG based CCPGU will result in smooth and continuous supply of electricity which is expected to result in continuous and smooth industrial production thus contributing towards economic development.

9.4.6 Waste Disposal

9.4.6.1 Water and Waste water

a. Potential Impacts

Water requirement during operation phase of the proposed project will be sourced from existing channel of sea. Domestic and process wastewater will be generated during operational phase. The wastewater can be a potential source of pollution to surface and sea water.

b. Criteria for Determining the Significance

A significant impact will be interpreted if the discharge effluent water does not meet the prescribed SEQS limits or exceeds the limits.

c. Mitigations Measures

- Appropriate facilities to be provided for collection, storage and routing the wastewater streams to treatment plant and facilities are to be provided;

- Appropriate sludge handling and disposal facilities are to be provided for waste treatment sludge.
- Effluent sewers to be periodically cleaned and inspected for integrity in order to ensure effective transport of effluents and prevent overflows and leakages and infiltration;
- Sanitary wastewater from all sections of the facility to be collected and routed to sanitary treatment system
- All run off from the process area to be routed for treatment prior to disposal.

d. Residual Impacts

- Residual impacts are foreseen to be low in this case if recommended mitigation measures are adhered with.

e. Monitoring Requirements

- Treated water from the WTP is to be periodically analyzed for relevant parameters in order to assess compliance with SEQS. Analysis reports will be submitted to SEPA as required; and
- Periodic audits to be conducted to assess implementation of the control measures and results of audits to be reviewed and corrective actions to be taken for any deviations.

9.4.6.2 Waste Generation and Disposal System

a. Potential Impacts

During scheduled and unscheduled maintenance work on the engines and auxiliary systems there can be considerable amounts of spare part and packaging waste. The large majority of the rejected engine spare part waste is metal and can be sold for recycling. Also maintenance on auxiliary systems gives rise to rejected spare part waste, which could consist of metal, electronic components, hazardous components (mainly batteries and filters) and other materials like rubber, plastic, glass fibre, graphite, porcelain, etc.

It should be kept in mind that the stated values are long term average ranges, within which typical values might fall. The true values are dependent on site conditions, quality of fuel and other fluids, habits of workers, maintenance work done, etc. The amount of hazardous waste is largely dependent on how hazardous products (e.g. lube oil and solvents) are delivered.

The estimated waste generation during operation phase is provided in **Exhibit 9.1**.

Exhibit 9.1: Anticipated Waste Generation during Operation

Waste Type	Estimated Daily Generation	Source	Onsite Waste Handling and Treatment	Disposal Method	Indicative Composition (of pollutants)
Sludge					
Sludge from oily water treatment	~4.6 m^3/day	Oily water treatment unit	To be collected and stored in tank.	To be handed over to third party, which is licensed by relevant government agency to treat hazardous waste.	Contains oil and small amounts of e.g. metals. The concentrations are dependent on fuel quality and operation of systems.
Sludge from biological treatment	~0.05 m^3/day	Biological water treatment unit	To be collected and stored in tank.	To be handed over to third party, which is licensed by relevant government agency to treat hazardous waste.	Dry content matter 3.8 – 8.2%
Waste in solid form					
Non-hazardous	40-300 kg/day	Offices, control rooms, social facilities, sanitary facilities, spare part packaging material, etc.	To be collected and stored at assigned area.	Part of the waste might be reusable, the rest should be sent for recycling or incineration/disposal by qualified waste vendor.	Domestic, paper, glass, landfilling waste, metal scrap (excl. spare parts), packaging material (wood, cardboard, plastic, polystyrene).

Waste Type	Estimated Daily Generation	Source	Onsite Waste Handling and Treatment	Disposal Method	Indicative Composition (of pollutants)
Hazardous	20-100 kg/day	Engine operation and offices	Should be handled, stored at assigned area and handed over, in accordance with IFCs EHS general guidelines section 1.6 Waste Management.	To be handed over to third party which is licensed by relevant government agency to treat hazardous waste.	Rags contaminated with hazardous products, contaminated cans and drums, used filters, lighting equipment, batteries, etc.
Filters (charge air and process ventilation)	6-15 kg/day	Charge air system (hazardous only if contaminated with oil) and process ventilation.	To be collected and stored at assigned area.	Sent for treatment by qualified waste vendor.	Depends on filter type.

CHAPTER 10

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

10.1 OVERVIEW AND SCOPE

The potential environmental impact during the construction and operations of the proposed combined cycle LNG based units on various environmental components such as social, biological and physical environment were predicted in the course of the ESIA. The ESIA has also identified mitigation measures to minimize the environmental impact of the proposed project, keeping these effects within acceptable limits.

The EMMP (Environmental Management and Monitoring Plan) has been designed to address how the proposed measures will be implemented. It defines the responsibilities of the project developer and contractor; develops a system of checks and balances; proposes actions that are to be taken by each role player; and lays down the required documentation, communication, and monitoring procedures.

10.2 PURPOSE AND OBJECTIVES

The purpose of this EMMP is not only to address the expected environmental impacts of the proposed project, but also to enhance project benefits and to introduce standards of good practice to be adopted for the proposed project.

The primary objectives of the EMMP are to:

- Facilitate the implementation of the mitigation measures that are identified in the ESIA;
- Define the responsibilities of the project proponent and contractor and to provide a means for effective communication of environmental issues between them;
- Identify monitoring parameters in order to ensure the effectiveness of the mitigation measures.
- An integrated Environment Management System play important role in sustainable industrial development if their Environment Management and Monitoring Plan is more effective and economically beneficial covering all activities of the industry and give proper implementable guidelines.

The specific EMMP for the proposed activities of the PGPL LNG Import Terminal-2 has been prepared by assessment of impact scale which has been categorized as high, medium and low obtained by multiplying impact severity into likelihood. The impact scaling criteria has been presented below in **Exhibit 10.1**, a detailed EMMP in **Exhibit 10.2**.

Exhibit 10.1: Impact Scaling Criteria

IMPACT SCALING CRITERIA			
Severity	**Rating**	**Likelihood**	**Rating**
HIGH	3	HIGH	3
MEDIUM	2	MEDIUM	2
LOW	1	LOW	1
IMPACT SCALE = SEVERITY X LIKELIHOOD			
HIGH = 7-9			
MEDIUM = 4-6			
LOW = 1-3			

SEVERITY

Impact severity has been categorized as follows:

HIGH: The anticipated environmental impact may adversely affect the environmental conditions.

MEDIUM The anticipated environmental impact may exhibit moderate effect onto the environmental conditions.

LOW The anticipated environmental impact is insignificant and may not affect the environmental conditions.

LIKELIHOOD

HIGH: The anticipated environmental impact is most likely to occur.

MEDIUM The anticipated environmental impact is likely to occur.

LOW The anticipated environmental anticipated environmental impact is less likely to occur.

Exhibit 10.2: Environmental Management and Monitoring Plan

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Construction Phase								
Topography & Landscape	Formation of heaps due to improper handling of construction residue	1 X 2 = 2 LOW	- Proper site leveling should be ensured, in order to minimize the probability of topographic changes at and project site flooding during rainy season - Ensure that construction material such as cement and or ready mix is handled properly and no residual material is left unattended so as to avoid the probability of formation of heaps and uneven structures	1 X 1 = 1 LOW	Surface topography	Project sites at Port Qasim and Korangi Power Complex	Monthly	KE by engaging IEMC
Ambient Air Quality	Construction activities may result in following impacts:	2 X 2 = 4 MEDIUM	- Use of standard construction equipment and vehicles; - Scheduled maintenance of back-up generators, equipment and vehicles including engine tuning, filter cleaning, etc.;	2 X 1 = 2 LOW	Emissions of CO, NOX, PM10, and SOx from sources such as construction machineries and vehicle movement	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	Impairment of ambient air quality Chronic health issues Upper respiratory disorders		- Water spraying will be done to reduce dust emissions; - Enclosed painting booths and dedicated fabrication areas in favor of wind direction so the fumes may divert away from the site; - The vehicle speeds on graded roads will be limited in order to minimize dust emissions					
Noise	Headaches Hearing problems Accumulation of stress hormones Hypertension	2 X 2 = 4 **MEDIUM**	- On site workers will be provided with adequate 'personal protective equipment' (PPE); - Construction equipment/ machineries will be provided with suitable silencers; - Regular maintenance of construction machinery and equipment will be ensured	2 X 1 = 2 **LOW**	Noise levels and Construction Equipment/Machinery Maintenance Report	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- Construction activities will be scheduled / planned in such a way as to prevent high noise activities during night times and simultaneous operation of multiple high noise equipment will be avoided to the extent feasible					
Surface and Ground Water Quality	Seawater contamination by oil spillage from construction vehicles and equipment	2 X 2 = 4 MEDIUM	- All liquid raw material such as oil, lubricants and chemical at all project sites will be stored within the storage yard with impermeable floors and roof top. - The storage yard should be protected with secondary containment facility with appropriate labeling, to significantly reduce the chances of liquid waste or material discharge into the sea during the accidental spill or rain water runoff.	1 X 1 = 1 LOW	pH, TSS, Temperature Oil and Grease and visual inspection of Surface Water Quality	Proposed project Site at Port Qasim	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Terrestrial Ecology	Minimal mortality to plant life Loss of foraging area for avifauna	2 X 1 = 2 LOW	- Green areas will be developed in vacant portions of proposed project areas; - Best and safe industrial practices should be adopted for the less disturbance of ecology of the area.	1 X 1 =1 LOW	Visual Inspection	Korangi Power Complex	Monthly Basis	KE by engaging IEMC
Soil Quality	Small scale excavations and site leveling may result in following impacts: Soil erosion Contamination of soil.	2 X 2 = 4 MEDIUM	- Careful use of heavy machineries and equipment should be ensured in order to prevent leakages onto the soil. - A spill prevention response team will be available throughout all the activities for immediate action on site	2 X 1 = 2 LOW	Visual Inspection	Proposed project sites at Port Qasim and Korangi Power Complex	Monthly Basis	KE by engaging IEMC
Aquatic Ecology	Small scale impact on aquatic ecosystem	2 X 2 = 4 MEDIUM	- Existing drainage has bearing capacity of more effluent and will sustain rise in effluent	2 X 1 = 2 LOW	Fish population density and productivity by fauna sampling and its laboratory analysis.	Proposed project Site at Port Qasim	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			discharge caused during construction activities; - Construction activities will be performed with complete standard procedures and minimal discharge will be produced					
Health & Safety	Lack of awareness among general laborers about safety may lead to accidents Unskilled and untrained workers might cause harm to themselves and others Construction works may	3 X 2 = 6 MEDIUM	- Ensure that hazards associated with manual lifting are controlled by proper lifting techniques, work rotation system will reduce the chances of being exposed to work related stress associated with construction activities. - Trained personnel will be appointed for the specific work - Unauthorized personnel will not be allowed to access the project site without permission and safety permits. - Arrangement of proper first aid unit and emergency vehicle to	2 X 1 = 2 LOW	HSE inspections Risk assessment reports Record of Safety Talks Record of safety Incidents (Major & Minor) Record of PPEs Visual Assessments	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	include many risks and hazards that may lead to severe injuries		take affected personnel to the nearest medical facility. - Workers should be facilitated by providing appropriate work specific PPE's; - Accidents records will be maintained					
Road Safety and Traffic Management	Traffic Congestion Risk of accident	2 X 1 = 2 LOW	- Trained drivers and operators to drive the construction vehicles - Obey traffic and safety rules/precautions and traffic management plan.	1 X 1 = 1 LOW	Driver's license and traffic rules	NIL	NIL	NIL

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Livelihood & Economy	The proposed project will have positive impacts on local economy, however small scale conflicts between local vendors and project developer may occur	2 X 1 = 2 LOW	- Specify time scale for construction activities - People from neighboring areas will be considered for unskilled employment - Suppliers and Vendors of neighboring areas will be given priority - Employment opportunities will be increased and the preference will be given to locals.	1 X 1 = 1 LOW	Complaint register and Grievance Redress Mechanism (GRM)	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC
Solid waste	Health hazards Unaesthetic conditions	3 X 2 = 6 MEDIUM	- Separate bins will be placed for different type of wastes - plastic, paper, metal, glass, wood, and cotton; - The material to be used during construction phase should be limited and should not exceed the needed amount so as to prevent solid waste production at project site.	1 X 1 = 1 LOW	Visual inspections Assessment of solid waste quantity and type	All Project Installation and Modification Sites	Monthly	KE by engaging IEMC

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- No waste will be dumped at any location outside the proposed site boundary; - All hazardous waste will be separated from other wastes. Hazardous wastes will be disposed of through approved waste contractors; - Record all waste generated during the construction period will be maintained. - Training will be provided to personnel for identification, segregation, and management of waste.					
Operational Phase								
Air	Chronic Respiratory health effects	2 X 3 = 6 **MEDIUM**	- Ensure Fuel to Air Ratios are maintained; - Ensure power plant maintenance.	2 X 1 = 3 **LOW**	CO and NOx	Project Site at Port Qasim	Quarterly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
			- Ensure Fuel to be used of approved quality.					
Noise	Power plant operations may result in elevated levels of noise which may result in following impacts: Stress Hypertension Hearing loss Headache	1 X 3 = 3 LOW	- KE Employees accessing the area will always wear PPE's like ear protection muffs or ear plugs; - Proper maintenance of all the equipment to be utilized during operational phase will be maintained throughout the entire life cycle of the proposed project - Unauthorized personnel will not be allowed to access high noise areas.	1 X 2 = 2 LOW	Noise levels	Project Site at Port Qasim	Quarterly	KE
Aquatic Environment	Change in diversity of benthic community	2 X 3 = 6 MEDIUM	- Retain effluent prior to final discharge for treatment unless the quality remains within SEQS;	2 X 1 = 2 LOW	MBI Marine outfall Parameters as per SEQS or SEPA requirement	Benthic faunal sampling stations at outfall and intake channel of	Quarterly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	Water pollution		- The treated water can be reutilized for green areas			BQPS-III at Port Qasim		
Health & Safety	Lack of awareness among general laborers about safety may lead to accidents Unskilled and untrained workers might cause harm to themselves and others Health hazards	2 X 3 = 6 MEDIUM	- Ensure that all the safety and security procedures are in place and implemented in true spirit. - Ensure proper maintenance of firefighting systems during the entire life cycle of the proposed project. - Necessary training regarding safety aspects to the personnel working at the project site will be given. - Material Safety Data Sheet (MSDS) for chemicals, if any, will accompany the consignment. - The project developer must ensure implementation of proper HSE policy at all project locations so as to reduce the chances of occurrence of frequent hazards.	2 X 2 = 4 MEDIUM	Record of Safety Talks Record of safety Incidents (Major & Minor) Record of PPEs Visual Assessments	All Project Installation and Modification Sites	Monthly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Livelihood and Economy	Proposed project will reduce the energy deficit of Karachi. people will benefit in form of employment and business activities Operational phase activities can cause health and safety risk	2 X 1 = 2 **LOW**	- Possibility of recruitment of local workers having pertinent education skills will be explored; - Local businesses such as fabricators, maintenance service providers, food suppliers, transporters, etc., are likely to have business opportunities associated with the operation of the plant - Mechanism will be developed for local community engagement for complaints and suggestions;	1 X 1 = 1 **LOW**	Complaint register and Grievance Redress Mechanism (GRM) Local Consultations records		As and when required	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Water and Waste Water	Heated effluent discharge and untreated wastewater may result in seawater pollution and impacts on aquatic ecology	2 X 2 = 4 MEDIUM	- Appropriate facilities to be provided for collection, storage and routing the wastewater streams to treatment plant and facilities are to be provided; - Appropriate sludge handling and disposal facilities are to be provided for waste treatment sludge. - Effluent sewers to be periodically cleaned and inspected for integrity; - Sanitary wastewater from all sections of the facility to be collected and routed to sanitary treatment system - All run off from the process area to be routed for treatment prior to disposal.	2 X 1 = 2 LOW	Parameters as per SEQS or SEPA requirements	Water sampling stations at outfall and intake channel of BQPS-III at Port Qasim	Monthly	KE
Solid waste	Health impacts	2 X 3 = 6 MEDIUM	- The solid waste management plan will be developed and facilities for collection, storage	2 X 1 = 2 LOW	Within the site premises	All Project Installation and	Monthly	KE

Aspect	Impact	Impact Scale Severity X Likelihood	Mitigation Safeguards	Residual Impact	Monitoring Parameter	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
	Unaesthetic view Property loss Unhygienic conditions		and transportation will be established and organized; - A safe and designated area will be selected for disposal of waste and EPA certified contractors will be hired; - Dumping of solid waste will be prohibited around the facilities.			Modification Sites		

CHAPTER

11 CONCLUSION

ESIA of the proposed 02 X 450 MW RLNG Based CCPGU project has achieved the following goals:

- Identification of national and provincial environmental regulatory requirements that apply to the proposed project activities;
- Identification of the environmental features of the proposed project area including the physical ,biological and social disturbance and likely impact of the project on the environment;
- Recommendation of appropriate mitigation measures that the project developer will incorporate and ensure as per this ESIA into the project to minimize the adverse environmental impacts.

Baseline physical, biological, socio-economic and cultural data and information was collected from a variety of primary and secondary sources, including field surveys, review of relevant literature and online publications. The collected data was used to organize profiles of the physical, biological and socio-economic environments, likely to be affected by the proposed project. Primary and secondary stakeholders were consulted through scoping meetings and consultation processes. These included communities, industries and institutional stakeholders. The aim of public consultation was to assure the quality, comprehensiveness and effectiveness of the ESIA as well as to ensure that the views and opinions of the local people were adequately taken into account in the decision making process. Further, an Environmental and Social Impact Assessment Report was made to highlight the potential impacts of the described proposed project on the area's physical, biological, socio- economic and cultural environments.

After assessing the proposed project activities and investigating the proposed project area, the environmental consultants, GEMS have concluded that:

"If the activities are undertaken as described in this ESIA report, and the recommended mitigation measures along with environmental management plan is adopted specifically, the proposed BQPS-III 900 MW RLNG Based Combined Cycle Power Plant project will not result in any long-term impacts on the physical and biological environment of the proposed project area. Additionally the proposed project installation will significantly contribute towards reduced environmental pressure in terms of air quality as natural gas is recognized as a comparatively clean burning fuel and it emits less particulates and negligible SO_2, as well as less NOx and CO_2 than other fossil fuels. It will also improve plant overall efficiency. Moreover the proposed project will create employment opportunities for local residents and play vital role in overcoming the power shortfall in the country, since Karachi is the industrial hub of Pakistan thus the continuous power supply will not only boost the industrial and economic development of country but also result in a long-term net beneficial impact on air quality as well as social wellbeing of local community".