HUBCO

The Hub Power Company Ltd.
11th Floor, Ocean Tower
Block-9, Main Clifton Road
Karachi, Pakistan

T +92 21 3587 4677-86
+92 21 3583 9018
F +92 21 3587 0397

July 31, 2015

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

Dear Sir,

Subject: Application for Grant of a Generation License for 2x660 MW Coal Based Power Generation Plant along with a dedicated coal import Jetty at Hub Baluchistan Pakistan

I, Khalid Mansoor, being the duly authorized representative of The Hub Power Company Limited (HUBCO), as Main Sponsor by virtue of Power of Attorney dated 16th February 2015, hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to HUBCO, pursuant to section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997, for the subject Project. This Project shall be developed by a Special Purpose Vehicle (SPV) having equity participation of HUBCO and China Power International Holdings (CPIH). HUBCO and CPIH are in process of setting up the SPV in Pakistan. Once the SPV in Pakistan is established, the generation license will be novated / assigned to this SPV.

I certify that the documents-in-support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, and undertake to abide by the terms and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

* A Pay Order in the sum of Rupees six hundred ninety seven thousands three hundred and sixty only (Rs. 697,360), being the non-refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

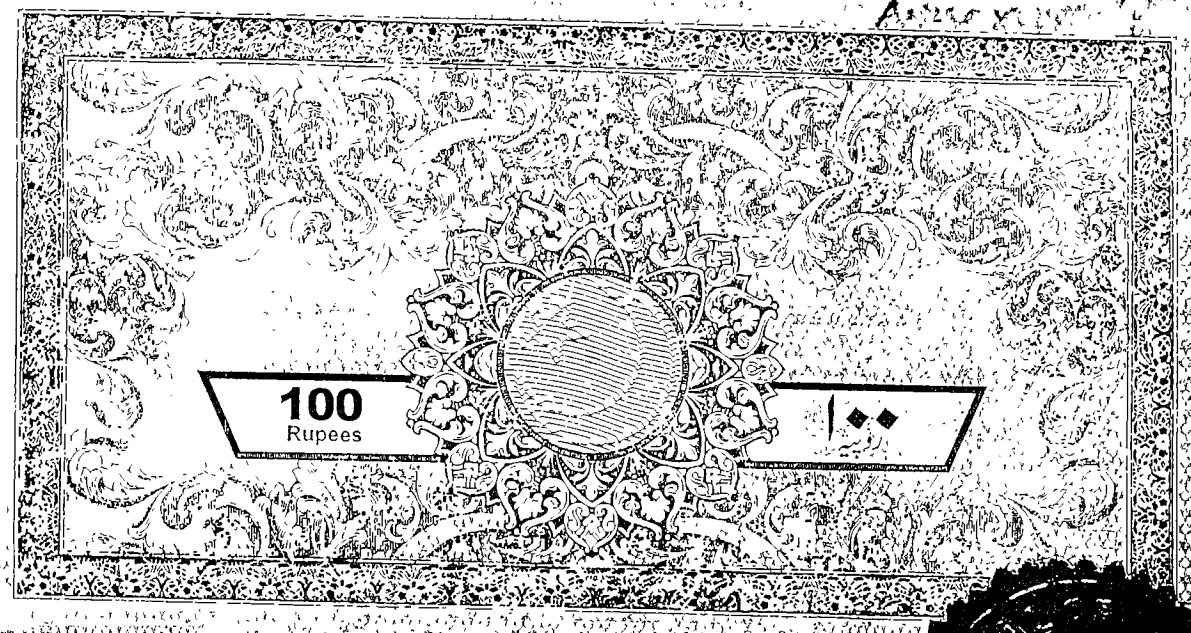
We will appreciate your positive and prompt action in this regard.

* Alongwith Pay Order of Rs. 2520/- (two thousand five hundred twenty only).

Kind regards,

Khalid Mansoor,
Chief Executive Officer,
The Hub Power Company Limited

D134649



ZAFAR ALAM STAMP VENDOR
Licence No. 30 Seat No. 8 Shed A,
City Court, Karachi.
S.NO. 1871 DATE 3 DEC 2014
ISSUED TO M/S ADDRESS M. Shahid Qureshi
Advocate
THROUGH TO WITH ADDRESS L.No. 3945 KBA
PURPOSE
VALUE RS. (ATTACHED)
STAMP VENDOR'S SIGNATURE

OFFICIAL SEAL ★ CITY COURT Karachi. ★ NOTARY PUBLIC ★

GENERAL POWER OF ATTORNEY

KNOW ALL MEN BY THESE PRESENTS that we, THE HUB POWER COMPANY LIMITED, a Company incorporated in Pakistan under the Companies Ordinance, 1984 (hereinafter referred to as "the Company") and having our Registered Office at 3rd Floor, Islamic Chamber of Commerce Building, Block 9, Clifton, Karachi-75600, do hereby appoint Mr. Khalid Mansoor, holding CNIC No.42301-4000955-5, Chief Executive of the Company, to be our true and lawful Attorney in our name and on our behalf to do all or any of the following acts, deeds and things relating to or in connection with the affairs of the Company:

1. To appear and act in all courts, civil, revenue or criminal, whether original or appellate, in the offices of the District Registrar and Sub- Registrar of Deeds and Assurances for registration of documents and in any other office of the Federal, Provincial and Local Governments, including without prejudice to the generality of the foregoing, any Union Council, District Council, Cantonment Board, Municipal Corporation or Notified Area, any Co-operative Society, Karachi Development Authority, Karachi Municipal Corporation, Capital Development Authority, Islamabad, City Deputy Collector's Office, Securities and Exchange Commission of Pakistan, State Bank of Pakistan, Collector of Customs, Excise & Taxation Offices and the Chief Controller of Imports and Exports in all matters concerning the business or property of the Company.

2. To present deeds and documents for registration, to execute and to admit execution thereof, to receive consideration and to do such further and other acts as may be necessary for the due and proper registration of any document for and on behalf of the Company.

3. To commence, institute, prosecute and defend any action or suit whether at law or in equity or other proceedings necessary to protect the Company's interests, business or property and compromise, settle or enforce the same whether by arbitration or otherwise.

Contd...P/2-

4. To compromise, compound or withdraw cases, to confess judgements and to refer cases to arbitration.

5. To sign and verify plaints, written statements, petitions of claims and objections, memoranda of appeal and all kinds of applications and all other forms of pleadings in any such court or office.

6. To accept service of any summons, notice or writ issued by any court or officer against the Company.

7 To apply to any court or officer for copies of records and documents or for certified copies of any decree, order or judgement and to obtain such copies.

8. To apply for inspection of and to inspect judicial records and the documents and records in any public office and to obtain copies of such documents and records.

9. To file and receive bank documents, to deposit and withdraw money and to grant receipts therefor.

10. To obtain refund of stamp duty or repayment of court fees.

11. To appoint and remunerate any barrister, solicitor, advocate, vakil, pleader, mukhtar, revenue agent or any legal practitioner or any accountants, valuers, surveyors and estate agents for such services as may be deemed appropriate, from time to time.

12. To make and sign applications to appropriate government departments, local authorities or other competent authority for all and any licences, permissions and consents required by any order, statutory instrument, regulation, byelaw or otherwise in connection with the management and affairs of the Company.

13. To execute all bonds, deeds and documents and give such security as may be required now or at any future time by the Government of Pakistan or by any person, corporate body, company or firm to enable the Company to carry on its business.

14. To apply or subscribe for, buy, sell, negotiate, transfer, endorse, receive or deliver Government Promissory Notes, Government Securities and such other documents and things of a like nature as may be necessary or proper for carrying on the business of the Company and to do all or any acts and things which may be necessary or expedient in connection therewith.

15. To ask, demand, use, recover and receive all rents, interest, debts, moneys, effects, produce, profits, securities, goods, deeds, documents and other muniments of title, chattels and things which are or may hereafter be due or deliverable to the Company or relate to any of the properties belonging to the Company or which may belong to the Company or on any account whatsoever (expressly including any sum or sums of money which now is or are or may at any time hereafter be payable for or on account of principal, interest or dividend by the Government of Pakistan or by any person, corporate body, company or firm, to the Company as the holder of any securities, debentures and shares or on account of any such securities, debentures and shares being cancelled or paid off or on any other account whatsoever) and to sign and give effectual receipts, acquittances and discharges for the same or any part or portion thereof.

16. To receive certificates of shares, stock, debentures, debenture stock and other securities of any company or other corporation to which the Company may now or hereafter be entitled and to receive money due in respect thereof whether by way of principal, interest, profit, dividend or otherwise and to sign and deliver receipts, acquittances and discharges for the moneys so received.

Contd:...P/3-

17. To attend, represent, vote or act for the Company at any meeting of members, shareholders, debenture holders, creditors or any class thereof of any company or other corporation in which the Company is interested and to appoint representatives or proxies for attending, representing, voting or acting for the Company at all or any such meetings.

18. To make payments to any person, corporate body, company or firm for any service rendered to the Company and for such other purposes of the Company as may be necessary for carrying on of the Company's business and to sign an deliver all receipts, charges and drafts on the bank and other accounts of the Company or on the customers of the Company and to endorse all bills and bills of exchange received by the Company which may be necessary or may be expedient in the judgement of the Attorney to be signed, endorsed or given for the purpose of carrying on of the Company's business.

19. To obtain securities from any person, corporate body, company or firm for the due performance of any contract in respect of rendering any service or supplying any material to the Company and to accept the same on such terms as may be deemed proper or expedient by the Attorney.

20. To arrange for and accept any surety or sureties guarantor or guarantors for the due performance of any contracts entered into by or on behalf of the Company and to release such surety or sureties and to discharge such guarantor or guarantors in due course.

21. To realise debts due to the Company and to receive any money due to the Company from any person, corporate body, company or firm and to grant receipts and discharges for the same.

22. To purchase, lease, hire or otherwise acquire plant, machinery, equipment or fixtures of trade required for the purposes of the Company and its business and to execute such contracts and deeds as may be necessary in respect thereof.

23. To buy all such material, articles or things as may be required by the Company and to enter into contracts with suppliers and to cancel, modify or vary the same.

24. To acquire office premises for the Company and houses for the executives and officers of the Company on rent from any person, corporate body, company or firm and execute all Agreements, Lease Deeds and all other related documents in respect thereof.

25. To make payments of all dues and submit plans of buildings relating to the Company's properties or lands on the Company's behalf before any competent authority and to obtain receipts therefor.

26. To negotiate and to enter into and complete contracts with any person, corporate body, company or firm for the lease or purchase of any lands and buildings and for the erection or construction of any buildings and structures and for the installation of any machinery, plant or fixtures on any lands and buildings so leased or purchased and to demolish, alter, repair, add to, and improve any building or structure and to let, sub-let, surrender or give up any immovable property held by the Company.

27. To purchase, lease or otherwise acquire vehicles for the Company and to sign and execute leases and all other related documents in respect thereof.

28. To prepare, adjust, settle or cause to be prepared adjusted or settled all matters of accounts whatsoever and examine the same and to settle, adjust, arrange, compromise or submit to arbitration any accounts, debts, disputes, claims, actions, or proceedings in which the Company may be involved.

Contd....P/4-

29. To appear before any authority to represent the Company, to appear in public meetings or elections or official assemblages and vote for and elect any person or persons and take part in deliberations in the name and on behalf of the Company.

30. To use, sign and attest the name and style of the Company in any transaction, deed, document or muniment of title on all such occasions as may be necessary or expedient for conducting the business of the Company or for the due and proper management of the lands and buildings leased or purchased or to be leased or purchased by the Company.

31. To transact, manage and carry on the business of the Company and do all matters and things requisite and necessary or in any manner connected with or having reference to the administration, control and operation of the business and affairs of the Company.

32. To manage the business affairs, investments, securities and property of the Company.

33. To engage, employ, retain, dismiss, terminate or dispense with the services of personnel, agents, contractors, legal and technical advisers and other professionals (including those engaged pursuant to contracts for supply of fuel and operations and maintenance of the plants) and to insure against liability to such personnel or persons arising under any statute or otherwise.

34. To take all such measures as may be necessary for ensuring the safety of the personnel of the Company, its contractors and third parties.

35. To insure the moveable and immovable assets of the Company.

36. To avail Finance Facility(s) and/or borrow money from any Bank or Banks or financial institution, Development Finance Institutions (DFIs), any domestic and/or international organization/bank/DFI or Government or Semi-Government Agency on such terms as the Board may approve from time to time and to secure the repayment thereof by pledge, mortgage or hypothecation of Stocks, shares or other securities or assets of the Company and for that purpose or in connection therewith to sign, execute, register, deliver and renew, agreements, assurances, deeds, promissory notes, mortgage or receipts and negotiate, endorse, assign and transfer any such securities or assets aforesaid.

37. To exercise all day to day management powers of the Company except those prescribed by the Companies Ordinance 1984 or any other law to be mandatorily performed with the prior approval of the board of directors or the shareholders (as the case may be).

38. To appoint substitute or substitutes and delegate to such substitute or substitutes all or any of the powers and authorities hereby conferred on the said Attorney except that the substitute or substitutes shall not have the power of substitution conferred on the said Attorney and to revoke such appointment as the said Attorney may think fit such substitutes being officers of the Company and any such substituted Attorney or Attorneys shall have powers to act on behalf of the Company as if such substitute or substitutes had been originally appointed in this Deed.

39. To execute and sign all such deeds and documents as may be required or proper for or in relation to all or any of the matters or purposes aforesaid.

40. GENERALLY to do all other acts and things incidental to the exercise of the aforesaid powers.

Contd....P/5-

41. And the Company hereby agrees that all acts, deeds and things lawfully done by the Company's Attorney shall be construed as acts, deeds and things done by the Company and the Company undertakes to ratify and confirm all and whatsoever that the Attorney shall lawfully do or cause to be done for the Company by virtue of the power hereby given.

This Power of Attorney supersedes and hereby revokes any prior power of attorney issued in favour of Mr. Khalid Mansoor from the undersigned and shall rescind upon the Attorney (Mr. Khalid Mansoor) ceasing to be the Chief Executive of the Company for any reason whatsoever.

IN WITNESS WHEREOF this Power of Attorney has been executed on behalf of The Hub Power Company Limited this 16th day of February 2015.

CHAIRMAN

In presence of:

WITNESS
HASAN REZAUR RAHIM
CNIC 42201-6103761-3
c/o DH Corporation, Karachi

WITNESS
SYED JAMIL SHAH
CNIC 42201-0544024-5
c/o Hubco, H.O., Karachi

ATTESTED

Muhammad Suleman
Notary Public
Karachi (Pakistan)

04 MAR 2015

ATTESTED
Muhammad Naeem (Advocate)
NOTARY PUBLIC
KARACHI PAKISTAN

GOVERNMENT OF PAKISTAN

CERTIFICATE OF INCORPORATION

(Under section 32 of the Companies Ordinance, 1984 (XLVII of 1984)

Company Registration No. I-00746

I hereby certify that "THE HUB POWER COMPANY LIMITED"

is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is limited by shares

Given under my hand at Islamabad

this 6th day of August

one thousand nine hundred and ninety one.

Fee Rs. 153,560.00 (Rupees one hundred fifty three thousand five hundred and sixty only).

(NAZIR AHMAD SHAIKH),
Deputy REGISTRAR
OF COMPANIES
ISLAMABAD.

CRO-I

No. DR.I/27141-27146.
Dated 01 AUG 1991.

THE COMPANIES ORDINANCE, 1984

Company Limited by Shares

MEMORANDUM OF ASSOCIATION

OF

THE HUB POWER COMPANY LIMITED

I The name of the Company is THE HUB POWER COMPANY LIMITED

II The Registered Office of the Company shall be situated in the Province of Sindh

III. The objects for which the Company is established are:-

(1) To carry on at suitable locations in Tehsil Hub, District Lasbela, Balochistan and other places in Pakistan the business of power generation distribution and sale in all its branches and aspects and by the use of such forms of energy and in such manner as may be deemed feasible and sell and deliver the electricity thus generated.

(2) To finance design construct, own, operate and maintain an oil fired steam power station with four generating units with a total initial installed capacity of upto 1292 MW together with all machinery equipment and works ancillary thereto (hereinafter referred to as "Power Station") at a suitable location in Tehsil Hub, District Lasbela, Balochistan or elsewhere in Pakistan and to do all such acts, deeds and things, without limitation whatsoever as may be necessary or desirable in that connection.

(3) To carry on anywhere in Pakistan the business of power generation and distribution in all its branches and asoects and in particular to construct, lay down, establish, maintain and fix all necessary power stations together with ancillary works, cables, wires, lines, accumulators, lamps, and to generate, accumulate, distribute, sell and supply electricity

(4) To construct and maintain roads, bridges, wharves, quays, jetties and piers, pipelines and storage tanks for water, petroleum products, natural gas and other substances, water desalination and treatment plants and such other works as may be required for all or any of the above purposes

(5) To carry on the business of electrical engineers, electricians, engineers, contractors,consultants, agents and manufacturers of electrical plant, machinery, equipment and apparatus, and of generating, producing and supplying light, heat, sound and power by electricity, galvanism, magnetism or otherwise, suppliers of electricity whether for the purpose of light, heat, motive power, telephonic, telegraphic, industrial or other purposes and generally to install, execute, provide, work and maintain all necessary plant, machinery, equipment, cables, wires, accumulators, lamps, exchanges, telephones and apparatus.

(6) To import, export, buy, sell, hire or deal in plant, machinery, equipment, cables, wires, accumulators, lamps, exchanges, telephones, fittings and furniture and apparatus of every kind with special reference to plant, machinery, equipment or apparatus connected with the producing, storing, supplying, using, regulating or measuring the supply or facilitating the use of electricity or electrical currents or force

(7) To buy, sell, import, hire, manufacture, deal in, and turn to account plant, machinery, implements, conveniences, provisions, articles and products capable of being used in connection with the operations of or required by workmen and others employed by the Company or incidentally or conveniently connected with any such business as aforesaid

(8) To purchase, take in exchange or on lease, rent, occupy or otherwise acquire any lands, hereditaments and estates and any property and effects thereon or used or connected therewith and to acquire any grants, concession, leases, rights easements, licenses, privileges and any other interests in land

(9) To acquire, erect, construct, lay down, enlarge, replace, balance, modernise, alter and maintain any buildings, works, and machinery necessary or convenient for the Company's business

(10) To sell, lease, improve, manage, develop, mortgage, exchange, turn to account or otherwise deal with, dispose of absolutely conditionally, or for any limited interest, and grant any leave or license in respect of all or any of the property, rights or privileges of the Company, and to distribute in specie as dividend or bonus any moneys, shares, stocks, debentures or debenture stock that may be accepted as consideration for any such sale, lease exchange or other disposition

(11) To sell, transfer or give any option of purchase over the whole or any part of the undertaking property and assets of the Company for such consideration and on such terms as the Company may think fit

(12) To promote, amalgamate with or buy up any other company for the purpose of acquiring all or any of the property and liabilities of this Company or for any other purpose which may seem directly or indirectly calculated to benefit this Company and to take or otherwise acquire and hold shares in any other company having objects altogether or in part similar to those of this Company or carrying on any business capable of being conducted so as directly or indirectly to benefit this

Company.

(13) To enter into partnership or into any arrangement for sharing profits, union of interest, co-operation, joint adventure, reciprocal concession, or otherwise with any person or company carrying on or engaged in or about to carry on or engage in any business or transaction which this Company is authorised to carry on or engage in or any business or transaction capable of being conducted so as to directly or indirectly benefit this Company, to guarantee the contracts of or otherwise assist any such person or company and to take or otherwise acquire shares and securities of any such company and to sell, hold, re-issue with or without guarantee, or otherwise deal with the same.

(14) To join or become members of any association, company or society formed or to be formed for the protection or advancement of the interests of employers or investors or others engaged in any trade or business and to subscribe to or subsidise any such association, company or society.

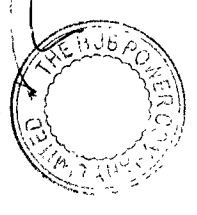
(15) To enter into any arrangement or agreement with any Government or Authority, Federal, Provincial, Municipal, local or otherwise that may seem conducive to the Company's objects or any of them, to obtain from any such Government or Authority any rights, privileges and concessions which the Company may think desirable to obtain and carry out, exercise and comply with any such arrangement, agreements, rights, privileges and concessions, and to apply for and obtain licenses, provisional orders, special Acts or other statutory or legislative authority for supplying electricity for any public or private purposes.

(16) To promote any Bill or Bills in any legislature or other like body or make any application or applications to any public authority for any order, provisional order or license and to enter into any contract, to bear and pay the expenses of or in connection with the same or arising thereout, and to underwrite or guarantee the capital required for carrying out any undertaking authorised by any such Act, order or license.

(17) To purchase or otherwise acquire any patent, brevets d'inventions, trade marks, licenses, concessions and the like conferring any exclusive or non-exclusive or limited right to use any invention which may seem capable of being used for any of the purposes of the Company or the acquisition of which may seem calculated directly or indirectly to benefit the Company, and to use, exercise, develop or grant licenses in respect of or otherwise turn to account, the Property and right so acquired.

(18) To pay for any property, rights or benefits acquired by the Company either in cash or in shares with such rights, in respect of dividend or repayment of capital or otherwise, as may be deemed fit by the Company or by any securities which the Company has power to issue or partly in one mode and partly in another and generally on such terms as the Directors may approve.

(19) To issue all or any part of the original or enhanced share capital of the Company at par or at a premium or discount subject to any permission required under the law.



(20) To borrow moneys, to lawfully raise moneys in such manner as the Company shall think fit and in particular by the issue of such securities, bonds and instruments payable to bearer or otherwise, and either permanent or redeemable or repayable or convertible into shares and collaterally to secure the repayment of any such moneys so raised or any such securities or instruments of the Company by means of a trust deed or otherwise.

(21) To make advances upon the security of any property, rights or benefits acquired by the Company and upon the security of land, buildings and hereditaments or any interest or estate therein in any part of the world and upon any other assets real or personal or upon personal security but not to act as investment company.

(22) To invest the surplus moneys of the Company not immediately required upon such securities and in such manner as may from time to time be determined.

(23) To subscribe or guarantee money for any purpose which may be considered likely, directly or indirectly, to further the objects of the Company or for any national, charitable, benevolent, public, general or useful object or for any exhibition.

(24) To open maintain and operate bank accounts, make, draw, endorse, accept, discount, execute, issue and negotiate Bills of Exchange, promissory notes, cheques or any other negotiable or transferable instruments.

(25) To guarantee or otherwise become liable for the performance by any person or company of any obligation, contract or undertaking and to guarantee the title to or quiet enjoyment of property either absolutely or subject to any qualifications or conditions and to guarantee persons or companies interested or about to become interested in any property against any loss, actions, suits, proceedings, claims or demands in respect of any insufficiency or deficiency of title or in respect of encumbrances, burdens or outstanding rights any or the interest on or other payments in connection with any securities or the repayment of any capital or principal sums of funds.

(26) To take out any Insurances that the Company deems necessary or appropriate and to pay the premium therefor.

(27) To accept a gift or gifts of any movable or immovable property of whatsoever kind or wheresoever situate from any person, company or corporation.

(28) To institute and defend in any forum legal proceedings of every kind or description whatsoever, enter into arbitration agreements and refer disputes to arbitration, pay, satisfy or receive payments in respect of, or compound or compromise any claim, demand, action, suit or proceeding of any nature whatsoever made or brought by or against the Company notwithstanding that the same may not be valid in law.

(29) To remunerate any person or company for services rendered in placing or assisting to place or in guaranteeing any of the shares in the Company's capital or any debentures or other securities of the Company.

(30) To employ experts to investigate into or examine the conditions, prospects, value, character and circumstances of any business, concerns and undertakings and generally of any assets, property or rights.

(31) To employ or engage persons as employees or consultants or managers in or about the business of the Company and to indenture, contract or otherwise engage workmen, skilled and unskilled.

(32) To grant pensions, allowances, gratuities and bonuses to the persons employed by or trading with the Company and to aid in the establishment, support and subscribe to any associations or institutions, calculated to benefit persons employed by the Company or having dealings with the Company.

(33) During the construction of the Power Station and all works in connection therewith to pay from time to time, for a period which may extend to the close of the half-year during which the Power Station to be constructed shall be actually completed and commences sale or distribution of energy, a return on debentures, bonds or other securities in accordance with the terms thereof and to charge all such sums so paid to capital account as part of the original cost of construction of such Power Station.

(34) To pay or reimburse out of the funds of the Company all expenses which the Company may lawfully pay, incident to the promotion, formation and registration of the Company and advertising of or raising money for the Company by shares, debentures, bonds or other securities and the issue of its capital, including brokerage and commission for obtaining applications for or taking, placing or underwriting shares, debentures, bonds or other securities.

(35) To employ contractors, managers, consultants and other skilled persons to operate, manage and maintain the Power Station operated by the Company where the Directors deem it advantageous to do so.

(36) To constitute and regulate separate branches or departments of the Company's business and to appropriate thereto respectively any of the assets of the Company and any of the capital issued or to be issued of the Company and from time to time to vary the constitution or regulations of any such branches or departments or any such appropriations and if thought fit to amalgamate all or any of the said branches or departments.

(37) To procure the Company to be registered or recognised in any country or place outside Pakistan and to keep Branch Registers.

(38) To carry on any other business or activity of any nature whatsoever whether inside or outside Pakistan which may seem to the Directors to be capable of conveniently or advantageously carried on in connection or conjunction with any business of the Company hereinbefore or hereinafter authorised or to be expedient with a view directly or indirectly to enhancing the value of or to rendering profitable or more profitable any of the Company's assets or utilising its skills, know-how or expertise.

(39) To do all or any of the above things in any part of the world as principals, agents, contractors, sub-contractors, trustees or otherwise and by or through trustees, agents, subsidiary company or otherwise and either alone or in conjunction with others.

(40) To do all such other things as are incidental or conducive to the attainment of the above objects, this general statement of objects being deemed as enabling and not in any way as restrictive of the foregoing objects.

AND it is hereby declared that the word "company" in this clause (when applied otherwise than to this Company) shall be deemed to include any authority, partnership or other body of persons whether incorporated or not incorporated, and the word "persons" shall be deemed to include any partnership, association or other body of persons and any company or corporation if the context so admits and the intention is that the objects set forth in each of the several paragraphs of this clause have the widest possible construction and shall be in no wise limited or restricted by reference to or inference from the terms of any other paragraph of this clause or the name of the Company except as otherwise expressed therein or by the juxtaposition of any two or more objects or by any objects being deemed a main or dominant object but each shall be and be deemed to be an independent object.

AND that none of such sub clauses or the objects therein specified or the powers thereby conferred shall be or be deemed to be subsidiary or ancillary merely to the objects mentioned in any of the other sub-clauses of this clause or any of them but the Company shall have full power to exercise all or any of the powers conferred by any part of this clause in any part of the world notwithstanding that the business, undertaking, property, rights, or acts proposed to be acquired, dealt with or performed do not fall within the objects of the earlier or any other sub-clauses of this or any of them.

AND it is hereby declared that the Company shall not engage in banking or the business of an investment company or any unlawful business and that nothing in the object clauses shall be construed as enabling it to engage in such business.

IV. The liability of the Members is limited.

V. **(as amended by Special Resolution dated 7 August 1994)**

The Authorised Share Capital of the Company is Rs.12,000,000,000 (Rupees Twelve Thousand million) divided into Twelve Hundred million (1,200,000,000) Ordinary Shares of Rs.10 each with the rights, privileges and conditions attaching thereto provided by the regulations of the Company for the time being with power to increase and reduce the capital of the Company and to sub divide the ordinary shares in the capital for the time being into several classes.

We are several persons whose names and addresses are subscribed below are desirous of being formed into a Company in pursuance of these Articles of Association, and we respectively agree to take the number of shares in the capital of the Company set opposite our respective names:-

Name and Surname (present and former) in full (in Block Letters)	Father's/Husband's Name in full	Nationality with any former nationality	Occupation	Residential address in full	Number of shares taken by each subscriber	Signature
1. MOHAMMED AHMED ALIREZA	AHMED YUSUF ALIREZA	SAUDI ARABIAN	Chairman	c/o Xenel Industries Ltd. P.O. Box No 2824, Jeddah 21461 Kingdom of Saudi Arabia	1	
2. KHALID AHMED ALIREZA	-do-	-do-	-do-	-do-	1	
3. MOHAMMED ASHRAF TUMBI	HAJI ABDUL SHAKOOR TUMBI	PAKISTANI	General Manager (Finance)	-do-	1	
4. ADNAN ABDULLAH MAIMANI	ABDULLAH IBRAHIM MAIMANI	SAUDI ARABIAN	Chief Legal Advisor	-do-	1 (Signed)	
5. VILAIAT HUSAIN ABEDI	BAHADAR HUSAIN	-do-	Executive	-do-	KAIRAS N. KABRAJI (duty constituted attorney)	
6. JAMES ALISTAIR STRACHAN CHAPMAN	JAMES LESLIE CHAPMAN	BRITISH	General Manager (Construction)	-do- -do-	1	
7. JOHN THOMAS FARNDON	LESLIE PARNDON	-do-	Project Manager	12 Toucan Way, Kingswood Basildon, Essex SS16 5ER UK.	1	

Dated the 16th day of July 1991

Address to above signatures: ASHFAQ HUSAIN QURESHI
S/O ASGHAR HUSAIN QURESHI.

(Signed) Ashfaq Hussain Qureshi

Occupation: Advocate
Full Address: B-83,
Mohammad Ali Society,
Karachi

THE COMPANIES ORDINANCE, 1984

COMPANY LIMITED BY SHARES

ARTICLES OF ASSOCIATION

OF

THE HUB POWER COMPANY LIMITED

(As substituted and adopted by Special Resolution dated 7th August 1994)

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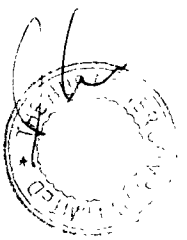
PROCEEDINGS OF DIRECTORS



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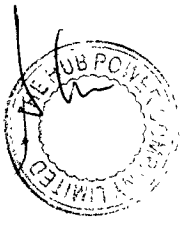


THE COMPANIES ORDINANCE, 1984

Company Limited by Shares

ARTICLES OF ASSOCIATION

OF

THE HUB POWER COMPANY LIMITED
(As substituted and adopted by Special Resolution dated 7th August 1994)

PART I

PRELIMINARY

1. INTERPRETATION

The marginal notes hereto shall not affect the construction hereof and in these presents, unless there is anything repugnant in the subject or context:

"**Chief Executive**" means the Chief Executive for the time being of the Company;

"**Company**" means The Hub Power Company Limited;

"**Directors**" means the Directors for the time being of the Company whether elected under Article 71, nominated under Article 73 or appointed by co-option under Article 74;

"**Dividend**" includes bonus;

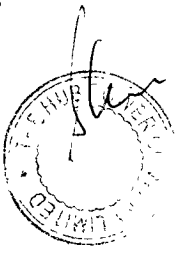
"**Implementation Agreement**" means the agreement so called dated 3 August 1992, as amended from time to time, between the President of the Islamic Republic of Pakistan for and on behalf of the Islamic Republic of Pakistan ("GOP") and the Company;

"**Initial Shareholders**" means:

(1) XENEL INDUSTRIES LIMITED, a company incorporated in the Kingdom of Saudi Arabia whose registered office is at Bab Jadeed, Jeddah, Saudi Arabia (hereinafter referred to as "Xenel");

(2) HAWKER SIDDELEY POWER ENGINEERING LIMITED, a company incorporated in England whose registered office is at Burton-on-the-Wolds, Loughborough, Leicestershire, England;

(3) MITSUI & CO. LTD., a company incorporated in Japan whose registered office is at 2-1 Ohtemachi, 1-Chome, Chiyoda-ku, Tokyo, Japan;



(4) ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES CO., LTD., a company incorporated in Japan whose registered office is at 2-1 Ohtemachi, 2-Chome, Chiyoda-ku, Tokyo, Japan;

(5) CANADIAN UTILITIES LIMITED, a company incorporated in the province of Alberta, Canada, whose registered office is at 10035 105th Street, Edmonton, Alberta, Canada;

(6) NATIONAL POWER INTERNATIONAL HOLDINGS BV, a company incorporated in The Netherlands, whose registered office is at Hoekenrode 1102 BR, Amsterdam Z.O., The Netherlands (hereinafter referred to as "NPBV");

(7) K&M ENGINEERING AND CONSULTING CORPORATION, a corporation organised and existing under the laws of the State of Delaware, USA whose principal office is at 2001 L Street, NW Washington DC, USA; and

(8) HRPG LTD., a company incorporated in Grand Cayman whose registered office is at Morgan Grenfell (Cayman) Limited, PO Box 1984, Elizabethan Square, Grand Cayman, British West Indies;

"**Member**" has the meaning assigned thereto in Clause (21) of Sub-section (1) of Section 2 of the Ordinance;

"**Office**" means the registered office for the time being of the Company;

"**Ordinance**" means the Companies Ordinance, 1984 or any statutory modification or re-enactment thereof for the time being in force;

"**Ordinary Resolution**" means a resolution passed at a General Meeting when the votes cast (whether on a show of hands or on a poll, as the case may be) in favour of the resolution (including the casting vote, if any, of the Chairman) by Members who, being entitled to vote in person, or by proxy, do so vote, exceed the votes if any cast against the resolution by Members so entitled and voting;

"**Register**" means the Register of Members to be kept pursuant to Section 147 of the Ordinance;

"**Registrar**" means a Registrar, a Deputy Registrar, an Additional Registrar, a Joint Registrar or an Assistant Registrar of Joint Stock Companies;

"**Seal**" means the Common Seal of the Company;

"**Special Resolution**" has the meaning assigned thereto by Clause (36) of Sub-section (1) of Section 2 of the Ordinance;

Terms defined in the Implementation Agreement shall have the same meanings when used herein.

Expressions referring to writing shall unless the contrary intention appears be construed as including references to printing, lithography, photography and other modes of representing, transmitting or reproducing words in a visible form.

Words importing the singular number include the plural number and vice versa.

Words importing the masculine gender include the feminine gender.

Words importing persons include corporations.

Save as aforesaid any words or expressions defined in the Ordinance shall if not inconsistent with the subject or context bear the same meaning in these Articles.

2. TABLE 'A' NOT TO APPLY

Save as reproduced herein the regulations contained in Table 'A' of the First Schedule to the Ordinance shall not apply to the Company.

3. NAME OF THE COMPANY

The name of the Company is "THE HUB POWER COMPANY LIMITED".

PART II
SHARES

4. AUTHORISED SHARE CAPITAL

The authorised share capital of the Company is Rupees twelve thousand million (Rs 12,000,000,000) divided into One thousand two hundred million (1,200,000,000) shares of Rupees Ten (Rs 10) each.

5. MINIMUM SUBSCRIPTION

The minimum subscription (within the meaning of Sub-section (8) of Section 68 of the Ordinance) on which the Directors may proceed to the first allotment of share capital shall be Rupees one hundred thousand (Rs 100,000).

6. COMPANY NOT TO PURCHASE OR GRANT FINANCIAL ASSISTANCE TO PURCHASE ITS OWN SHARES

Save as permitted by Section 95 of the Ordinance the funds of the Company shall not be employed in the purchase of or lent on the security of shares of the Company and the Company shall not give, directly or indirectly, any financial assistance, whether by way of loan, guarantee, the provision of security or otherwise for the purpose of or in connection with any purchase of or subscription for shares in the Company or any Company of which it may for the time being be a subsidiary.

7. ALLOTMENT OF SHARES

Subject to the provisions hereinafter contained the shares shall be under the control of the Directors, who may allot or otherwise dispose of the same to such persons, on such terms and conditions and at such times as the Directors think fit.

8. RESTRICTION ON ALLOTMENTS

The Directors shall as regards any allotment of shares duly comply with such of the provisions of Sections 68 to 73 of the Ordinance as may be applicable thereto.

9. COMMISSION

The Company may at any time pay a commission to any person for subscribing or agreeing to subscribe whether absolutely or conditionally for any shares in or debentures or other securities of the Company or for procuring or agreeing to procure subscriptions whether absolute or conditional for any shares in or debentures or other securities of the Company, but so that any statutory conditions and requirements shall be observed and complied with. Such commission may be satisfied by the payment of cash or the allotment of fully paid shares or partly in one way and partly in the other.

10. BROKERAGE

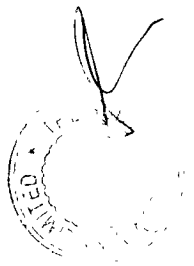
The Company may pay brokerage not exceeding one per cent. (or such other rate per cent. as may from time to time be specified by the Corporate Law Authority) of the price at which shares or debentures issued have been actually sold through the broker.

11. SHARES AT DISCOUNT

With the previous authority of the Company in General Meeting and the sanction of the Corporate Law Authority and upon otherwise complying with Section 84 of the Ordinance, the Directors may issue shares at a discount.

12. TRUST NOT RECOGNISED

Save as herein otherwise provided the Company shall be entitled to treat the registered holder of any share as the absolute owner thereof and accordingly shall not except as ordered by a Court of competent jurisdiction or as required by statute be bound to recognize any equitable contingent, future or other claim to, or interest in, such share on the part of any other person.



PART III

CERTIFICATES

13. CERTIFICATES

The certificates of title to shares shall be issued under the Seal and signed by at least two (2) Directors. A Director's signature on such Certificates may be affixed or printed by any mechanical or electronic method.

14. MEMBER'S RIGHT TO CERTIFICATE

Every person whose name is entered as a Member in the Register shall, unless the conditions of issue of the shares otherwise provide, be entitled without payment to receive within ninety (90) days after the allotment or within forty-five (45) days of the application for the registration of the transfer of any shares of the Company a certificate under the Seal specifying the shares held by him. If any Member shall require additional certificates he shall pay for each such certificate such sum not exceeding Rupees five (5) as the Directors shall determine provided that in respect of any shares held jointly by several persons the Company shall not be bound to issue more than one certificate and delivery of a certificate for any shares to one of several joint holders shall be sufficient delivery to all.

15. ISSUE OF NEW CERTIFICATES

If a certificate be defaced, lost or destroyed, it may be renewed on payment of such fee (if any) not exceeding Rupees five (5) and on such terms (if any) as to evidence and indemnity and the payment of out-of-pocket expenses of the Company in investigating evidence, as the Directors think fit. In the case of shares held jointly by several persons any one of the joint holders may request the renewal of a certificate.

PART IV

TRANSFER AND TRANSMISSION OF SHARES

16. TRANSFER OF SHARES

Every transfer of shares must be in writing in the form specified in Regulation 9 of Table 'A' of the First Schedule to the Ordinance or in any other form which the Directors shall approve and must be left at the Office accompanied by the certificate or, if no such certificate is in existence, the letter of allotment of the shares to be transferred and such other evidence, if any, as the Directors may require to prove the title of the intending transferor or his right to transfer the shares. Each such transferee shall truthfully disclose his nationality at the appropriate place on such transfer deed, and if he shall be the national of more than one state all such nationalities shall be disclosed in the application. Where the application involves the

transfer of shares to any person who would thereby become the registered holder of more than five (5) per cent. of the issued share capital of the Company or the transfer of shares to or from a person who, immediately prior to such transfer, was the registered holder of more than five (5) per cent. of the issued share capital of the Company, the Company shall forthwith deliver the application and the accompanying declaration of nationality to the Controller of Capital Issues, Government of Pakistan.

17. EXECUTION OF TRANSFER

The instrument of transfer of any share shall be duly stamped and executed both by the transferor and the transferee and the transferor shall be deemed to remain the holder of such share until the name of the transferee is entered in the Register in respect thereof. Each signature to such transfer shall be duly attested by the signature of one witness who shall add his address and occupation.

18. IN WHAT CASES THE DIRECTORS MAY DECLINE TO REGISTER TRANSFER

The Directors shall not refuse to transfer any fully paid shares unless:-

18.1 the transfer deed is for any reason defective or invalid provided that the Company shall within thirty (30) days from the date on which the instrument of transfer was lodged with it notify the defect or invalidity to the transferee who shall after removal of such defect or invalidity be entitled to re-lodge the transfer deed with the Company; or

18.2 the declaration submitted with the share transfer deed discloses a nationality which is specifically proscribed for membership of the Company in any Consent Order issued to the Company by the Controller of Capital Issues; or

18.3 the Controller of Capital Issues notifies the Company within thirty (30) days of the delivery of the application and declaration to him that the true nationality (or one of the true nationalities) of the transferee is proscribed for membership of the Company.

If the Company refuses to register the transfer of any shares, owing to any attachment or prohibitory order of a competent authority or otherwise, the Company shall within forty-five (45) days after the date on which the instrument of transfer was lodged with it, send to the transferee notice of the refusal indicating reasons for such refusal

19. RESTRICTIONS ON TRANSFER BY INITIAL SHAREHOLDERS

No Initial Shareholder shall transfer any shares in the Company owned by it at any time prior to the Commercial Operations Date or for a period of ten (10) years after the Commercial Operations Date except for:

(a) a transfer to other Initial Shareholders;

(b) subject to the national security interests of Pakistan as such interest shall be determined in the sole discretion of GOP, a transfer to an affiliate of any Initial Shareholder (for the purposes of this paragraph, "affiliate", in relation to any person, means a company or corporation which is either (i) a Holding Company or a Subsidiary of such person, or (ii) a Subsidiary of a Holding Company of which such person is also a Subsidiary);

(c) subject to the national security interests of Pakistan as such interest shall be determined in the sole discretion of GOP, a transfer required by law or by the operation of law or by order of a court, tribunal or governmental authority or agency with appropriate jurisdiction;

(d) subject to the national security interests of Pakistan as such interest shall be determined in the sole discretion of GOP, a transfer resulting from the realisation of a security interest in or over any shares;

(e) a transfer to which GOP has given its approval in its sole discretion exercised reasonably; and

(f) the transfer of any shares in excess of those subscribed for pursuant to the Forty-five Million Two Hundred and Eighty Thousand Dollars ($45,280,000) equivalent in Rupees of shares or other securities in the Company committed by the Initial Shareholders for the purposes of achieving Financial Closing.

20. RESTRICTIONS ON TRANSFERS BY INITIAL SHAREHOLDERS AFTER THE TENTH ANNIVERSARY OF THE COMMERCIAL OPERATIONS DATE

No Initial Shareholder shall transfer any shares in the Company after the expiry of a period of ten (10) years from the Commercial Operations Date except with the approval of GOP, which shall only be withheld where GOP determines in its sole discretion that such a transfer would be prejudicial to the national security interests of Pakistan; Provided that such approval shall be deemed given unless it is refused within twenty-one (21) days of having been requested.

21. TRANSMISSION OF REGISTERED SHARES

The executors, administrators or nominees appointed under Section 80 of the Ordinance as the case may be of a deceased Member not being one of several joint holders shall be the only persons recognized by the Company as having any title to the shares registered in the name of such Member. In case of the death of any one or more of the joint holders of any shares the survivors or survivor shall be the only persons recognized by the Company as having any title to or interest in such shares. Before recognizing any executor or administrator the Directors may request him to obtain a Grant of Probate or Letters of Administration, Succession Certificate or other legal representation as the case may be from a competent court provided nevertheless that where the Directors in their absolute discretion think fit it shall be lawful for the Directors to dispense with the production of Probate or Letters of

Administration, Succession Certificate or such other legal representation upon such terms as to indemnity or otherwise as the Directors in their absolute discretion may consider necessary.

22. TRANSFER OF SHARES OF INSANE, DECEASED OR BANKRUPT MEMBER

This Article is hereinafter referred to as the "Transmission Article"

22.1 Any committee or guardian of a Member being of unsound mind or any person becoming entitled to or to transfer shares in consequence of the death or bankruptcy or insolvency of any Member upon producing such evidence as the Directors consider sufficient as to the capacity under which he proposes to act under this Article or as to his entitlement may with the consent of the Directors be registered as a Member in respect of such shares or may subject to the regulations as to transfer hereinbefore contained transfer such shares.

22.2 A person so becoming entitled under the Transmission Article shall subject to the right of the Directors to retain such dividends or moneys as hereinafter provided have the right to receive and give a discharge for any dividends or other moneys payable or other advantages arising in respect of the shares but he shall have no right to receive notice of or to attend or vote at Meetings of the Company or save as aforesaid to any of the rights or privileges of a Member in respect of the shares unless and until he shall be registered as the holder thereof

22.3 The Directors shall have the same right to refuse to register a person entitled by transmission to any shares or his nominee as if he were the transferee named in an ordinary transfer presented for registration.

23. NO FEE ON REGISTRATION

No fee will be charged by the Company in respect of the registration of any instrument of transfer or other document relating to or affecting the title to any shares or otherwise for making any entry in the Register affecting the title to any shares.

24. WHEN REGISTER OF MEMBERS MAY BE CLOSED

The Company may on giving at least seven (7) days' previous notice by advertisement in some newspaper circulating in the Province in which the Office is situate and also in a newspaper circulating in the Province in which the stock exchange in which the Company is listed is situate close the Register of Members for any period not exceeding in the aggregate forty-five (45) days in each year but not exceeding thirty days (30) at any one time.

PART V

INCREASE, REDUCTION AND ALTERATION OF CAPITAL

25. POWER TO INCREASE CAPITAL

The Company in General Meeting may from time to time by Ordinary Resolution increase its capital by such sum to be divided into shares of such amounts as may be deemed expedient.

26. ON WHAT CONDITIONS NEW SHARES MAY BE ISSUED

Subject to Section 90 of the Ordinance, the new shares may be issued upon such terms and conditions and with such rights and privileges annexed thereto as the resolution creating the same shall direct and if no direction shall be given as the Directors shall determine.

27. NEW SHARES TO BE OFFERED TO EXISTING MEMBERS

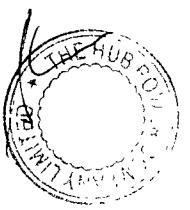
Subject to any direction to the contrary that may be given by the resolution that sanctions the increase of capital all new shares shall be offered to the Members in proportion as nearly as the circumstances admit to the existing shares held by each Member irrespective of class and such offer shall be made by notice specifying the number of shares to which the Member is entitled and limiting a time within which the offer if not accepted will be deemed to be declined and after the expiration of such time or on receipt of an intimation from the Member to whom such notice is given that he declines to accept the shares offered the Directors may subject to the provisions of Section 86 of the Ordinance dispose of the same in such manner as they think most beneficial to the Company. The Directors may likewise so dispose of any new shares which by reason of the ratio which the new shares bear to the shares held by persons entitled to an offer of new shares cannot in the opinion of the Directors be conveniently offered under this Article.

28. HOW FAR NEW SHARES TO RANK WITH SHARES IN ORIGINAL CAPITAL

Except so far as may otherwise be provided by the conditions of issue or by these presents any capital raised by the creation of new shares shall be considered part of the original capital and shall be subject to the provisions herein contained with reference to transfer, transmission and otherwise.

29. REDUCTION OF CAPITAL

The Company may by Special Resolution reduce its share capital in any manner and with and subject to any incident authorised and consent required by law.



30. SUB-DIVISION AND CONSOLIDATION

Subject to the provisions of Section 92 of the Ordinance the Company may by Ordinary Resolution:-

30.1 consolidate and divide the whole or any part of its share capital into shares of larger amount than its existing shares;

30.2 sub-divide its shares or any of them into shares of smaller amount than is fixed by the Memorandum of Association;

30.3 cancel any shares which at the date of the passing of the resolution in that behalf have not been taken or agreed to be taken by any person and diminish the amount of its share capital by the amount of the shares so cancelled.

31. POWER TO MODIFY RIGHTS

If at any time the share capital is divided into different classes of shares, the rights attached to any class may be varied in the manner specified in Section 108 of the Ordinance.

PART VI

DIRECTORS' POWERS TO BORROW OR RAISE MONEY

32. POWER TO BORROW OR RAISE MONEY

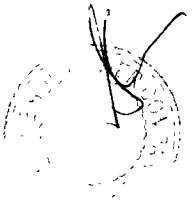
The Directors may from time to time at their discretion borrow or raise money and secure the payment of any sum or sums of money for the purposes of the Company on such terms and conditions as they may consider expedient.

33. CONDITIONS ON WHICH MONEYS MAY BE RAISED

The Directors may raise such moneys in such manner and upon such terms and conditions in all respects as they think fit as to repayment or otherwise and in particular by the issue of any instrument in the nature of redeemable capital or debentures or debenture-stock or bonds and other securities of the Company and whether or not convertible into ordinary shares of the Company and whether or not charged upon all or any part of the property of the Company both present and future.

34. SECURITIES MAY BE ASSIGNABLE FREE FROM EQUITIES

Debentures, debenture-stock, bonds and other securities may be made assignable free from any equities between the persons to whom the same may be issued or transferred.



35. ISSUE AT DISCOUNT OR WITH SPECIAL PRIVILEGES

Any debentures, debenture-stock or other securities may be issued at a discount, premium or otherwise and with any special privileges as to redemption, surrender, drawings, allotment of shares, and, subject to the provisions of Section 114 of the Ordinance, attending and voting at meetings of the Company, appointment of Directors and otherwise.

36. REGISTER OF MORTGAGES TO BE KEPT

The Directors shall cause a register of mortgages to be kept and maintained in accordance with Section 135 of the Ordinance and shall cause the requirements of Sections 121, 122 and 128 of the Ordinance in that behalf to be duly complied with. The Directors shall also cause due compliance with the provisions of Section 130 of the Ordinance as to keeping a copy of every instrument creating any mortgage or charge or modifying the terms and conditions thereof at the Office.

37. INSPECTION OF COPIES AND REGISTER OF MORTGAGES

The Company shall comply with the provisions of Section 136 of the Ordinance as to allowing inspection of copies kept at the Office in pursuance of Section 130 of the Ordinance and as to allowing inspection of the register of mortgages to be kept at the Office in pursuance of Section 135 of the Ordinance.

38. TRANSFER OF DEBENTURES

The provisions relating to transfer of shares herein contained shall apply mutatis mutandis to transfer of debentures, bonds and other securities of the Company other than any shares or other securities issued in bearer form.

PART VII

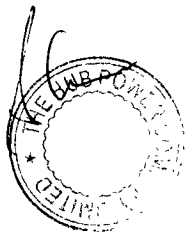
GENERAL MEETINGS

39. THE STATUTORY GENERAL MEETING

The Statutory General Meeting of the Company shall be held within the period required by Section 157 of the Ordinance.

40. WHEN ANNUAL GENERAL MEETINGS TO BE HELD

The Company shall hold, in addition to any other General Meeting, a General Meeting as its Annual General Meeting within eighteen (18) months from the date of its incorporation and thereafter once at least in every calendar year within a period of six (6) months following the close of its financial year and not more than fifteen (15) months after the holding of its last preceding Annual General Meeting.



41. EXTRAORDINARY GENERAL MEETING

All General Meetings of the Company other than the Statutory General Meeting and the Annual General Meeting shall be called Extraordinary General Meetings.

42. WHEN EXTRAORDINARY GENERAL MEETING TO BE CALLED

The Directors may whenever they think fit call an Extraordinary General Meeting and Extraordinary General Meetings shall also be called on such basis or in default may be called by such requisitioners as is provided by Section 159 of the Ordinance.

43. NOTICE OF MEETINGS

Twenty-one (21) clear days' notice at the least specifying the place, the day and the hour of the General Meeting along with a statement of the business to be transacted at the General Meeting and, in the case of special business, a statement complying with Section 160(1)(b) of the Ordinance shall be given to every Member of the Company, to any person entitled to a share in consequence of the death or insolvency of a Member, if the interest of such person is known to the Company, to the Auditors and to every Director of the Company in the manner hereinafter mentioned; Provided that in the case of any emergency affecting the business of the Company the Directors may apply to the Registrar for permission to hold any Extraordinary General Meeting at shorter notice and upon such permission being granted may hold the Extraordinary General Meeting at the shorter notice specified by the Registrar.

44. NOTICE REQUIRED IN CASE OF SPECIAL RESOLUTION

Where it is proposed to pass a Special Resolution at a General Meeting not less than twenty-one (21) clear days' notice specifying the intention to propose the resolution as a Special Resolution shall be given provided that if all the Members entitled to attend and vote at any such Meeting so agree a resolution may be proposed and passed as a Special Resolution at a General Meeting of which less than twenty-one (21) days' notice has been given.

45. AS TO OMISSION OR NON-RECEIPT OF NOTICE

The accidental omission to give notice to or the non-receipt of notice by any Member shall not invalidate any resolution passed at any General Meeting.

46. BUSINESS OF AND RESOLUTIONS AT GENERAL MEETINGS

All business shall be deemed special business that is transacted at an Extraordinary General Meeting and all that is transacted at an Annual General Meeting with the exception of the ordinary business of the Company, that is to say, consideration of the profit and loss accounts, balance sheets and the reports of Directors and auditors, the declaration of a dividend, the appointment of auditors and fixing their remuneration and the election of Directors. Unless otherwise specifically required by the Ordinance or these Articles all ordinary business and all special business shall be transacted by Ordinary Resolution.

47. QUORUM TO BE PRESENT WHEN BUSINESS COMMENCES

No business shall be transacted at any General Meeting unless a quorum of Members is present at the time when the Meeting proceeds to business. At least three (3) Members present personally who represent not less than twenty-five (25) per cent. of the total voting power either of their own account or as proxies shall be a quorum. A person appointed under Article 57 to represent another company or corporation at the General Meeting shall be deemed to be a "Member personally present" for the purpose of meeting the quorum, required under this Article.

48. WHEN IF QUORUM NOT PRESENT MEETING TO BE DISSOLVED AND WHEN TO BE ADJOURNED

If within half an hour from the time appointed for a General Meeting a quorum is not present the meeting if called upon the requisition of Members shall be dissolved; in any other case it shall stand adjourned to the same day in the next week at the same time and place and if at such adjourned meeting a quorum is not present within half an hour from the time appointed for the Meeting the Members present being not less than two (2) shall be a quorum and may transact the business for which the meeting was called.

49. CHAIRMAN OF GENERAL MEETING

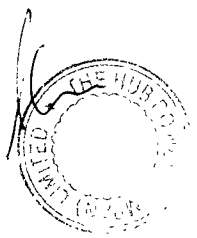
The Chairman, if any, of the Directors elected under Article 82 shall preside as Chairman at every General Meeting of the Company but if there is no such Chairman or if at any General Meeting he is not present within fifteen (15) minutes after the time appointed for holding the Meeting or is unwilling to act as Chairman any one of the Directors present may be elected to be Chairman and if none of the Directors is present or is willing to act as Chairman the Members present shall choose one of their number to be Chairman.

50. POWER TO ADJOURN GENERAL MEETING

The Chairman of a General Meeting may with the consent of the General Meeting at which a quorum is present and shall if so directed by the meeting adjourn the meeting from time to time but no business shall be transacted at any adjourned meeting other than the business left unfinished at the Meeting from which the adjournment took place. When a meeting is adjourned for twenty-one (21) days or more, notice of the adjourned meeting shall be given in the same manner as in the case of an original meeting. Save as aforesaid it shall not be necessary to give any notice of an adjournment or of the business to be transacted at the adjourned meeting.

51. HOW QUESTIONS TO BE DECIDED AT MEETINGS. CASTING VOTE

Every question submitted to a meeting shall be decided in the first instance by a show of hands; in the case of an equality of votes, whether on a show of hands or on a poll, the Chairman of the meeting shall have a casting vote.



52. WHAT IS TO BE EVIDENCE OF THE PASSING OF A RESOLUTION WHEN POLL NOT DEMANDED

At any General Meeting unless a poll is (before or on the declaration of the result of the show of hands) demanded in accordance with the provisions of Section 167 of the Ordinance, a declaration by the Chairman that a resolution has or has not been carried or has or has not been carried unanimously or by a particular majority and an entry to that effect in the books containing the minutes of the proceedings of the General Meetings shall, until the contrary is proved, be evidence of the fact without proof of the number or proportion of the votes cast in favour of or against such a resolution.

53. POLL

If a poll is duly demanded it shall be taken subject to Section 168 of the Ordinance in such manner and at such time and place as the Chairman of the meeting directs and either at once or after an interval or adjournment of not more than fourteen (14) days from the day on which the poll is demanded and the result of the poll shall be deemed to be the decision of the General Meeting on the resolution on which the poll was taken. The demand for a poll may be withdrawn at any time by the person or persons who made the demand.

54. IN WHAT CASES POLL TAKEN WITHOUT ADJOURNMENT

A poll demanded on the election of a Chairman or on a question of adjournment shall be taken forthwith and a poll demanded on any other question shall be taken at such time, being not more than fourteen (14) days from the day on which it is demanded, as the Chairman of the Meeting shall direct.

55. RIGHT OF DIRECTORS TO ATTEND GENERAL MEETINGS

Every Director of the Company shall have the right to attend any General Meeting of the Company and also to take part in the discussion thereat.

PART VIII

VOTES OF MEMBERS

56. VOTES OF MEMBERS

On a show of hands every Member who, being an individual, is present in person or being a company or corporation is present by a representative or proxy shall have one vote and on a poll every Member present in person or by a representative or proxy shall have one vote for each share held by him provided that in the case of election of Directors, the provisions of Article 71.1 shall apply. Nothing contained in these Articles shall prevent a Member of the Company from binding himself by contract with any other Member or Members to vote his shares or other voting securities in any particular manner at an election of Directors or otherwise at any General Meeting of the Company.

57. REPRESENTATION OF COMPANIES OR CORPORATIONS AT GENERAL MEETING

Any company or corporation which is a Member of the Company may by resolution of its Directors or in such other manner as may be permitted or required by its constitution, authorise, in writing, any person to act as its representative at any General Meeting of the Company and the person so authorised shall be entitled to exercise the same powers on behalf of the company or corporation he represents as if he were an individual Member. A representative so appointed shall not be deemed to be a proxy.

58. JOINT HOLDERS

In case of joint holders the vote of the senior who tenders a vote whether in person or by proxy shall be accepted to the exclusion of the votes of the other joint holders, and for this purpose seniority shall be determined by the order in which the names stand in the Register.

59. INSTRUMENT OF PROXY TO BE IN WRITING PROXIES MAY BE GENERAL OR SPECIAL

The instrument appointing a proxy shall be in writing and be signed by the appointer or his attorney duly authorised in writing or if the appointer is a body corporate be under its common seal or be signed by an officer or an attorney duly authorised by it. A proxy need not be a Member. A proxy who is appointed for a specified meeting only shall be called a Special Proxy. Any other proxy shall be called a General Proxy. A Special Proxy shall be valid only for the meeting to which it relates and it cannot be used for more than one meeting.

60. INSTRUMENT APPOINTING A PROXY TO BE DEPOSITED AT THE OFFICE

The instrument appointing a proxy and the power of attorney or other authority if any under which it is signed or a notarially certified copy of that power or authority shall be deposited at the Office not less than forty eight (48) hours before the time for holding the Meeting at which the person named in the instrument proposes to vote and in default the instrument of proxy shall not be treated as valid.

61. FORM OF PROXY

An instrument appointing a proxy shall be in the form specified in Regulation 39 of Table 'A' in the First Schedule to the Ordinance or in any other form which the Directors may approve.

62. WHEN VOTE BY PROXY VALID THOUGH AUTHORITY REVOKED

A vote given in accordance with the terms of an instrument appointing a proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the proxy or of the authority under which the proxy was executed or the tran...

of the share in respect of which the proxy is given unless an intimation in writing of the death insanity revocation or transfer shall have been received by the Company at the Office at least twenty-four (24) hours before the commencement of the Meeting or adjourned Meeting at which the proxy is used provided nevertheless that the Chairman of any meeting shall be entitled to require such evidence as he may in his discretion think fit of the due execution of an instrument of proxy and that the same has not been revoked

63. OBJECTION TO VALIDITY OF A VOTE

No objection shall be made to the validity of any vote except at the General Meeting or adjourned General Meeting at which such vote shall be tendered, and every vote not disallowed at such General Meeting shall be valid for all purposes. Any objection made under the provisions of this Article shall be referred to the Chairman of the General Meeting whose decision shall be final and conclusive.

PART IX

DIRECTORS

64. NUMBER OF DIRECTORS

The number of elected Directors shall not be less than seven (7) nor (unless otherwise determined by the Company in General Meeting) more than twelve (12). The Directors shall fix the number of elected Directors of the Company not later than thirty-five (35) days before the convening of the General Meeting at which the Directors are to be elected and the number so fixed shall not be changed except with the prior approval by Ordinary Resolution of a General Meeting.

65. SHARE QUALIFICATION OF A DIRECTOR

The qualification of a Director shall be holding of at least one share of the Company in his own name. The aforesaid qualification shall not be applicable for instances mentioned in section 187(h) of the Companies Ordinance 1984 and to a person representing a company which is a Member in which case the relevant Member or Members holding shares of the aforesaid value may give a written notice to the Directors that a person named in such a notice being a Director is the representative of that Member or those Members and so long as such notice has not been withdrawn the Director so named shall not require any qualification. No person shall be appointed or nominated a Director or Chief Executive of the Company unless the written consent of such person has been filed by the Company with the Registrar

66. REMUNERATION OF DIRECTORS

The remuneration of each Director, other than the Chairman, Chief Executive and any full-time Directors, shall be determined by the Directors. The remuneration of a Director for performing extra services including the

holding of the office of Chairman shall be determined by the Directors.

67. EXPENSES INCURRED BY DIRECTORS

Subject to the approval of the Directors every Director shall be entitled to be repaid all travelling and hotel expenses incurred by him in or about the business of the Company including the costs of travelling to and from meetings of the Directors or of any committee of the Directors.

68. DIRECTORS MAY CONTRACT WITH COMPANY

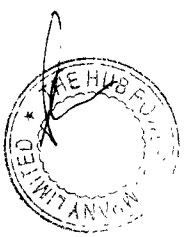
No Director shall be disqualified by his office from contracting with the Company either as a vendor, purchaser or otherwise nor shall any such contract or any contract or arrangement entered into by or on behalf of the Company in which any Director shall be so concerned or interested be avoided nor shall any Director so contracting or being so concerned or interested be liable to account to the Company for any profit realised by any such contract or arrangement by reason of such Director holding that office or of the fiduciary relation thereby established provided that the nature of his interest has been disclosed by him at the time and in the manner specified in Section 214 of the Ordinance.

69. DISCUSSION AND VOTING BY INTERESTED DIRECTOR

Save as provided in Section 216 of the Ordinance no Director shall, as a Director, take any part in the discussion of or vote on any contract or arrangement in which he is in any way, whether directly or indirectly concerned or interested nor shall his presence count for the purpose of forming a quorum at the time of such discussion or vote, and if as a consequence of the Directors or some of them being concerned or interested in any contract or arrangement a quorum is not available for the transaction of any business on account of the provisions of Section 216 of the Ordinance, the Directors shall call an Extraordinary General Meeting of the Company to transact such business and the decision of the meeting shall be carried into effect.

70. DIRECTOR MAY BECOME MEMBER OR DIRECTOR OF A COMPANY IN WHICH THE COMPANY IS INTERESTED

Any Director of the Company may be or become (a) a member or director of any other company including a company promoted by the Company or in which it may be interested as vendor, shareholder or otherwise or (b) a partner in any firm, and no such Director shall be accountable for any benefit received as a member or director of such company or as a partner of such firm.



PART X

APPOINTMENT ELECTION AND REMOVAL OF DIRECTORS

71. ELECTION OF DIRECTORS

As and from the first Annual General Meeting of the Company the Directors shall, unless the number of persons who offer themselves to be elected is not more than the number of Directors fixed under Article 64, be elected by the Members of the Company in General Meeting in the following manner, namely:-

71.1 a Member shall have such number of votes as is equal to the product of the number of voting shares or securities held by him and the number of Directors to be elected;

71.2 a Member may give all his votes to a single candidate or divide them between more than one of the candidates in such manner as he may choose; and

71.3 the candidate who gets the highest number of votes shall be declared elected as Director and then the candidate who gets the next highest number of votes shall be so declared and so on until the total number of Directors to be elected has been so elected.

72. TENURE OF DIRECTORS

A Director elected under Article 71 shall hold office for a period of three years unless he earlier resigns in writing left at the Office, offers to resign in writing, and the Directors resolve to accept such offer, becomes disqualified from being a Director or otherwise ceases to hold office. A retiring Director shall be eligible for re-election.

Notwithstanding that the number of persons offering themselves for election as Directors is not more than the number of Directors fixed under Article 64, the number of votes cast in favour of each candidate and the name of the Member casting such votes shall be recorded in the minutes of the meeting.

73. CREDITORS AND OTHER SPECIAL INTERESTS MAY NOMINATE DIRECTORS

In addition to the Directors elected or deemed to have been elected under Article 71 the Company may have up to four (4) Directors nominated by the Company's Creditors or other special interests (including a Member) by virtue of contractual arrangements.

74. CASUAL VACANCY

Any casual vacancy occurring among the elected Directors may be filled up by the Directors and the person so appointed shall hold office for the remainder of the term of the Director in whose place he is appointed.

75. COMPANY MAY REMOVE DIRECTORS

The Company may by Resolution in General Meeting remove a Director appointed under Article 74 or elected in the manner provided for in Article 71, provided that a resolution for removing a Director shall not be deemed to have been passed unless the number of votes cast in favour of such a resolution is not less than:-

75.1 the minimum number of votes that were cast for the election of a Director at the immediately preceding election of Directors if the resolution relates to removal of a Director elected in the manner provided in Article 71; or

75.2 the total number of votes for the time being computed in the manner laid down in Article 71 divided by the total number of Directors for the time being appointed under Article 74 or elected in the manner provided for in Article 71, if the resolution relates to removal of a Director appointed under Article 74.

76. VACATION OF OFFICE OF DIRECTOR

A Director shall ipso facto cease to hold office if:-

76.1 he becomes ineligible to be appointed a Director on any one or more of the grounds enumerated in Clauses (a) to (h) of Section 187 of the Ordinance;

76.2 he absents himself from three (3) consecutive meetings of the Directors or from all meetings of the Directors for a continuous period of three (3) months whichever is the longer without leave of absence from the Directors;

76.3 he or any firm of which he is a partner or any private company of which he is a director;

76.3.1 without the sanction of the Company in General Meeting accepts or holds any office of profit under the Company other than that of Chief Executive or a legal or technical advisor or a banker;

76.3.2 accepts a loan or guarantee from the Company in contravention of Section 195 of the Ordinance;

76.4 fails to obtain within two (2) months of his appointment or at any time thereafter ceases to hold the share qualification, if any, necessary for his appointment.

77. APPOINTMENT OF ALTERNATE DIRECTOR

A Director may, with the approval of the Directors, appoint any person (including another Director) to be his alternate or substitute Director to act for him during his absence from Pakistan of not less than three months and such appointment shall have effect and such appointee, while he holds office as an alternate Director shall be entitled to notice of meetings of the Directors and to attend and vote thereat accordingly and generally to exercise all the rights of such absent Director.

For the purposes of the proceedings at such meetings the provisions of these Articles shall apply as if an alternate Director (instead of his appointer) were a Director. An alternate Director shall not require any share qualification and he shall ipso facto vacate office as such if and when his appointer vacates office as a Director or returns to Pakistan. If any alternate Director shall be himself a Director, his voting rights shall be cumulative but he shall not be counted more than once for the purposes of quorum. Any appointment or removal under this Article shall be effected by notice in writing under the hand of the Director making the same.

PART XI

PROCEEDINGS OF DIRECTORS

78. MEETING OF DIRECTORS

The Directors may meet in together for the despatch of business, adjourn and otherwise regulate their meetings as they think fit provided that they shall meet at least four (4) times in a calendar year. In addition the Directors shall meet as often as is required by the business of the Company.

79. DIRECTORS MAY SUMMON A MEETING; NOTICE OF MEETINGS

A Director may at any time convene a meeting of the Directors. Seven (7) clear days' notice of a meeting shall ordinarily be given to all Directors including those who are not for the time being resident in Pakistan but in the case of urgent business a meeting of the Directors may be called at shorter notice provided that a majority of the Directors have previously consented in writing to the meeting being called at such shorter notice. The notice shall be given by email or fax sent to the email address or fax number, if any, provided by such Director. The failure of any Director to attend any such meeting called at short notice at which a quorum is present shall not affect the validity of any business transacted thereat.

80. AGENDA AT BOARD MEETINGS

Every notice convening a meeting of the Board shall set out the agenda of the business to be transacted thereat in full and sufficient detail and if any papers are attached to the notice they shall be communicated to the Directors by fax, email or courier or such other means as shall be appropriate, in the circumstances, for the most expeditious communication thereof. Unless otherwise agreed to by a majority of the Directors present, no item of business shall be transacted at such meeting which has not been included in the agenda for the meeting.

81. CHAIRMAN AND VICE-CHAIRMEN

The Directors may elect a Chairman and a Vice-Chairman (or two (2) or more Vice-Chairmen) and determine the period for which each is to hold office but if no such Chairman or Vice-Chairman is elected, or if at any meeting the Chairman or Vice -Chairman is not present within ten (10)

minutes after the time appointed for holding the same or is unwilling to act as chairman, the Directors present may choose one of their number to be chairman of the meeting If at any time there is more than one Vice-Chairman the right in the absence of the Chairman to be chairman of a meeting shall be determined as between the Vice-Chairmen present (if more than one) by seniority in length of appointment or otherwise as resolved by the Directors.

82. QUORUM

The quorum for a meeting of the Directors shall be one third of the total number of Directors for the time being (which if not a whole number shall be rounded up to the nearest whole number) or six (6) whichever is the greater.

83. POWER OF QUORUM

A meeting of the Directors at which a quorum is present shall be competent to exercise all or any of the authorities, powers and discretions by or under these Articles for the time being vested in or exercisable by the Directors generally and shall do so by means of a resolution passed by the affirmative vote of a majority of their number.

84. RESOLUTION WITHOUT BOARD MEETING VALID

Except for the matters specified in Section 196 of the Ordinance, a Resolution in writing signed by all the Directors for the time being in office shall be as valid and effectual as if it had been passed at a meeting of the Directors duly called and constituted. For this purpose, it shall be permissible to circulate the text of the proposed resolution duly signed by the Chairman or the Chief Executive and obtain the signatures of all the other Directors thereon separately by fax (the signed original whereof shall be sent in due course by mail or courier to the Company for its record) and such resolution shall be effective as soon as the text of the resolution signed by each of the other Directors shall have been faxed to and received by the Company

85. DIRECTORS MAY ACT NOTWITHSTANDING VACANCY IN THEIR BODY

The continuing Directors may act notwithstanding any vacancy in their body but so that if their number falls below the minimum fixed by or under these Articles, the Directors shall not except for the purposes of increasing the number of Directors pursuant to Article 74 or summoning a General Meeting act so long as the number is below the minimum.

86. POWER TO APPOINT COMMITTEES AND TO DELEGATE

The Directors may delegate any of their powers or discretions not required to be exercised in their meeting (including without prejudice to the generality of the foregoing all powers and discretions whose exercise involves or may involve the payment or remuneration to or the conferring of any other benefit on all or any of the Directors) to committees. Any such committee shall, unless the Directors otherwise resolve, have power to sub-delegate to

sub-committees any of the powers or discretions delegated to it Any such committee or sub-committee shall consist of one or more Directors. Insofar as any such power or discretion is delegated to a committee or sub-committee, any reference in these Articles to the exercise by the Directors of the power or discretion so delegated shall be read and construed as if it were a reference to the exercise thereof by such committee or sub-committee. Any committee or sub-committee so formed shall in the exercise of the powers so delegated conform to any regulations which may from time to time be imposed by the Directors

87. AUDIT & HUMAN RESOURCE AND REMUNERATION COMMITTEES

The Directors shall designate from among their number two (2) committees, to be called respectively the Audit Committee and the Human Resource and Remuneration Committee with the following compositions and powers-

87.1 The Human Resource and Remuneration Committee (formerly the Compensation Committee) and the Audit Committee shall each consist of at least three and not more than five (5) Directors Atleast one member of the Committee shall be an independent Director

At least one of the members of the Audit Committee must have relevant financial experience The Chairman of the Audit Committee shall be an independent director, who shall not be the chairman of the Board

87.2 The Chief Executive, Secretary and Human Resource Manager may, at the invitation of the Human Resource and Remuneration Committee, attend and speak at meetings of the Human Resource and Remuneration Committee but shall have no voting rights The Chairman of the Directors shall be entitled without invitation to attend and speak at meetings of the Human Resource and Remuneration Committee but he shall not have the right to vote unless he is also a member ex-officio of the Human Resource and Remuneration Committee

87.3 The Chief Executive, and other persons, not being Directors, may, at the invitation of the Audit Committee, attend and speak at meetings of the Audit Committee but shall have no voting rights The Chairman of the Directors shall be entitled without invitation to attend and speak at meetings of the Audit Committee but he shall not have the right to vote unless he is also a member ex-officio of the Audit Committee

87.4 The Directors shall delegate the following powers exclusively to the Human Resource and Remuneration Committee-

(a) the establishment and maintenance of the remuneration policy of the Company,

(b) the review of remuneration targets and incentives of the Company,

(c) the review of contractual obligations with senior management of the Company,

(d) the selection and recommendation to the Board after international search and interview processes of candidates for the posts of Chief Executive, Director of Finance, Technical Director, and Construction Director of the Company should those posts become vacant. The Board shall not be obliged to appoint the candidate so selected, but shall not appoint any person to those posts who has not been recommended by the Human Resource and Remuneration Committee.

87.5 The Directors shall delegate the following powers exclusively to the Audit Committee:-

(a) the review of annual and interim financial statements prior to their presentation to the Board,

(b) liaison with the Company's auditors;

(c) the review of the scope and extent of internal audits and special investigations, compliance and declaration of interests by the Directors.

87.6 The quorum for a meeting of the Human Resource and Remuneration Committee and the Audit Committee shall be three (3) members (or their alternate Directors appointed in accordance with Article 77). If any alternate Director is also member of the Committee his voting rights on the Committee shall be cumulative but he shall not be counted more than once for the purposes of quorum.

88. MEETINGS OF THE COMMITTEES

The committees of the Board shall meet at such times as the Board shall determine, or in the absence of a determination by the Board, at the direction of the chairman of the committee. The committees of the Board shall have such powers to act in-between meetings of the Board as the Board shall delegate to them provided that no committee shall conduct any business or act under any delegation where such act would otherwise require to be performed by the Board at their meeting or as otherwise required by the Ordinance.

89. PROCEEDINGS OF COMMITTEE

The meetings and proceedings of any such committee consisting of two (2) or more members shall be governed by the provisions herein contained for regulating the meetings and proceedings of the Directors so far as the same are applicable thereto and are not superseded by these presents or any regulations made by the Directors under the last preceding Articles.

90. WHEN ACT OF DIRECTOR OR COMMITTEE VALID NOTWITHSTANDING DEFECTIVE APPOINTMENT

All acts done by any meeting of the Directors or by a committee of the Directors or

by any person acting as a Director or as a member of any such committee shall notwithstanding that it shall afterwards be discovered that there was some defect in the appointment of any such Director or person acting as aforesaid or that they or any of them was disqualified, be as valid as if every such person had been duly appointed and was qualified to be a Director

PART XII

POWERS OF DIRECTORS

91. GENERAL POWERS OF COMPANY VESTED IN THE DIRECTORS

The business of the Company shall be managed by the Directors who may pay all expenses incurred in promoting and registering the Company and may exercise all such powers of the Company as are not by the Ordinance or these presents or by a Special Resolution required to be exercised by the Company in General Meeting provided that no regulation made by the Company in General Meeting shall invalidate any prior act of the Directors which would have been valid if that regulation had not been made

PART XIII

CHIEF EXECUTIVE

92. APPOINTMENT OF CHIEF EXECUTIVE

The Company shall have a Chief Executive appointed in accordance with the provisions of Sections 198 and 199 of the Ordinance

93. CHIEF EXECUTIVE DEEMED TO BE A DIRECTOR

The Chief Executive shall if he is not already a Director elected under Article 71 be deemed to be a Director (in addition to the Directors appointed under Articles 73 and 74 or elected in the manner provided for in Article 71) and be entitled to all the rights and privileges and subject to all the liabilities of that office. Subject as aforesaid the terms and conditions of appointment of the Chief Executive shall be determined by the Directors

94. REMOVAL OF CHIEF EXECUTIVE

The Directors by resolution passed by not less than three-fourths of their number or the Company by a Special Resolution may remove a Chief Executive before the expiration of his term of office.

PART XIV

THE SEAL

95. CUSTODY OF SEAL

The Directors shall provide for the safe custody of the Seal and the Seal shall not be affixed to any instrument except by the authority of the Directors. Subject as aforesaid two (2) Directors or one (1) Director and the Secretary shall sign every instrument to which the Seal is affixed.

PART XV

RESERVES AND DIVIDENDS

96. RESERVES

The Directors may before recommending any dividend set aside out of the profits of the Company such sums as they think proper as a reserve or reserves which shall at the discretion of the Directors be applicable for meeting contingencies or for equalizing dividends or for any other purpose to which the profits of the Company may be properly applied and pending such application may at the like discretion be employed in the business of the Company or be invested in such investments (other than shares of the Company) as the Directors may, subject to the provisions of the Ordinance, think fit.

97. DECLARATION OF DIVIDEND

The Company in General Meeting may declare dividends but no dividend shall exceed the amount recommended by the Directors.

98. DIVIDENDS OUT OF PROFITS ONLY

No dividends shall be paid otherwise than out of the profits of the Company.

99. HOW PROFITS SHALL BE DIVISIBLE

The profits of the Company which it shall from time to time be determined to divide in respect of any year or other period shall be divisible among the Members in proportion to the number of the shares held by them respectively.

100. INTERIM DIVIDENDS

The Directors may from time to time pay to the Members such interim dividends as appear to the Directors to be justified by the profits of the Company.

101. TIME FOR PAYMENT OF DIVIDEND

Dividends shall be paid within the period laid down in Section 251 of the Ordinance.

102. NO INTEREST ON DIVIDEND

No dividend shall bear interest against the Company

103. DIVIDEND TO JOINT HOLDERS

Any one of several persons who are registered as the joint holders of any shares may give effectual receipt for any dividend payable in respect of such shares.

104. EFFECT OF TRANSFER

A transfer of shares shall not pass the right to any dividend declared thereon before the day of registration of the transfer.

105. RETENTION OF DIVIDENDS

The Directors may retain the dividends payable upon shares in respect of which any person is under the Transmission Article entitled to become a Member or which any person under that Article is entitled to transfer until such person shall become a Member in respect thereof or shall duly transfer the same.

106. UNCLAIMED DIVIDENDS

All dividends unclaimed for one year after having been declared may be invested or otherwise made use of by the Directors for the benefit of the Company until claimed.

PART XVI

CAPITALISATION OF PROFITS AND RESERVES

107. CAPITALISATION OF RESERVES

The Members of the Company in General Meeting may upon the recommendation of the Directors resolve that any undivided profit of the Company (including profits carried and standing to the credit of any reserve or reserves or other special account and profits arising from the appreciation in value of capital assets) be capitalized and distributed amongst such of the Members as would be entitled to receive the same if distributed by way of dividend on the shares and in the same proportions on the footing that they become entitled thereto as capital and that such capitalized fund be applied on behalf of such Members in paying up in full any unissued shares, debentures or securities of the Company which shall be distributed accordingly and that such distribution or payment shall be accepted by any such Members in full satisfaction of their interest in such capitalized sum. Whenever such a resolution as aforesaid shall have been passed the Directors shall make all appropriations and

applications of the undivided profits resolved to be capitalized thereby and all allotments and issues of fully paid shares, debentures or securities, if any, and generally shall do all acts and things required to give effect thereto, with full power to the Directors to make such provision by payment in cash or otherwise as they think fit in the case of shares, debentures or securities becoming distributable in fractions and also to authorise any person to enter, on behalf of all the Members interested, into an agreement with the Company providing for any such capitalisation and matters incidental thereto and any agreement made under such authority shall be effective and binding on all such Members.

PART XVII

MINUTES AND BOOKS

108. MINUTES TO BE RECORDED

The Company shall cause a fair and accurate summary of the minutes of all proceedings of General Meetings and meetings of its Directors and committees of Directors, along with the names of those participating in such meetings, to be entered in properly maintained books.

109. BOOKS OF ACCOUNT TO BE KEPT

The Directors shall cause to be kept proper books of account with respect to all sums of money received and expended by the Company and the matters in respect of which the receipt and expenditure takes place all sales and purchases of goods by the Company and all assets and liabilities of the Company.

110. BOOKS OF ACCOUNT TO BE KEPT AT OFFICE

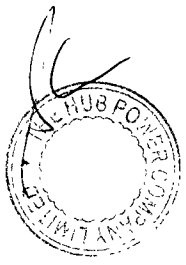
The books of account shall be kept at the Office or at such other place in Pakistan as the Directors may decide and when the Directors so decide the Company shall, within seven (7) days of the decision, file with the Registrar a notice in writing giving the full address of that other place.

111. ANNUAL ACCOUNTS AND BALANCE SHEET

The Directors shall as required by Sections 233 and 236 of the Ordinance cause to be prepared and to be laid before the Company in General Meeting such profit and loss accounts and balance sheets duly audited and reports as are referred to in those Sections.

112. DIRECTORS TO COMPLY WITH ORDINANCE

The Directors shall in all respects comply with such of the provisions of Sections 230 to 247 of the Ordinance as may be applicable.



PART XVIII

AUDIT

113. APPOINTMENT OF AUDITORS

Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255 of the Ordinance.

PART XIX

NOTICES

114. HOW NOTICE MAY BE GIVEN

A notice may be given by the Company to any Member either personally or by sending it by post to him to his registered address or if he has no registered address in Pakistan to the address, if any, within or outside Pakistan supplied by him to the Company for the giving of notices to him.

115. NOTICE SENT BY POST

Where a notice is sent by post, service of the notice shall be deemed to be effected by properly addressing, prepaying and posting a letter containing the notice and unless the contrary is proved to have been effected forty-eight (48) hours after the time when the letter containing the notice is posted.

116. NOTICE TO MEMBERS WHO HAVE NOT SUPPLIED ADDRESS

If a Member has no registered address and has not supplied to the Company an address within or outside Pakistan for the giving of notices to him a notice addressed to him or to the shareholders generally and advertised in a newspaper circulating in the Province in which the Office is situate shall be deemed to be duly given to him on the day on which the advertisement appears.

117. NOTICE TO JOINT HOLDERS

A notice may be given by the Company to the joint holders of a share by giving the notice to the joint holder named first in the Register in respect of the shares.

118. NOTICE TO PERSONS ENTITLED BY TRANSMISSION

A notice may be given by the Company to the persons entitled to a share in consequence of the death or insolvency of a Member by sending it through the post in a prepaid letter addressed to them by name or by the title of representatives of the deceased or assignees of the insolvent or by any like description at the address if any in Pakistan supplied for the purpose by the persons claiming to be so entitled or until such an address has been so supplied by giving the notice in any manner in which the

same might have been given if the death or insolvency had not occurred.

119. NOTICE OF GENERAL MEETING

In addition to any other mode provided by the Ordinance for notice of any General Meeting, notice of every General Meeting shall be given in the manner hereinbefore authorised to:

119.1 every Member of the Company except those Members who having no registered address within Pakistan have not supplied to the Company an address within or outside Pakistan for the giving of notices to them;

119.2 every person entitled to a share in consequence of the death or insolvency of a Member who but for his death or insolvency would be entitled to receive notice of the Meeting;

119.3 the Auditors of the Company for the time being; and

119.4 the Directors.

PART XX

SECRECY

120. MEMBERS NOT ENTITLED TO INFORMATION

No Member not being a Director shall be entitled except to the extent expressly permitted by the Ordinance or these presents or by the Chief Executive or the Directors to enter upon the property of the Company or to inspect or examine the Company's premises or properties or to require discovery of any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade or secret process or which may relate to the conduct of the business of the Company and which in the opinion of the Directors it will be inexpedient in the interest of the Members of the Company to communicate to the public.

PART XXI

INDEMNITY

121. INDEMNITY

Subject to the provisions of Section 194 of the Ordinance every Director, Chief Executive and other officer or servant of the Company shall be indemnified by the Company against and it shall be the duty of the Directors out of the funds of the Company to pay all costs, losses and expenses which any such officer or servant may incur or become liable to pay by reason of any contract entered into or act or thing

done by him as such officer or servant or in any way in the discharge of his duties including travelling expenses and in particular and so as not to limit the generality of the foregoing provisions against all liabilities incurred by him in defending any proceedings whether civil or criminal in which judgment is given in his favour or he is acquitted or in connection with any application under Section 488 of the Ordinance in which relief is granted to him.

PART XXII

WINDING UP

122. DISTRIBUTION OF ASSETS

122.1 If the Company is wound up the Liquidator may, with the sanction of a Special Resolution of the Company and any other sanction required by the Ordinance divide among the Members, in specie or kind, the whole or any part of the assets of the Company whether they consist of property of the same kind or not.

122.2 For the purpose aforesaid the Liquidator may set such value as he deems fair upon any property to be divided as aforesaid and may determine how such division shall be carried out as between the Members.

122.3 The Liquidator may with the like sanction vest the whole or any part of such assets in trustees upon such trusts for the benefit of the contributories as the Liquidator with the like sanction thinks fit but so that no Member shall be compelled to accept any shares or other securities whereon there is any liability.

We are several persons whose names and addresses are subscribed below are desirous of being formed into a Company in pursuance of this Memorandum of Association, and we respectively agree to take the number of shares in the capital of the Company set opposite our respective names:-

Name and Surname (present and former) in full (In Block Letters)	Father's/Husband's Name in full	Nationality with any former nationality	Occupation	Residential address in full	Number of shares taken by each subscriber	Signature
1. MOHAMMED AHMED ALIREZA	AHMED YUSUF ALIREZA	SAUDI ARABIAN	Chairman	c/o Xenel Industries Ltd P.O. Box No 2824, Jeddah 21461 Kingdom of Saudi Arabia	1	
2. KHALID AHMED ALIREZA	-do-	-do-	-do-	-do-	1	
3. MOHAMMED ASHRAF TUMBI	HAJI ABDUL SHAKOOR TUMBI	PAKISTANI	General Manager (Finance)	-do-	1	
4. ADNAN ABDULLAH MAIMANI	ABDULLAH IBRAHIM MAIMANI	SAUDI ARABIAN	Chief Legal Advisor	-do-	1 (Signed)	
5. VILAIAT HUSAIN ABEDI	BAHADAR HUSAIN	-do-	Executive	-do-	KAIRAS N. KABRAJI (duty constituted attorney)	
6. JAMES ALISTAIR STRACHAN CHAPMAN	JAMES LESLIE CHAPMAN	BRITISH	General Manager (Construction)	-do- -do-	1	
7. JOHN THOMAS FARNDON	LESLIE PARNDON	-do-	Project Manager	12 Toucan Way, Kingswood Basildon, Essex SS16 5ER UK.	1	

Dated the 16th day of July 1991

Witness to above signatures: ASHFAQ HUSAIN QURESHI
S/O ASGHAR HUSAIN QURESHI.

(Signed) Ashfaq Hussain Qureshi

Occupation: Advocate
Full Address: B-83,
Mohammad Ali Society,
Karachi

中国能建广东院
ENERGY CHINA GEDI

National Integrated
Class A certificate:
A 1 4 4 0 0 4 3 1 7

Feasibility Study Report for China Power HUBCO 2×660MW Coal-fired Power Plant Project

General Description

44-FC08931K-A01

Rev00

Guangdong Electric Power Design Institute of China Energy Engineering Group

July 2015 Guangzhou

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FOREWORD-1 EXECUTIVE SUMMARY

There are numerous issues affecting the power sector in Pakistan resulting in power shortage with a peak value of around 7,000MW. Electricity is one of the most fundamental requirements for any country. For Pakistan, GDP Growth has slowed down by at least 2% per annum due to the increasing power shortage. Availability of hydel and wind based plants in the country is seasonal as the prime objective of the country's Water Management System i.e. Dams is to manage water for agriculture, and electricity generation is considered a by-product. Wind on the other hand is seasonal, primarily available during the monsoon season. Therefore, base load power generation plants can either be nuclear or thermal. Thermal plants use oil, gas or coal as fuel to generate electricity. Furthermore, generation plants based on gas as a fuel have higher efficiencies making them more economical than oil, but still the per unit cost of electricity is higher. In addition to the power shortage, the fuel mix is also a systemic issue as approximately 60% of the power generated in the country is through Oil & Gas, which is i) expensive, and ii) not abundantly available as compared to some of the other countries that rely on these sources in similar or more proportions. Moreover, the Government of Pakistan is unable to pass on the real cost of power generation to the poor population and subsidies are budgeted.

However, due to ever increasing cost of fuel, the allocated subsidy runs out early in the financial year and an industry-wide 'circular debt' keeps building up. The most optimum way out is to shift the energy mix towards a more balanced form, which is in line with regional economies. Coal based power plants are needed on fast-track basis to take up the base load share from oil and gas. This will bring in much needed additional megawatts into the grid and contribute towards reducing the 'circular debt' issue to manageable levels. Once the power sector is more competitive than it is today, economic activity can be sustained leading to an overall economic revival for the country.

The current Government has launched various power projects to address the power shortage. However, private sector involvement is also crucial towards addressing this challenge. In order to facilitate fast-track power project development, various regulatory agencies are facilitating the private sector. One such step is the issuance of the 'Upfront Tariff for Coal based Power Projects' by NEPRA. Coal locally discovered in the form of Lignite in Thar would take few years to be mined and made available for power plants (thus is out of scope of this report). Therefore, electricity generation plants have to be designed and constructed based on imported coal till such time. This will be a cheaper source of generating electricity, which is of paramount importance, thus, leading towards correction in the unbalanced energy mix for the country. However, energy mix provides only a partial answer. Reliable arrangement needs to be put in place to remove inefficiencies from the electrical system, pass on the real cost to the consumers in the form of tariff and eliminate theft besides other points, which is out of scope of this report.

HUBCO explored different options for growth opportunities and is committed to play a strategic role in the development of Pakistan's power sector to provide necessary stimulus to

the economy. Financing such projects was not possible from local banks of Pakistan, thus forcing Pakistani companies to look out for options outside the country. At the same time, Government of Pakistan established China Pakistan Economic Corridor (CPEC) through which investment commitment was provided by Chinese Government for a lot of development projects in Pakistan. HUBCO partnered with one of the leading Top 5 Power Sector Companies of China through a 'Special Purpose Vehicle' to setup a 2x660MW Coal Based Power Plant beside the existing 4x323MW Oil-Fired Power Plant (Plant-1). Together with the Chinese partner, both organizations worked towards getting this project qualified as an actively promoted project. More efforts are being put in to get the project up the CPEC's fast track projects' list.

The Hub Power Company Limited ("HUBCO") is the first and largest Independent Power Producer (IPP) in Pakistan to be financed by the private sector in Southern Asia and is one of the largest power projects in private sector.

China Power International Limited ("China Power International") ("CPIH") was established in Hongkong, mainly engaged in development construction and operation of power supply project and committed to overseas investment and financing and capital operation.

In order to gauge feasibility of the project, a well renowned consultant of Chinese Power sector has been contracted. Guangdong Electric Power Design Institute Co., Ltd. of China Energy Engineering Group ("GEDI") was founded in 1958. GEDI is a leading Chinese engineering enterprise with National Comprehensive Engineering Class A qualification, substantial influence in the industry and strong competitiveness in the market. GEDI has been named an ENR-Construction Times Top 60 China Design Firms for straight ten years. Top 10 Project Contractors and Top Self-Innovation Firms of Engineering Industry. GEDI has experience of more than 50 years in survey, geotechnical investigation, consulting, EPC contracting and project management of electric power projects. With electric power industry as the fundamental area, GEDI is also able to undertake consulting, survey and geotechnical investigation, design, EPC contracting, project management and relevant technical service in 21 industries, namely, building, nuclear, coal, chemical, petro-chemical, medicine, oil and natural gas, electronic, telecommunication, broadcast, railway, highway, public works, irrigation works, marine industries.

HUBCO owns 1500acres of land, of which 70 acres has been utilized by Plant-1. Considering the successful operation of Plant-1 without any major issues, an executive decision was taken by both partners to utilize the same land instead of buying land elsewhere. Thus, ample land would be available for the power plant. Both partners have even discussed to have continued cooperation towards setting up additional units at the same site (after the current project is successfully implemented) up to 6x660MW power plants based on coal. For sake of clarity, the scope of the current plant and this report is 2x660MW power plant only and the next plants will be evaluated later.

Various options of coal fuel from well established markets of South Africa, Indonesia Australia were worked out to determine the performance (design) and check coal for the project. A separate study was conducted by both partners in order to determine the

commercial setup of coal supply, suppliers, carriers and other related parties. Main focus of the study was to come up with a reliable source and blend of coals for 30 years of continued plant operation, yet keeping the plant cost within the regime of Upfront Tariff. As a result of the studies, Design Coal was selected to be based on South African RB-III coal spec. Moreover, different blending options were considered with Indonesian Indo-C coal. Finalization of boiler and other plant parameters will be done considering these results to optimize the design of the plant.

Due diligence studies were conducted through third parties to assess options of getting coal on the ground at Hub site for the plant. Existing ports (KPT and Port Qasim) were visited and studied by third parties to gauge their operation and handling of an additional 4 million tons of coal for the plant. Trucking option was studied in order to bring coal from the ports to Hub site. Railway network was considered as another option. In addition to the existing infrastructure, multiple options of having a new jetty terminal at Hub site were also considered, for which a separate feasibility study was undertaken. Having a standalone Jetty Terminal for the project to import coal turned out to be the best solution. This is because existing road network cannot support the requirement in 'as-is' condition and a lot of road repairs and other associated works will be required, and rail lines are not laid to reach Hub site and have to have major infrastructure investment through local and federal governments. Please refer to the Jetty Feasibility Study for more information.

Grid study has been conducted by NTDC and was facilitated by both the partners. GEDI's design scope was limited up to the switch yard (gantry), beyond which it is the responsibility of the off-taker to ensure availability of power transmission lines, towers and associated infrastructure. Primary a 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station. NTDC has already issued NOC to establish 2x660MW power plant units at Hub Site implying the ensure availability of transmission lines before the RCOD of power plant.

As per directive of CPEC, both Chinese and Pakistani Governments agreed to have Chinese standards and equipment as design basis for the power plant. Furthermore, both partners agreed that Chinese codes and standards will provide base for design of the equipment, installation and civil structures. However, mandatory Pakistani laws, standards and other site specific requirements would take precedence over base Chinese standards respectively. Power plant scheme of major equipment and performance conditions selection are based on the years of Chinese experience with supercritical technology and the standards established on National level for the selected technology. The reliability, efficiency and auxiliary load requirement of the Upfront Tariff will be met for 30 years of operation and there will be margin for further optimization during the basis design phase.

Main equipment includes 2x660MW once-through supercritical, PC (Pulverized Coal) boilers with one reheat, supercritical parameter condensing turbines and three-phase AC generators, which will be capable to generate approximately 2x607 MW Net power output with the auxiliary load of 7.93% and efficiency of greater than 39% as per the requirement of Up-front Tariff. Project equipment and technology is being designed to meet the 85%

availability requirement of PPA (Power Purchase Agreement).

The selection of power plant equipment is done keeping in view the environmental impacts of coal fired technology and takes into account the current and near future values of environmental parameters. The design will meet the NEQS and Ambient Air Quality Standards of Pakistan as a minimum requirement and the stack limits defined are based on the current background concentration of air quality and the margins to be kept for future expansions. The Environmental equipment selected are to meet the emission limits defined in the report and will comprise of low NOx burners, Flue Gas Desulfurization, Particulate matter removal and high stack. Wastewater treatments systems for plant effluents, coal yard runoffs, sewage streams will be the part of plant design so that all the liquid streams meet the NEQS limits before entering into the sea. The plant battery limits are to meet the Industrial noise limits for day and night times.

Supercritical steam technology has its own associated hazards that need to be controlled within allowable ranges. It has been decided by both partners to give personnel and equipment safety paramount importance and priority over all other items for the project. Therefore, world class safety standards will be employed for this project, which will start from design phase and continue till the life cycle of this project and plant. HUBCO has had a rich safety culture at the existing site due to its association with RoSPA, and is currently aligning its process with DuPont's recommended safety practices for operational and personnel safety. CPIH, also has number of years of experience of developing, implementing, operating and maintaining super critical coal based power plants, would add immensely to the overall safety culture at the project site.

Project schedule has been developed by both partners and shared with relevant authorities in both countries, which is also in line with the Upfront Tariff requirements. In order to further streamline the activities and aim to bring the first unit online before end of 2018, a target of 36 months and 42 months from Financial Close has been selected for the EPC for unit 1 and 2 respectively. PPIB has issued Letter of Intent (LOI) for the project to the Project Owner (partners), which implies that the date of applying for the Upfront Tariff is around mid-September 2015. Before Tariff application, Generation License application has to be submitted, which shall be obtained prior to applying for Letter of Support (LOS). After having LOS, IA and PPA can be signed, for which project company has been advised to start negotiations with CPPA and other authorities by end July 2015. Therefore, project company must work very closely with all relevant authorities to obtain required certificates, letters and other permissions.

The Upfront Tariff mentions Capital Cost Indexation mechanism that is the basis of determining the overall project cost and is linked directly with US PPI. It is imperative for the EPC of the plant to determine the most prudent contracting strategy to stay within the negotiated EPC price. EPC Price escalation in this project will make this project non-feasible due to indexed tariff. Since the project design is based on Chinese codes, it is recommended to go ahead with Chinese EPC contractors. However, the most important thing is the approach the EPC contractor will take.

One of the main corporate objectives of the project is to work for the surrounding communities and locality as part of the Corporate Social Responsibility (CSR). This will be done with the help of HUBCO because of their experience in providing such works, and CPIH has showed keen interest in supporting this important initiative. Social and welfare work will be carried out in the vicinity of the power plant in order to improve the living standards of the poor people, provide them with basic necessities of life like clinics, schools, technical training and education centres etc.. Therefore, this cost will be budgeted in the project's overall cost. This project is also feasible from a social and welfare perspective as there is a lot of room for improvement.

Therefore, in light of the aforementioned facts, this project is considered highly feasible and should help the country in arriving at optimum fuel mix ration and should have a positive impact on acute shortage in the power sector.

FOREWORD-2 ABBREVIATIONS AND DEFINITIONS

PAKISTAN
Islamic Republic of Pakistan

CHINA
Peoples Republic of China

HUBCO
The Hub Power Company Limited

CHINA POWER INTERNATIONAL
China Power International Limited

OWNER
HUBCO and CHINA POWER INTERNATIONAL together

NEPRA
National Electricity and Power Regulatory Authority of Pakistan and is the Power Purchaser for the Project

NTDC
National Transmission and Dispatch Company Limited of Pakistan which will plan for power evacuation

PPA
Power Purchase Agreement between OWNER and NEPRA

ESIA
Environmental and Social Impact Assessment of Plant (if not otherwise stated)

ESP
Electrostatic Precipitator for control of particulate matter to atmosphere

FGD
Flue Gas Desulfurization System for Sulfur Oxides Emission Control to atmosphere

SWFGD
Sea Water based Flue Gas Desulfurization System for Sulfur Oxides Emission Control to atmosphere

SWRO
Sea Water Reverse Osmosis System taking Sea Water as feed water

BWRO
Brackish Water Reverse Osmosis System taking SWRO product or other less saline water as feed water

DESIGN COAL

Coal selected to determine the optimum power plant performance parameters keeping in view the coal market study and with the intent of finalizing the performance coal for PPA

CHECK COAL

Coal selected to cover the wide range of coal available in the market and which will be the basis for the best blend with the design coal for optimum equipment sizing and cost

STANDARD COAL CONSUMPTION

Standard Coal Consumption is based on Chinese Standard Coal having NAR Heating Value of 7000 Kcal/Kg while using the heat requirement based on design coal. The purpose of defining this coal consumption is to benchmark with similar technologies in China in terms of efficiency and cost

NAR

Net Heating Value of As Received Coal

GAR

Gross Heating Value of As Received Coal

ARB

Coal parameter on As Received Basis

ADB

Coal parameter on Air Dried Basis that included inherent moisture but no free moisture

DB

Coal parameter on Dry Basis after excluding total moisture

DAF

Coal parameter on Dry Ash Free Basis

BMCR

Boiler Maximum Continuous Rate at mean site conditions unless otherwise stated

TMCR

Turbine Maximum Continuous Rate at mean site conditions unless otherwise stated

VWO

Valves Wide Open condition of main steam turbine which corresponds to BMCR steam flow at mean site conditions

1. General

1.1 Project background

The installed power generation capacity of Pakistan has grown by about 16 percent in recent years from 2008 to 2012, while electricity shortages have increased sharply by 242 percent. The supply and demand gap is still increasing and in 2014, the power shortage peak reached ~5,384MW. To deal with power supply shortage and to maintain economic stability and fast development, The Government of Pakistan has developed mid-term (2011-2015) and long-term (2030) development plans for power sector. Focus is given to development of large hydropower and coal power projects. It actively seeks foreign fund and technical supports.

In May 2013, Chinese Premier Li Keqiang visited Pakistan and proposed building China-Pakistan Economic Corridor and conducting cooperation in major project, energy and resource, agricultural irrigation, information communication and other fields to bring economic and trade relation between the two countries closer and promote joint development of both countries.

From July 22 to August 3, 2013, on the invitation from government of Pakistan, relevant leaders of China Power International Limited (China Power International in short) visited Pakistan.

On April 14, 2014, China Power International made a public announcement and established China Power International Pakistan Project Department.

From October 22 to 30, 2014, senior management of China Power International went to Pakistan and met Pakistan's Prime Minister Nawaz Sharif. Prime Minister Nawaz Sharif extended welcome to the investment of power plant project from China Power International and asked government departments to support China Power International in their projects by providing good policies and safe environment. China Power International and their project partner reached a consensus and obtained strongest support from Pakistani government, Chinese embassy in Pakistan and many partners which laid a solid foundation for development of the company's international projects to effectively control the associated risks.

With strong support of Chinese and Pakistani governments and joint efforts of China Power International and HUBCO, China Power HUBCO 2×660MW coal-fired power plant project has been listed as one of the major projects for China-Pakistan Economic Corridor.

1.2 General information of Investors

China Power HUBCO 2×660MW coal-fired power plant project is invested jointly by China Power International Limited and The Hub Power Company Limited with equity investment of 51% and 49% respectively.

1.2.1 China Power International Limited

With approval of the former State Planning Commission and Ministry of Foreign Trade,

China Power International Limited ("China Power International") was established in Hongkong, mainly engaged in development construction and operation of power supply project and committed to overseas investment and financing and capital operation. At the end of 1998, in the spirit of State Council Guo Ban Fa [1998] No. 146 document, China Power International was reconstructed as a wholly-owned subsidiary of State Power Corporation. During that period, the company had breakthrough in preventing operation risk and enhancing assets quality. Especially in 1997, capital injection was done in a very short time and debt asset ratio was reduced. It dealt with Asian financial crisis in 1997 properly. At the end of 2002, in power system reform, China Power International became a wholly-owned company of China Power Investment Corporation.

In 2013, power generation of China Power International was 91181GWh, coal consumption was 313.6g/kW, utilization hours of coal-fired units were 5042h, operating revenue of 32.889 billion yuan, and total profit of 4.429 billion yuan. The total assets were 109.966 billion yuan and asset-liability ratio was 73.26% at the end of year 2013.

As of the end of 2013, installed capacity of China Power International was 22,494.8MW, including 16,966.5MW thermal power (including coal power, gas power and garbage power), 4,508.8MW hydropower, 919.5MW wind power and 100MW solar energy.

1.2.2 The Hub Power Company Limited

The Hub Power Company Limited ("HUBCO") is the first and largest Independent Power Producer (IPP) in Pakistan to be financed by the private sector in Southern Asia and is one of the largest power projects in private sector. HUBCO was established about 20 years ago when a consortium of international investors, governments and commercial banks came together to finance a major infrastructure project in a developing country like Pakistan. Today HUBCO stand at a distinctive position where its growth leads to the development of Pakistan.

The HUBCO's main power plant currently in operation is of 1320 MW Gross (4x323 MW) capacity and is located near Hub, Baluchistan. HUBCO is the only IPP in the country to go into expansion and has set up a 213 MW plant at Narowal in Punjab province. HUBCO is also the owner of Pakistan's first renewable energy IPP, namely Laraib Energy which is a run-of-the river hydel based power project.

With the combined production capacity of over 1600 MW Gross, and a firm commitment to provide long-term solution to the energy challenges in the country, HUBCO and its subsidiaries are well positioned to emerge as the "Hub of Power" for Pakistan. To continue pioneering company's role in the power sector of Pakistan, HUBCO's Board of Directors has given management the mandate to develop a 2 x 660 MW (with an aspiration of 6 x 660 MW) Imported Coal Based power plant to not only help the country in overcoming the current power crisis but also to provide the people of Pakistan with cheap electricity using Optimum energy mix.

1.3 Study scope

Scope of the feasibility study is prepared according to "Regulation for contents and details of

feasibility study report of fossil fuel power plant" (DL/T 5375-2008) and is in accordance with project construction requirements in Pakistan. The Report includes assessment of site conditions, determination of unit equipment, power plant principle process systems and arrangement scheme, general planning and design of auxiliary facility works, analysis on environmental protection, project implementation condition and construction schedule, investment estimate and economic benefits, and various risks.

The feasibility study conducts site topography, geological investigation and hydro-meteorological survey and information collection work.

Other special studies conducted separately but are referenced in this report are

- Grid interconnection study report
- Environmental and social impact assessment report for Plant
- Analysis of Supply of Coal to 2x660 MW coal fired Power Plant at Hub Site
- Feasibility study report for Jetty.
- Environmental and social impact assessment for Jetty

1.4 General situation of project

1.4.1 General situation of project site

China Power Hubco 2×660MW coal-fired power plant project is located southwest of Baluchistan Province, N 24°54′9″ and E 66°41′31″. It is about 20km from the downtown area of Hub and is within the Hubco's 1500-acre (600hm^2) power generation unit site and close to HUBCO Power Plant (Oil-fired units). In this project adopts the site at northwest of HUBCO Power Plant, north side of its intake open cahnnel and west side of 500kV outgoing line corridor. Land area within the plant enclosing wall is about 43.4hm^2.

Baluchistan Province (Baluchistan) has an area of 340,000 km^2 and is the province with the largest area in Pakistan. It has a population of 7,167,000, making up 5% of the total population in the country. It is the province with the least population. The entire province is divided into 29 districts with the capital of Quetta. The main cities include Hub, Gawadar, Usta, Chaman, Sibi, Kalat.

Baluchistan Province is close to Afghanistan at the north, Iran at the west and the Arabian Sea at the south. It is the only way from East Asia to West Asia, also the potential trade channel of transit for Central Asian countries and Afghanistan and the potential energy channel from Middle East and Central Asia to Far East. It has very important geographic position.

1.4.2 Feasibility study basis

Main feasibility basis include (without order of precedence)

1. Regulation for contents and details of feasibility study report of fossil fuel power plant (DL/T 5375-2008), whose content refer to Annexure 1;

3. Applicable Regulatory and Government documents in Pakistan;

4. Power Purchase Agreement (PPA) - refer to draft version in Annexure 2;

7. Up Front Tariff for Coal Power Plants in Pakistan- refer to Annexure 3;

8. Environmental and Social Impact Assessment (ESIA)

9. Other supporting documents which are included in the Annexures.

1.4.3 Codes and standards

Order of precedence for codes and standards to be:

1. Mandatory codes, standards and regulations in Pakistan.

2. Site specific requirements

3. Chinese codes and standards

1,4.4 Main design principles

1) China Power Hubco 2×660MW coal-fired power plant project constructs 2×660MW supercritical coal-fired units and reserves extension conditions for 4×660MW units. Only seawater intake channel is designed for 6 units to provide assistance in construction phase of future projects, however, all the other facilities are designed for 2 units. For this phase of project, living area (township) is considered at the northern side of plant (near to the entrance of existing plant), however, techno-economic and environmental evaluation regarding the location of living area will be conducted in basic design phase. Refer to drawing no. 44-FC08931K-A02-Z02, 03 for the proposed location.

2) Desulphurization equipment is built simultaneously and Sea water desulphurization process is considered at present stage. Low-NOx burners are selected and space along with related duct work for SCR denitrification equipment is reserved for the time being. Plant emissions, effluents, noise etc will at least meet the National Environmental Quality Standards (NEQS) of Pakistan and the limits mentioned in ESIA report.

3) Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3.

4) Annual utilization hours of the units are 7446 h (according to the 85% availability requirement in Up Front Tariff (Annexure 3) , that is 365×24×85%=7446 h).

5) Plant efficiency should more than 39% as per "Up Front Tariff" (Annexure 3).

6) Main equipment:

The parameter of main equipments mentioned below are the typical 600MW grade parameters as per GB/T 754-2007 "Parameter series of steam turbines for power plant", and many units under such parameters have been operated safety and efficiency in China.

Boiler: 660MW supercritical once-through pulverized coal boiler, corner tangential combustion, one reheat cycle, single furnace balance draft, ∏ type arrangement, dry bottom, full steel frame suspension structure. Boiler outlet steam parameters (BMCR condition) (tentatively): 25.4MPa (g)/571℃/568℃, guaranteed efficiency of boiler ≥93.3% (low heating value). Final parameters shall be determined through tendering.

Steam turbine: adopting 660MW supercritical parameter, one reheat cycle, tandem compound, three-cylinder-four-extraction, condensing turbine. Inlet rated steam parameters of turbine (TMCR condition) (tentatively): 24.2MPa (a)/566℃/566℃. Final parameters shall be determined through tendering.

Generator: adopting 660MW water, hydrogen and hydrogen cooled three-phase AC non-salient pole synchronous motor, static and self-shunt excitation.

7) Ash and slag system considers separate removal of ash and slag and dry ash removal and dry slag removal.

8) The once through cooling water system is used in the plant. Fresh water is provided by the sea water desalination system.

9) Plant outgoing line is considered based on 500kV as per Annexure 1.

1.5 Main equipments list and design terminal points

1.5.1 Main equipments list

The main equipments or systems are as follows:

Item	Main equipments or systems
1	Boiler
2	Turbine
3	Generator
4	Thermal system
5	Combustion system
6	Coal handling system
7	Coal pulverization system
8	Ash handling system
9	Cooling water system
10	Seawater desalination system
11	Waste water treatment system
12	Seawater desulfurization system
13	Electrical system
14	Instrument & control system
15	Stack
16	Coal yard
17	Emergency ash yard

18	Hydrogen station
19	Ventilation & air conditioning system
20	Fire protection system

1.5.2 Design terminal points

Design terminal points (are as follows:

Item	Description	Terminal point (TP)
1	Grid connection (outgoing lines)	At the power plant 500kV distribution device outgoing
2	Coal	Stacker/Reclaimer of coal yard in plant
3	Air Emissions	Outlet of stack
4	Seawater intake	Sea water intake channel inlet in Arabian Sea
5	Seawater discharge	Sea water discharge culvert outlet in Arabian Sea
6	Plant access road	Connected to existing access road of existing Hubco Power Plan

Note: Detailed positions of TPs in plot plan refer to "MAIN DESIGN TERMINAL POINTS LIST" of 44- FC08931K-A02-Z03~05.

1.6 Contracting strategy suggestion

In order to control project cost and speed up project construction, we suggest selecting a Chinese EPC as the General Contractor. As to the selection of the main equipment for the power plant, we suggest determining the main equipment supplier through open bidding or invited bidding to ensure equipment quality and performance satisfying requirements of EPC bidding documents.

2. Power system

2.1 Brief of Pakistan

Pakistan, short for Islamic Republic of Pakistan, is located in northwest South Asia subcontinent. Pakistan borders Arabian Sea in the south, India in the east, China in northeast, Afghanistan in northwest and Iran in the west. The coastline is 980 kilometers long. The climate is subtropical except the tropical climate in south area. The former capital is the largest city Karachi, and now the capital is changed to Islamabad. Pakistan has 79.6 million square kilometers land area (not including the Pakistani controlled Kashmir) and 1.97 billion people (2013) including 63% of the Punjabi, Sindhi accounted for 18%, 11% Pashtun, and Baloch accounted for 4%.

Pakistan administrative division includes four provinces and two federal territories which can be shown in figure 2.1.

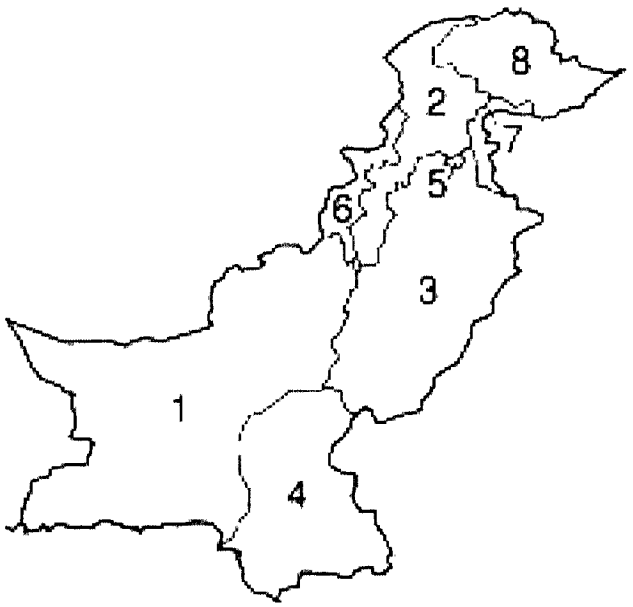


Figure 2.1 Pakistan administrative division

Province:

1- Baluchistan, land area is 347,190 square kilometers, capital is Quetta.

2- Khyber Pakhtunkhwa, land area is 74,521 square kilometers, capital is Peshawar.

3- Punjab, land area is 74,521 square kilometers, capital is Lahore.

4- Sindh, land area is 140,914 square kilometers, capital is Karachi.

5- Islamabad, land area is 906 square kilometers.

6- FATA, land area is 27220 square kilometers, Pakistani controlled Kashmir.

7- Azad Kashmir, land area is 13297 square kilometers

8-northern area, 72,496 square kilometers

Main cities:

Karachi, Islamabad, Lahore, Rawalpindi, Peshawar, Faisalabad, Timur Dan, Hyderabad, Sukkur, Gilgit, Quetta, Gwadar Port

The mainly information from section 2.1~2.9 quoted from "State of Industry Report 2014" (http://www.nepra.org.pk) by National Electrical Power Regulatory Authority.

2.2 Main parameters of electric power system

Rated Frequency: 50Hz Frequency tolerance: ±0.5Hz

Rated voltage and voltage tolerance can be shown in table 2.2.

Table 2.2 Rated voltage and voltage tolerance

Rated voltage	Normal condition		N-1condition	
	Highest voltage	lowest voltage	Highest voltage	lowest voltage
500kV	540kV	475kV	550kV	450kV
220kV	238kV	209kV	245kV	198kV
132kV	143kV	125kV	145kV	119kV
66kV	+5%Un	-5% Un	+10% Un	-10% Un
11kV	+5% Un	-5% Un	+10% Un	-10% Un
400V	+5% Un	-5% Un	+10% Un	-10% Un

2.3 Power grid structure and its operation management

The main transmission sector is composed of network of 500 kV and 220 kV transmission lines and grid stations. The corresponding transformation capacity is shown in table 2.3-1:

Table2.3-1 Transformation capacity of 500kV and 220kV network (as on June 30th 2014)

voltage class	Number of substation	Length of transmission lines	Transformation Capacity
500kV	13	5,183km	17,400MVA
220kV	35	9,104km	21,030MVA

The following map shows layout of the NTDC network.

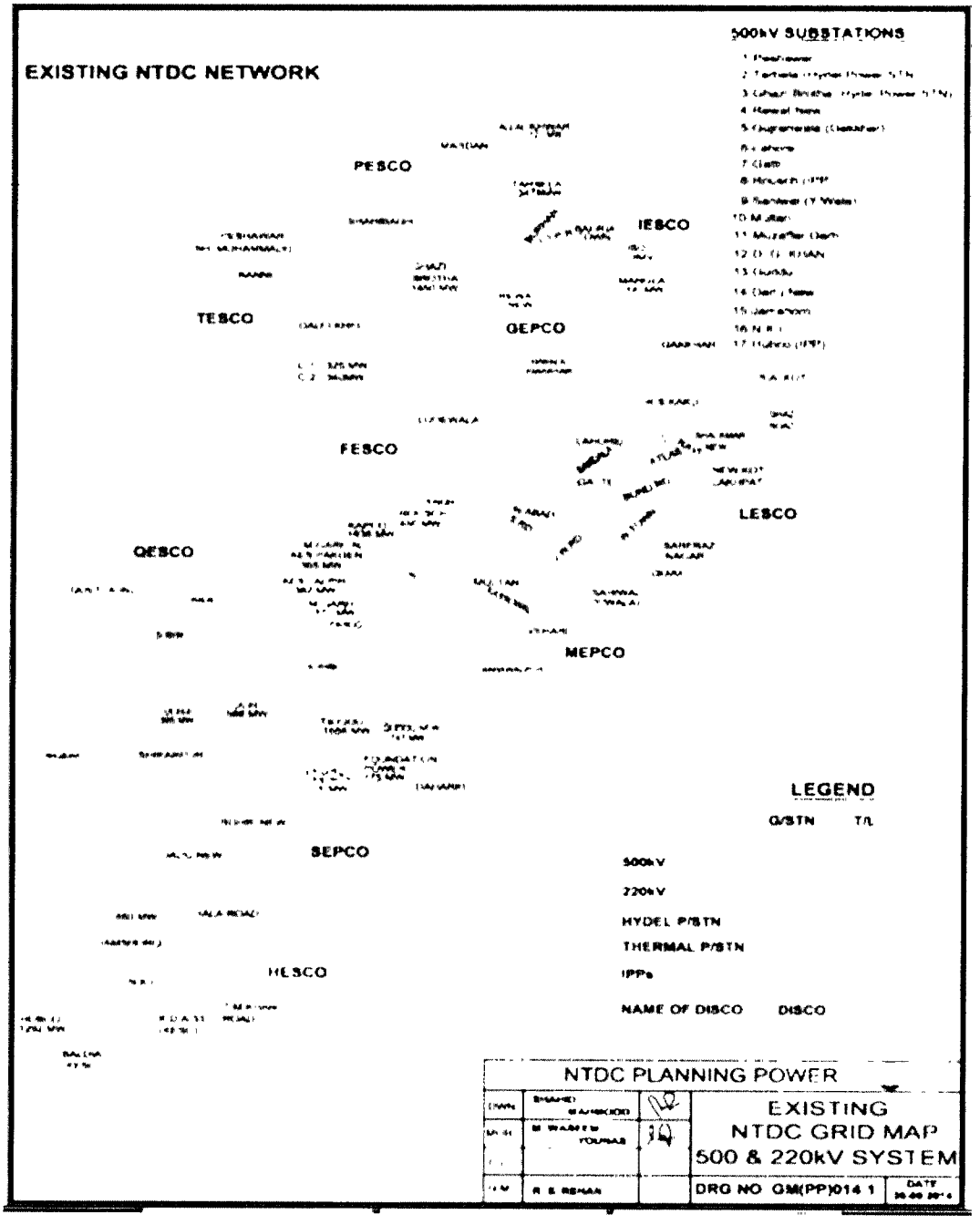


Figure 2.3 Layout of 500kV and 220kV power grid

NDTC has a critical responsibility for operation and management of power grid, and Distribution Companies (DISCOs) is independent of NTDC to do load management. The main Distribution Companies and its corresponding service area can be shown in table 2.3-2.

Table2.3-2 Service Area of Distribution Companies

DISCO	Service area
Distribution Companies working in public sector	

PESCO	Whole Province of Khyber Pakhtunkhwa, except tribal areas
TESCO	Federally Administrated Tribal Areas (FATA) and Frontier Regions
IESCO	Federal Capitallslamabad, Rawalpindi, Attock, Jhelum, Chakwal
GEPCO	Gujranwala, Sialkot Mandi Bahauddin, Hafizabad, Narowal, Gujrat
LESCO	Lahore, Sheikhupura, Kasur, Okara, Nankana
FESCO	Faisalabad, Sargodha, Khushab, Jhang, Toba Tek Singh, Bhalwal, Mianwali, Bhakkar
MEPCO	Multan, Rahim Yar Khan, Khanewal, Sahiwal, Pakpattan, Vehari, Muzaffargarh, Dera Ghazi Khan, Leiah, Rajan Pur, Bahawalpur, Lodhran, Bahawalnagar
HESCO	AII Province of Sindh except Karachi, Sukkur Ghotki, Khairpur; Kashmore, Kandhkot Jacobabad, Shikarpur; Larkana, Kambar; Shahdadkot, Dadu and some portions of Jamshoro, Naushehro Feroz, Shaheed Benazirabad and Rahimyar Khan
SESCO	Sukkur, Ghotki, Khairpur; Kashmore, Kandhkot, Jacobabad, Shikarpur; Larkana, Kambar, Shahdadkot, Dadu and some portions of Jamshoro, Naushehro Feroz, Shaheed Benazirabad and Rahimvar Khan
QESCO	Whole Province of Baluchistan, except Lasbela where K-Electric is responsible for distribution of power
Distribution Companies working in private sector	
KEL	Entire Karachi and its suburbs upto Dhabeji and Gharo in Sindh and over Hub, Uthal Vindhar and Bela in Baluchistan
BTPL	Barea town

2.4 Installed Capacity and type

The total nominal power generation capacity of Pakistan as on 30th June 2014 was 24,375 MW and 0.124kW per capita. The installed power generating capacity of Pakistan from 2010 to 2014 is given in table 2.4-1:

Table 2.4-1 Installed Generation Capacity by Type **unit: MW**

Type	2010	2011	2012	2013	2014
Thermal	15,047	16,363	16,069	16,041	16,366
Hydel	6,555	6,645	6,730	6,947	7,116
Nuclear	462	787	787	787	787
Wind	0	0	1	50	106
Total	22,064	23,795	23,587	23,825	24,375

Table 2.4-1 shows that the growth of power generation capacity of Pakistan is quite slow as a developing country.

As on 30th June 2014, installed thermal generation can be classified by fuel shown in table 2.4-2, generations using gas occupy more than half of the capacity of thermal power and generations using coal are too less to be eliminated.

Table 2.4-2 Thermal Electricity Generation by Fuel

Fuel Type	Number of Generation	Installed capacity (MW)	Capacity Proportion (%)
oil	14	3,890	23.77
gas	32	9,531	58.24
flex-fuel	4	2,795	17.08
coal	1	150	0.01
Total	51	16,366	100

Because generating units using oil and gas occupy majority of thermal power capacity, power generation cost is high. Power generation cost for classified generation is given in table 2.4-3.

Table 2.4-3 Unit fuel cost of generation **unit: Cents/kWh**

Fuel Type	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
Natural gas	3.9891	4.4207	5.1019	6.1546	6.0619
Fuel oil	11.6254	14.0978	19.1152	18.6186	18.7010
Diesel	16.5743	18.9715	25.2309	/	/
Coal	2.5621	2.8687	3.4978	3.5876	3.8557
Average	7.7147	11.9547	10.9278	12.0309	16.0722

Exchange 1 dollar at 97 u

2.5 Existing energy structure

One important cause of power industry dilemma is national energy structure. Less than 1% power plants in Pakistan adopt coal to generate power but the average global level is about 41%. In its neighbor – India, about 2/3 power plants generate power with coal.

On the other hand, 37% power in Pakistan is generated in expensive oil fuel power plants. Energy structure is not sustainable and needs to be changed.

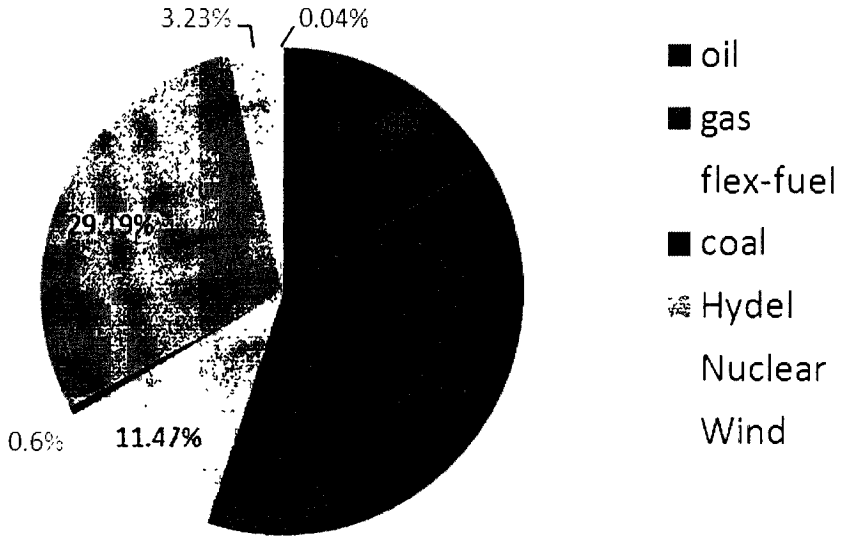


Figure 2.5-1 Energy structure of Pakistan

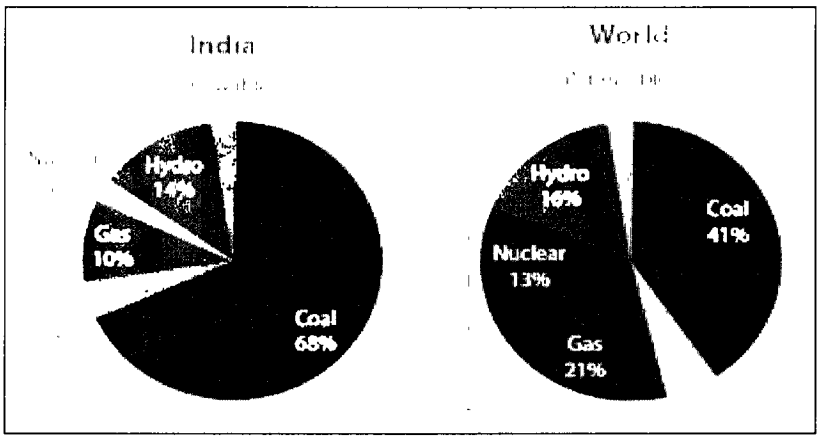
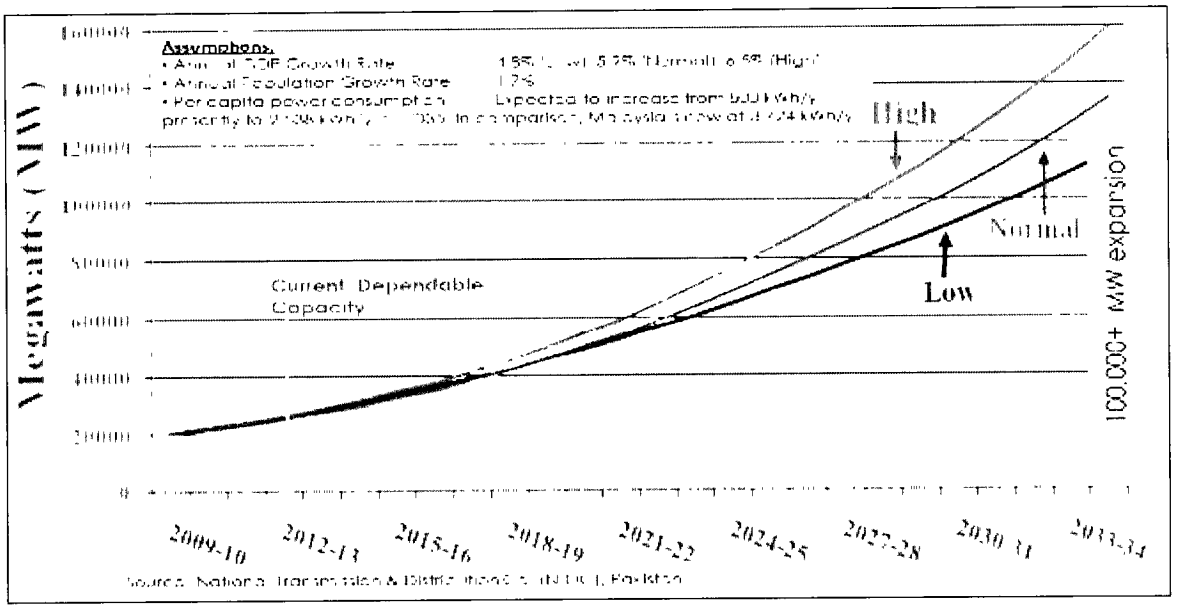


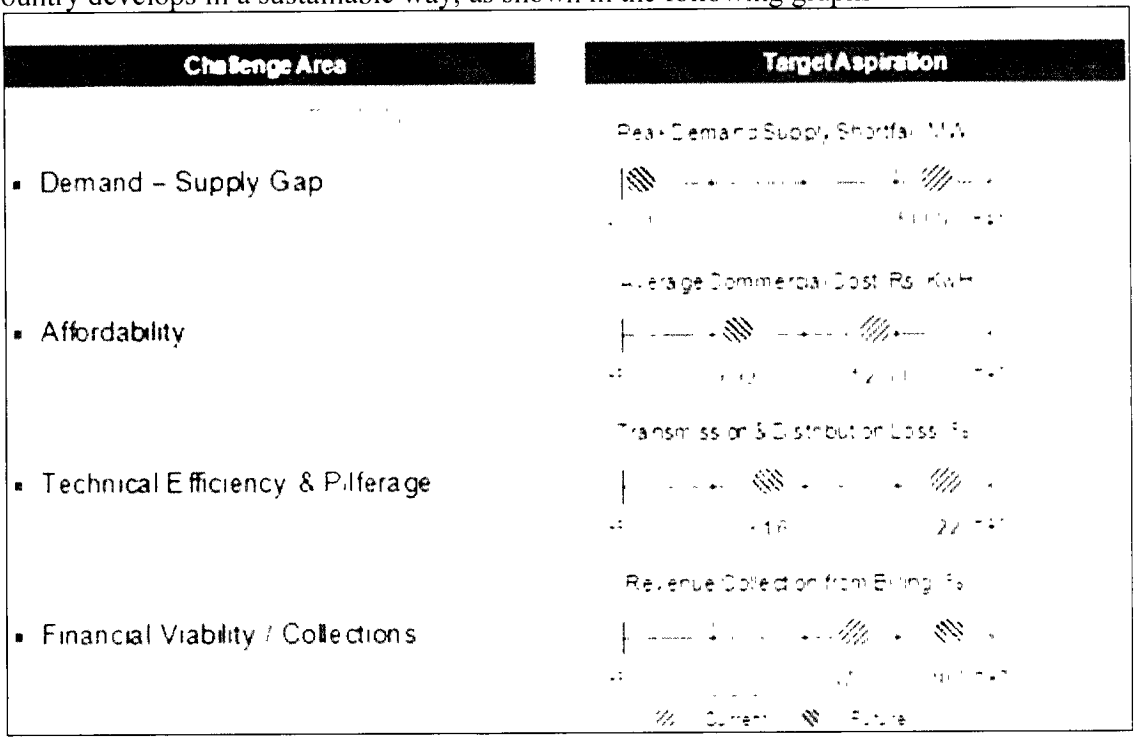
Figure 2.5-2 Energy structure of India and World

2.6 Power demand estimate

Based on micro economic forecast, NTDC conducts power demand forecast.



In the future 20 years, Pakistan will need about 100,000MW electric energy. It's key that the country develops in a sustainable way, as shown in the following graphs:



2.7 Power generation and power balance

From 30th June 2013 to 30th June 2014, total electricity consumption of Pakistan is 105,996GWh and per capita is 538kWh, table 2.7-1 shows generation capacity and its composition in recent years.

Table 2.7-1 Annual Power generation and its composition unit: GWh

Type	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014

Thermal	68,591	65,715	66,237	64,035	68,142
Hydel	28,492	31,990	28,652	30,524	32,671
Nuclear	2,668	3,130	4,872	4,181	4,501
Import	269	295	296	375	419
Wind	0	0	6	32	263
Total	100,020	101,130	100,063	99,147	105,996

Results of classified power load proportion are given in table 2.7-2:

Table 2.7-2 Statistics of classified power load proportion unit: %

Type	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
Domestic	45.72	46.18	45.90	46.63	47.00
Commercial	7.55	7.50	7.51	7.82	7.64
Industrial	26.89	27.72	28.7	29.09	29.26
Agricultural	13.17	11.76	11.28	11.04	10.05
Public lighting	0.62	0.57	0.63	0.66	0.60
Bulk supply and others	6.00	4.85	4.74	5.62	5.41
Traction	0.04	1.41	1.24	0.04	0.04
Total	100	100	100	100	100

Domestic power consumption hold the leading position, the trend of industrial power consumption is the most stable, and the electricity consumption of agriculture is declining year by year.

The following table shows summary of power balance from 2010 to 2014 of Pakistan

Table 2.7-3 Power balance from 2010 to 2014 of Pakistan unit: MW

Financial year	Projected power generation capability*	Peak demand	Deficit/surplus
2010	15,145	21,029	-5,884
2011	15,430	21,086	-5,656
2012	14,483	21,536	-7,053
2013	16,846	21,605	-4,759

2014	18,121	23,505	-5,384

*-- generation capability includes import generation capability

Table 2.7-3 shows that the overall power gap of Pakistan is relatively large. About 25% peak demand cannot be met, and power shortages are obvious.

2.8 Reason for power shortages

The reason for power shortages of Pakistan can be shown from the following aspects:

1) Lack of power grid transformation capacity.

As on 30th June 2014, the transmission capacity of 220kV network is only 21,030MVA, in which active component is 17,857.5MW if power factor is considered as 0.85(power factor in Pakistan is low, it should be at least 0.8 according to the requirement of NTDC). Peak power demand in 2014 reaches to 23,505MW and bottlenecks problem of power grid is obvious.

According to report of NEPRA, from the year of 2013 to 2014, there are 25 lines overloaded among the total 120 220kV transmission lines; among 31 500kV transformers there are five overloaded; among 118 220kV transformers there are 55 overloaded, which reflects that transmission capacity shortage is serious from another aspect.

2) Installed capacity is not enough; comparison between installed capacity and power demand is given in table 2.8-1.

Table 2.8-1 Comparison between installed capacity and power demand unit: MW

Year	Installed capacity	Peak demand
2010	22,064	21,029
2011	23,795	21,086
2012	23,587	21,536
2013	23,825	21,605
2014	24,375	23,505

It shows that Installed capacity and power demand are basically equivalent, which leads to shortage of spare capacity of the system. There is a risk for supply shortage under condition of generation maintenance and the non-planned outage.

3) Availability factor of generators is low. Comparing installed capacity to available power generation capacity, we obtain availability factor of generating equipment shown in table 2.8-2:

Table 2.8-2 Availability factor of generating equipment

Year	Installed capacity (MW)	Available Power Generation Capacity (MW)	Availability factor

2010	22,064	15,145	68.64%
2011	23,795	15,430	64.85%
2012	23,587	14,483	61.40%
2013	23,825	16,846	70.71%
2014	24,375	18,121	74.34%

Power Generation Capacity Availability factor is lower than 70% especially before 2013. This factor is really low in the power grid mainly based on thermal power. Bottlenecks of power grid is another important reason besides problem of generating equipment

Annual utilization hours of generators in 2014 are given in table 2.8-3:

Table 2.8-3 Annual utilization hours of generators

Type	Installed capacity (MW)	Power generation in 2014 (GWh)	Annual utilization hours (h)
Thermal	16,366	68,142	4163.63
Hydel	7,116	32,671	4591.20
Nuclear	787	4,501	5719.19
wind	106	263	2481.13
total	24,375	105,577	4331.37

We can see that utilization hours of generating equipment are not high enough, but this state is better comparing to power grid bottlenecks.

2.9 Summary of Pakistan power grid status

1) Level of power consumption of the whole society is not high, and per capita is only 538kWh. Domestic power consumption holds the leading position and proportion of industrial consumption is low.

2) Power grid construction lags behind which cannot meet power consumption demand of society.

3) Installed generation capacity is low and only 0.124kW per capita. As the main generating type, thermal generation need large amount of fuel oil and gas which increases cost of power generation and it suppresses demand for electricity to some extent.

2.10 Necessity of power plant construction

1) Meet the needs of power demand growth in Pakistan

The installed generation capacity has grown by about 16 percent in recent years from 2008 to 2012, while electricity shortages increase sharply by 242 percent. The peak power load of

Pakistan in 2014 is 23,505MW; meanwhile, overall installed capacity is only 24,375MW which is basically equivalent with electricity demand. The system is in the state of reserve capacity shortage. Especially under condition of generator maintenance and unplanned outage power supply shortage will occur. The supply and demand gas is still increasing. In 2014, the power shortage peak reached ~5,384MW.

Power shortage has become a huge social and economic problem. Industry is seriously affected and thus Pakistan lacks competitiveness in global environment. Quickly solving energy crisis will be a great economic drive for the Pakistan.

Leading independent power providers (IPP) in Pakistan including HUBCO are devoted to quickly develop power plants so as to solve the crisis. National Electric Power Regulation Authority (NEPRA) publishes "Upfront Tariff" for coal-fired power plants with the intent of promoting development of quick channel projects rather than a long process of "cost addition".

The installed capacity of HUB power plant is 1320MW and power input can reach to 1200MW after considering network loss and auxiliary power, which can reduce the pressure of power shortage in Pakistan.

2) Optimize power structure

The power structure in Pakistan is unsustainable; of which 16.0% was thermal generation using fuel oil, 29.2% was hydroelectric, 39.1% was thermal generation running on gas, 11.5% was flex-fuel station, 3.2% was nuclear and coal only occupied 0.6 percent.

This energy structure has a profound influence. For example, fuel cost was PKR 2,400/t when HUBCO was debugged in 1997, but it increased to PKR 65,000 recently. Fuel oil cost increased to18-19 cents/ kWh by 2600 percent at the same time. People in Pakistan cannot afford this, so government had to subsidy the thermal power plant based on oil to keep the price affordable for public, which lead to unsustainable cyclic debt. The only way is to exchange oil to coal to reduce cost of electricity generation.

3) Promote economic development and social stability in Pakistan

Due to electricity shortage, irrational power structure, and continuous increase of price of oil and natural gas, power generation costs have remained stubbornly high. Expensive electricity makes the government have to support considerable debt that is form to power plant subsidy, which had a bad influence on economic development and social stability of Pakistan. Construction of this project will help ease the power shortage, optimize the power structure, and promote economic development and social stability in Pakistan.

4) Be conducive to further development of China-Pakistan bilateral strategic cooperation partnership and common development in the new era.

Further deepening cooperation of China and Pakistan in energy area and supporting Pakistan government to solve energy shortage problem is conductive to promote economic development of Pakistan, the construction of China-Pakistan Economic Corridor and the process of China-Pakistan economic integration. Furthermore, this project can be good to

promotion of China-Pakistan bilateral strategic cooperation partnership and common development in the new era.

5) Construction of China-Pakistan Economic Corridor would bring linked development of regional economy, which has strategic significance on promotion of "One Belt and One Road" construction.

Premier Li Keqiang put forward to construct China-Pakistan economic corridor during his visit to Pakistan in May 2013, whose original intention was to enhance exchanges and cooperation in the fields of transportation, energy and marine between China and Pakistan, to strength bilateral exchanges and promote common development for each other. During the visit to China of the president of Pakistan in February 2014, two sides agreed to accelerate the construction of Pakistan Economic corridor. Pakistan is located on intersection of overseas route of "One Belt and One Road". After joining up China-Pakistan economic corridor, South Asia, Central Asia, North Africa and Gulf states can be tied together through the cooperation in the fields of economy and energy, which can form economic resonance. Furthermore, this will strengthen the strategic position of Pakistan as a bridge and link between the Eurasian and African continents, and be significant to promote construction of "One Belt and One Road".

2.11 Plant-grid connection scheme envisaging

According to "Grid Interconnection Study for Evacuation of Power from 2x660 MW HUBCO Coal Fired Power Plant to the National Grid (Report-1)" (Annexure 1) by National Transmission and Despatch Company Limited (NTDCL) planning (power) department, considering the capacity, indicated timeline & location of 2x660 MW HUBCO CFPP and the existing/planned system network in the vicinity, the following interconnection scheme has been proposed for its power evacuation to the National Grid:

"A 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station".

It is important to highlight that the above proposed interconnection arrangement for HUBCO CFPP would be modified later with the addition of other planned coastal power plants in future.

Final connection scheme shall be subject to plant-grid connection report and shall meet Pakistan grid regulations.

2.12 Conclusions

1) Pakistan power grid status

(1) Level of power consumption of the whole society is not high, and per capita is only 538kWh. Domestic power consumption holds the leading position and proportion of industrial consumption is low.

(2) Power grid construction lags behind which cannot meet power consumption demand of society.

(3) Installed generation capacity is low and only 0.124kW per capita. As the main generating type, thermal generation need large amount of fuel oil and gas which increases cost of power generation and it suppresses demand for electricity to some extent.

2) Necessity of power plant construction

(a) Meet the needs of power demand growth in Pakistan

(b) Optimize power structure

(c) Promote economic development and social stability in Pakistan

(d) Be conducive to further development of China-Pakistan bilateral strategic cooperation partnership and common development in the new era.

3) Plant-grid connection scheme

A 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station.

3. Fuel supply

3.1 Coal and coal quality

Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3. More details of coal quality and coal selection of design/check coal please see Annexure 4 and 11.

3.1.1 South African coal

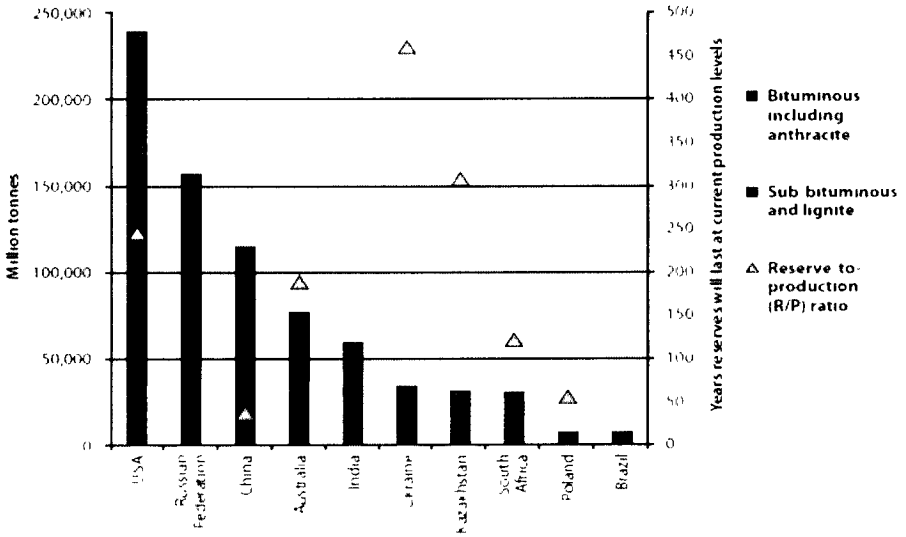
Hosting nearly 59 Bn of the proven black coal reserves, South Africa ranks as the 5th largest coal exporter in the world. Annual production clocks in at 250 Mn Metric Ton per annum, while exports account for only 25 – 30% of total production.

South African coal geological deposits are primarily bituminous in nature. Run of the Mill (ROM) coal ranges between 4,000 – 5,000 NAR, and predominantly contains high Ash content. Miners typically maintain washing plants to standardize coal grades from different mines.

Major reserves are found in the Central and East of the country, with significant deposits found in Witbank, Highveld and Ermelo in the Mpumalanga province.

Both Opencast and underground mining are in practice, with a trend towards open cast mining to improve working conditions. Raw coal has high heating value, low sulfur content (≤1%) and low nitrogen content. After washing and dressing, raw coal becomes merchantable of 4 primary grades of RB1, RB2, RB3 and sub-bituminous. Net calorific value (as received basis) of RB1 and RB2 is 6000kcal/kg, their difference lying in volatile matter, while RB3 normally carries higher Ash content; Net calorific value of RB3 stands at 5500kcal/kg and sub-bituminous 4800kcal/kg.

South Africa vs. Global – R/P Ratio 2010



(Picture quoted from Annexure 4)

Compared to other countries, South African coal output is highly standardized, owing to

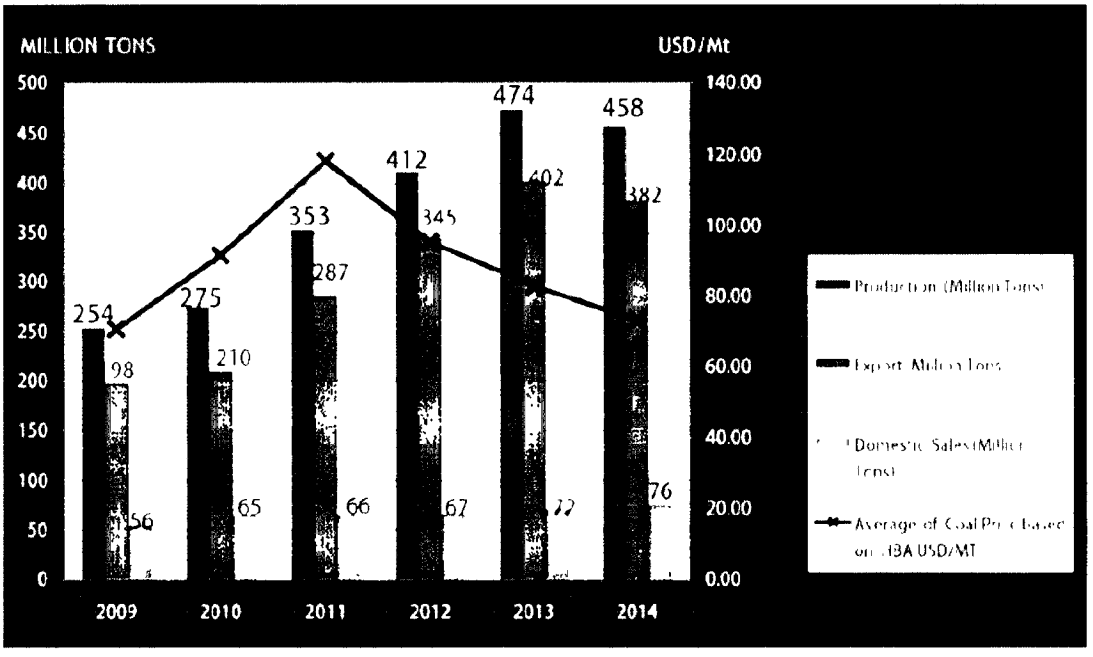
significant investment in washing facilities. Nearly 20% of the country's exportable product is reduced due to extensive washing.

South Africa exports nearly 65 – 70 Mn Metric Tons per annum of coal ranging predominantly from 5,000 – 6,000 kcal/kg. This range of coal however, is complicated by variations in Ash, Volatile Matter and Total Moisture. In all, there are nearly 36 different variations of coal which are sold from South Africa. Coal from South Africa is sold primarily on a spot basis (approximately 50 – 60% of the the total volume). With declining demand from Europe and increasing competition from Colombia (output expansion of approximately 10 – 20Mn Metric Tons per annum), coal availability from the country is expected to be fairly liquid.

3.1.2 Indonesian coal

Indonesia is currently the largest coal exporter in the world, exporting over 380 Mn MT per annum. Compared to Australian or South African origin coal, Indonesian reserves are considered 'young'. Large reserves are found in the range of 3,400-5,000 GAR category, while higher spec coal is incrementally rare.

Indonesian Coal Production, Export Consumption Data



(Picture quoted from Annexure 4)

Market is characterized by:

• Oligopolistic Structure: Very few large scale miners (Adaro, Banpu, Bumi, Kideco, KPC) along with significant number of smaller players.

• Logistical complexity: Transport of coal is primarily done through barges across the Mahakam River (East Kalimantan) and Barito River (South Kalimantan). Haulage on Barges is significantly cheaper than via road (approximately 40-60% cheaper depending on ground and weather conditions).

• Regulatory uncertainty: Mining activities can be carried out by obtaining either CCOW or IUP licenses. The CCOW (Coal Contract of Work) is the oldest mechanism in place. The license is basically a lease of government held property allowing the company to mine and market coal. The IUP license is the newer version of the mining licenses. Companies can either opt for IUP exploration or later upgrade to IUP OP (for production). CCOW license holders pay the government 13.5% Royalties on production while IUPs pay according to coal quality (4-6%)

• Domestic Obligations: Production Quota's in place whereby each miner has to submit annual coal production and marketing targets a year in advance. Only after government approval, can the miner promise producing the allowed quantity.

• Diverse investment structures: As per law, international investment in mines is limited and the government favors local participation in coal exploration and marketing. Regulation permits 100% foreign ownership at inception stage, however, over a period of 10 years, the foreign company has to strategically divest interest until it owns only 49% of the total position in the entity.

Despite the above challenges Indonesia, has become the largest coal exporter in the world, primarily owing to better margins due to low cost of production.

3.1.3 Coal quality

Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3.South African coal and Indonesia coal quality data is shown in Table 3.1.3-1 (quoted from Annexure 4), and check coal quality is calculated by these two coals.

Table 3.1.3-1 Coal Quality Data Table

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Technical analysis	%			
Total moisture	ar	9.27	25.3	17.29
Internal moisture	ad	4.44	15.64	9.84
Ash content	ad	18.5	5.57	12.26
Ash content	ar	17.56	4.93	11.25
Volatile matter	ad	24.98	40.07	32.2
Sulfur	ad	1.09	0.82	0.96
Sulfur	ar	1.035	0.73	0.88
Fixed carbon	ad	52.08		
Net calorific value	ar, kcal	5371	4712	4991
Gross calorific value	ar, kcal	5591	4918	5254
Gross calorific value	ad, kcal	5889	5554	5721
Grindability index		53	43	48
Element analysis	%			
Carbon	d	65.25	69.58	67.21
Hydrogen	d	3.81	5.17	4.42
Nitrogen	d	1.64	1.33	1.50
Sulfur	d	1.14	0.98	1.06
Oxygen	d	8.8	16.22	12.15
Ash analysis	%			
Silicon dioxide	db	53.39	41.65	50.82
Aluminum oxide	db	22.65	21.48	22.39
Iron oxide	db	6.56	13.96	8.18
Calcium oxide	db	6.92	6.93	6.92
Magnesium oxide	db	2.23	2.49	2.29

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Sodium oxide	db	0.19	0.68	0.30
Potassium oxide	db	0.66	1.38	0.82
Titanium oxide	db	1.06	0.98	1.04
Manganese oxide	db	0.50	0.09	0.41
Sulfur oxide	db	5.22	9.27	6.11
Phosphorous oxide	db	0.62	0.23	0.53
Ash fusion temperature	°C			
Deformation temperature	degc	1240	1110	1175
Softening temperature	degc	1270		
Hemispherical temperature	degc	1290		
Flow temperature	degc	1310		
Grain size	%			
<50		99.2	92.54	95.87

3.2 Coal consumption

Coal consumption of the units in this project is shown in Table 3.2-1.

Table 3.2-1 Unit Coal Consumption

Unit capacity / Item	Value	1×660MW		2×660MW	
		Design coal	Check coal	Design coal	Check coal
Hourly coal consumption	t/h	252.22	270.79	504.44	541.58
Daily coal consumption	t/d	6053.28	6498.99	12106.56	12997.98
Annual coal consumption	10^4t/a	187.80	201.63	375.61	403.26

Notes: 1) Daily utilization hours are 24h;

2) Annual utilization hours are 7446h.

3) Under BMCR and fuel heating value is based on ar.

3.3 Coal transportation

3.3.1 South African coal transportation

South African coal is transported by sea to the power plant of this project.

Coal from South Africa is primarily exported from a single port, Richard's Bay Coal Terminal (RBCT). The port has a handling capacity of 91 Mn Metric Tons per annum, and is located in the East of the country. RBCT has 6 berths and 4 ship loaders (range of 8,500 – 12,000 tons per hour loading rate). With a draft restriction of 19 meters, the port is able to cater to 150,000 DWT vessels.

Main export region for South African coal is EU and India, which together account for nearly half of annual exports. This is a deviation from historical trends where EU accounted for the lion's share in exports. However, rapid development in power generation in India has led the country to source coal from alternative locations, which has helped the South Africa diversify the export base.

RBCT is connected to the Mpumalanga collieries via Transnet Rail; the network has a throughput capacity of 72 Mn Metric Ton per annum, which is currently the most significant bottleneck in port utilization.

While Transnet plans to expand network throughput to comparable levels, experts believe the same will be realizable only by 2019.

Coal handling at the port is a highly mechanized operation. Rail cars, are decoupled and tipped over underground hoppers. These hoppers are connected via conveyor system to the coal yard. The coal is tested and allotted to specific stockpiles to ensure reliability of export grades.

Transport distance from Richards Bay Coal Terminal in South Africa to the project site is about 4,300kts.

3.3.2 Indonesian coal transport

Indonesian coal is transported by sea to the power plant of this project.

With weak indigenous demand for coal in Indonesia, the export markets become integral to sustainability of investment in mining operations. Inland logistics are critical to enable exportable coal from reaching the market in time and cost effectively. Most coal in Indonesia is land locked, essentially leading to increased emphasis on developing logistical capabilities.

Road haulage is highly expensive in Indonesia due to a variety of reasons. With marshy conditions across the country, road development requires high up-front investments in securing right-of-way as well as development costs. Estimates for road development range

from US$ 1.0 – 1.5 Million per KM. with some mines over 150-200 Km from the nearest river/sea ports, this would serve as a severe impediment in coal transport.

Further to investment costs, river barge transport is significantly more cost effective compared to road haulage. Estimates of transport costs by barge to port range between US$ 0.06 – 0.08 per Km per MT compared to road alternatives of US$ 0.12 – 0.16 per Km per MT. Apart from the costs, the severe bottlenecks in operating via roads further depresses development efforts.

There are very few roads capable of handling 2x80 MT coal trucks (private networks over short distances e.g. Adaro are present). Most coal therefore is carried via barges across rivers. Given the weak international coal prices, together with complexity of setting up road network, most development of coal mines has occurred around East and South Kalimantan. Both these regions are blessed with an array of water networks connecting the inland mining to sea ports.

In East Kalimantan, the Mahakam River serves as the principal mode of transportation. Significant number of barges and operators are present in the region to accommodate ever growing industry volumes. The Mahakam River connects the mines to port in Samarinda, which is one of the principal sea ports out of East Kalimantan. The Barito River, serves similar purpose for South Kalimantan export market.

Oceanography indicates that draft near landmass is very shallow and therefore, most of the coal trade is done from mid-sea loading points. Selection of mid-sea loading points is a function of swell, draft, weather and proximity to river deltas. Ship-loaders prefer gearless vessels as it does not obstruct conveyor/grabs of loading equipment.

In Kalimantan the bulk of transport is conducted via the Mahakam (East Kalimantan) and Barito (South Kalimantan) rivers. River transport is not only cost effective, it is sometimes the only route to outer anchorage in Indonesia. While other tributaries are used to transport coal on smaller barges, a draft of over six (6) meters on the Mahakam and Barito allow for use of 330ft barges. River jetties serve two principal services, first is to allow blending of coal inland. This increases homogeneity of coal for tailor made products. Secondly, since outer anchorages are at sea, smaller barges with shallow draft find it difficult to transport coal in harsh weather conditions. Furthermore, the cost per metric ton of using a 330ft barge (approximately 8,000 – 10,000 MT capacity), is much lower compared to use of smaller barges. Barge operators are often un-related to miners/traders, significant capital buildup during the late 2000, has led to over capacity with experts estimating that nearly 30-40% under-utilized asset base. Situation in Sumatera is considerably different from Kalimantan, especially since the waterway network in Sumatera is not as detailed as that of Kalimantan.

Transport distance from coal production place in southeast Kalimantan in Indonesia to the project site is about 3,900kts.

More details of coal transportation please see Annexure 4.

3.4 Ignition and combustion oil supply

Light diesel oil is used for ignition and combustion of the boiler, and temporary is transported by truck to the power plant.

Characteristics of light diesel oil and their specification limits for the existing Hubco power plant are referenced below. It is acceptable to use this light diesel oil for startup of coal fired unit of this project. In case any specification limit exceeds then it will be reviewed in the basic design phase.

TEST	TEST METHOD	SPECIFICATION LIMIT
Specific gravity 60/60 □F	ASTM D 1298	To be reported
Distillation 90% recovery, □C (□F)	ASTM D 86	Max 365 (689)
Colour ASTM	ASTM D 1500	Max 3
Flash point (PMCC), □C (□F)	ASTM D 93	Min 54 (130)
Sulphur content, % wt	ASTM D 1551/1266/4294	Max 1 0
Copper strip corrosion 3 hrs. at 50□C (122□F)	ASTM D 130	Max No: 1 STR IP
Viscosity, Kinematic 40□C cSt	ASTM D 445	Min 1 0 Max 6 5
Cloud point, □C (□F) Winter/Summer	ASTM D 2500	Max. 6(43) / 9(48)
Pour point, □C (□F) Winter/Summer	ASTM D 97	Max 3(37) / 6(43)
Conradson carbon residue on 10% distillation residue, % wt	ASTM D 189	Max. 0.2
Ash, % wt.	ASTM D 482	Max 0 01
Sediment, % wt	ASTM D 473	Max. 0 01
Water, % Vol.	ASTM D 95	Max. 0.10 (import)
Cetane number or Centane Index	ASTM D 613 ASTM D 976	Min 45 Min 45
Strong acid number mg KOH/g	ASTM D 3242 / D - 664	Nil
Total acid number mg KOH/g	ASTM D 3242 / D - 664	Max 0 5
Calorific value BTU/Lb	ASTM D 240/4868	TYPICAL 19000*

- CV is not the part of PSQCA (PSI) specification however this is a typical value

3.5 Conclusions

1) Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3.

2) The transportation of South African coal and Indonesian coal are both transported by sea to the power plant.

3) Light diesel oil is used for ignition and combustion of the boiler, and temporary is transported by truck to the power plant.

4. Plant Site Condition

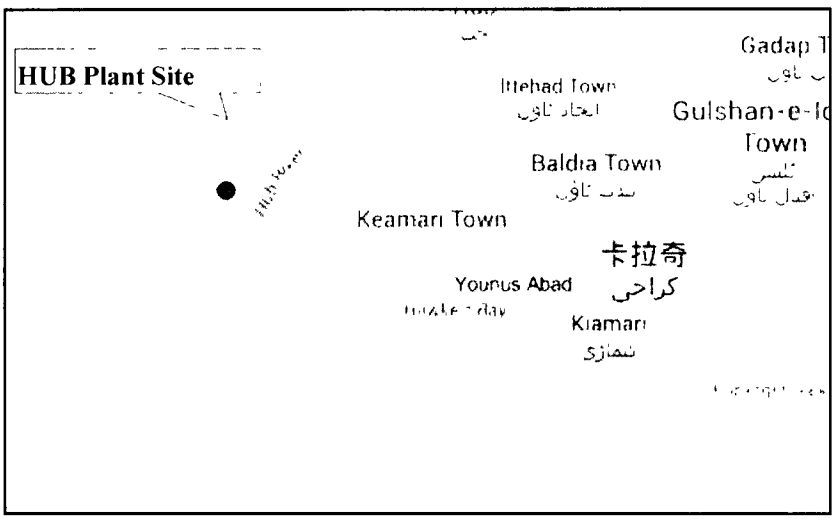
4.1 Overview of Plant Site

4.1.1 Introduction of Hubco

Hubco is one of the large scaled power generation companies in Pakistan. Hubco plans to become an independent 5000MW power generation enterprise by relying on coal fired power generation units in the next decade. Hubco now has 1,500-acre land for power generation units (Hub plant site), 70-acre land of which is for Hubco Power Plant (4×323MW oil fired units) and very suitable for developing into a "Power Supply Industrial Park". Hubco Power Plant Project is the embodiment of this development goal and has become a demonstration of success. Construction of CLP Hub 2×660MW Coal Fired Power Generation Project will take a further step for the accomplishment of this goal.

4.1.2 Geographic location

The plant site is located in the southwest of Hub City in Baluchistan Province, north latitude N 24°54'9", east longitude E66 °41'31", about 20km from the center of Hub City. The geographic location of the plant site is shown below.



Plant Site Geographic Location Map

Baluchistan Province has an area of 340,000km^2 and is the largest province in Pakistan. Its population is 7.167 million, accounting for 5% national total population, and it is a province with the smallest population. The whole province is divided into 29 regions and the capital is Quetta and the main cities are Hub, Gwadar, Huzda, Chaman, Sibi, Kalat etc.

Baluchistan Province is adjacent to Afghanistan to the north, borders on Iran to the west and is close to the Arabian Sea to the north. It is the only way from East Asia to West Asia and also a potential trade channel for Central Asian countries and Afghanistan to carry out entrepot trade and a potential energy channel from the Middle East and Central Asia to the Far East. Its geographic location is very important.

4.1.3 Plant site conditions

1) The built Hubco oil-fired power plant

Hubco plans to develop super-sized power generation projects with reference to Indian model and build an electric power center in the Hub plant site. Presently, Hubco 4×323MW oil-fired power plant has been built in the plant site center by south and it is an important electric power supply center in Pakistan.

The plant went into commercial operation in 1997 and its generating capacity is 10% national power demand. The plant operates flexibly and has been the main units for Pakistan state grid. The four units are directly cooled by seawater taken from the west and discharged to the south. Water is taken through open ditch and introduced from west into the main building for a length of 600m. Water is discharged also through open ditch to the south into the Hub River for a length of 1km. The total generating capacity of the four units can reach 1,292MW and 1,200MW is connected through 500kV single-circuit transmission line from the north of power plant to the northeast into the state grid. According to the requirements of Pakistan State Grid for the capacity of power transmission lines, the power transmission lines supply power through two parallel single circuits and each circuit is 100% reserve so that when one circuit fails or is in maintenance, power can be transmitted via the reserve line.

Fresh water resource is deficient near the plant site. Hub River often dries and the power plant uses sea water desalination. Domestic water is purchased. Fuel is heavy oil and supplied via pipe into the power plant.

Satellite Map of Built Oil Fired Unit

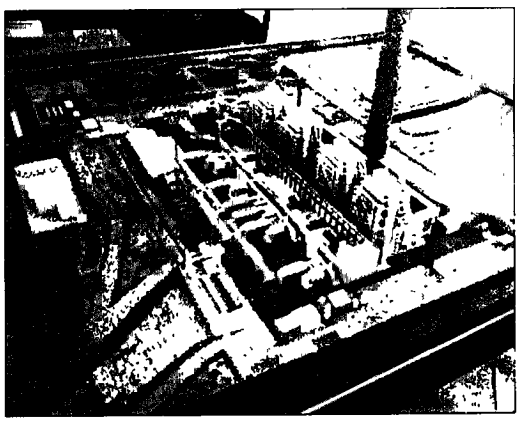


Photo of Built Oil Fired Unit Model

2) Natural conditions

The 2×660MW coal fired units in this project are adjacent to the Arabian Sea and located on the site north of the existing water intake open channel of oil fired units and west of the 500kV outgoing line corridor.

The plant site is flat and open and ground elevation is usually 2.5~6.0m. Some local areas are sandy hillock and surface vegetation is sparse.

Protection for the power plant is designed for 200-year return period flood and effect of dam breaking water level of the upstream Hub reservoir needs to be considered. At present related data is not available and 200-year return period flood level and Hub reservoir dam breaking level remain to be further determined. These related data will influence the determining of the

outdoor ground level and will be determined after flood analysis assessment is completed in basic design phase. Flood control planning and vertical planning refer to section 5.1.1(item 7) and section 5.1.3.

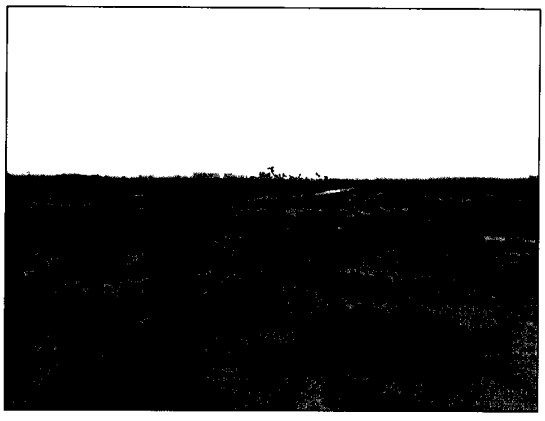


Photo of Plant Construction Site

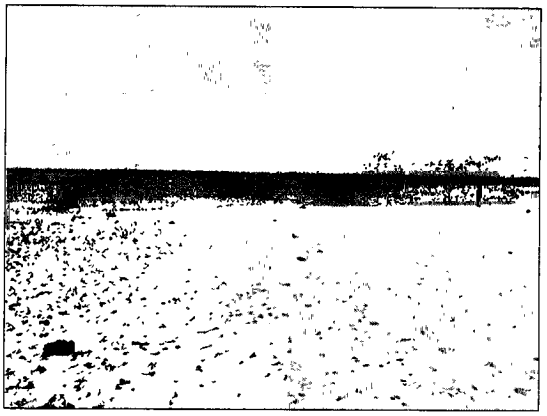


Photo of Sea Area West of Plant Construction Site

Pakistan is situated in the northwest of South Asian subcontinent and architectonically it is in Eurasian plate collision zone and belongs to earthquake activity zone. Main fault near the plant site is Pab fault which is about 6km from the plant site. In the plant site, foundation conditions are good, carrying capacity is high, accumulated earth stress increase is very small and recorded earthquakes near the plant site are very few.

According to historical earthquake records, four earthquakes have been recorded in the 50km range around the plant site. Earthquake magnitude is less than 4.7th degree and it belongs to area with moderate potential earthquake loss. According to HUBCO power plant survey report conclusions, foundation conditions are good, carrying capacity is high, accumulated earth stress increase is very small and recorded earthquakes near the plant site are very few. Therefore, the site is suitable for construction.

As per the seismic zoning map in the "Building Code of Pakistan (Seismic Provisions-2007)" (BCP SP-2007) (refer to Annexure 10) (shown as Figure 4.6-2) as well as Table 2-1 and Table 2-2, the site belongs to the seismic zone 2B (with the Peak Horizontal Ground Acceleration range from 0.16 to 0.24g), the peak ground acceleration with exceedance probability of 10% in 50 years is 0.20g (shown as Figure 4.6-3) and the corresponding seismic basic intensity scale is VIII according to Chinese "Code for seismic design of buildings (GB 50011-2010)".

Such unfavorable geologic functions as sand liquefaction, landslide, avalanche and underground cavern are not found on and near the site.

There are no valuable cultural relics in the site range and the site does not sit on exploitable mineral resources.

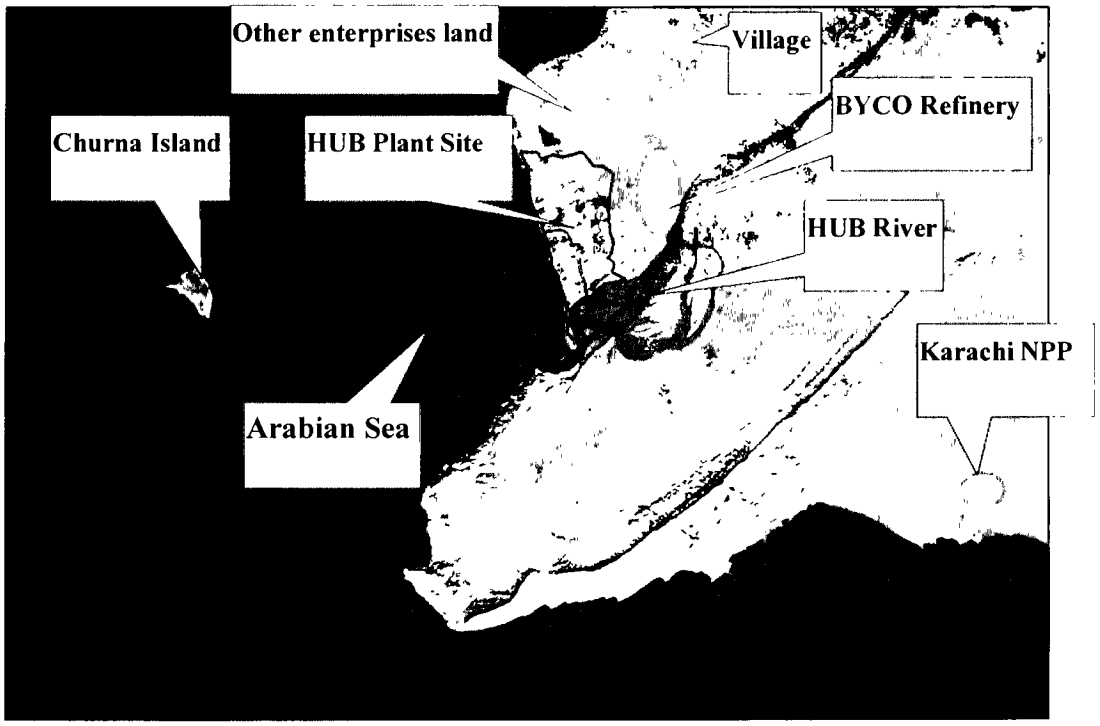
The construction site avoids the built oil fired power plant facilities and basically there is no relocation work amount in the plant.

The plant site is about 8km from the southwest Churna Island (navy firing field) and navy's

approval documents may need to be obtained for construction of dock and maritime facilities. The plant site is about 45km from the east Jinnah International Airport and approval from aviation authorities will be required before the commencement of construction work.

4.1.4 Surrounding environment of plant site

West of the plant site is the Arabian Sea, south is estuary of Hub River, east is adjacent to the built BYCO Refinery and north is other enterprises' undeveloped land. 8km southwest of Hub Plant site is Churna Island (navy firing field) and about 2km northeast of the plant site is a village. The plant site is about 55km from the northeast Hub Reservoir and 10km from the southeast Karachi Nuclear Power Plant.



Sketch of Surrounding Environment of Plant Site

4.2 Transport

The plant site is adjacent to Karachi. Karachi is the largest city in Pakistan and has a developed road network as well as Karachi Port and Airport. The airport is 45km from the plant site and there are scheduled flights to and from the world. Karachi Port is the largest port in Pakistan and is 30km from the plant site. Handling equipment includes various shore cranes, movable cranes, container cranes, floating cranes, gantry cranes, forklift trucks and tractors etc. and maximum hoisting capacity of floating cranes can reach 125t. The oil terminal can receive maximum 75,000DWT oil tankers. Several gantry cranes are prepared in the container terminal. Port area has 28hm2 freight shed and warehouse and 47hm2 open-stacking area. Big ship anchor ground water depth is 16m. Qasim Port is a deep-water seaport in Karachi, Sindh, Pakistan, on the coastline of the Arabian Sea and is 65km from the plant site. It is Pakistan's second busiest port, handling about 35% of the nation's cargo (17

million tons per annum). Qasim Port and Karachi Port, the busiest port of country, together handle more than 90% of all external trade of Pakistan.

1) Access road: you can travel from Karachi to HUB plant site by taking No. 25 national highway, shifting to HUB chawki-Arabian sea Rd in HUB Town and then the access road of the plant. A south-north road has been built on the plant site to allow for access to HUBCO Power Plant. Roads in the HUB plant site area are under quite good conditions, and they are two-lane city roads with asphalt pavement.

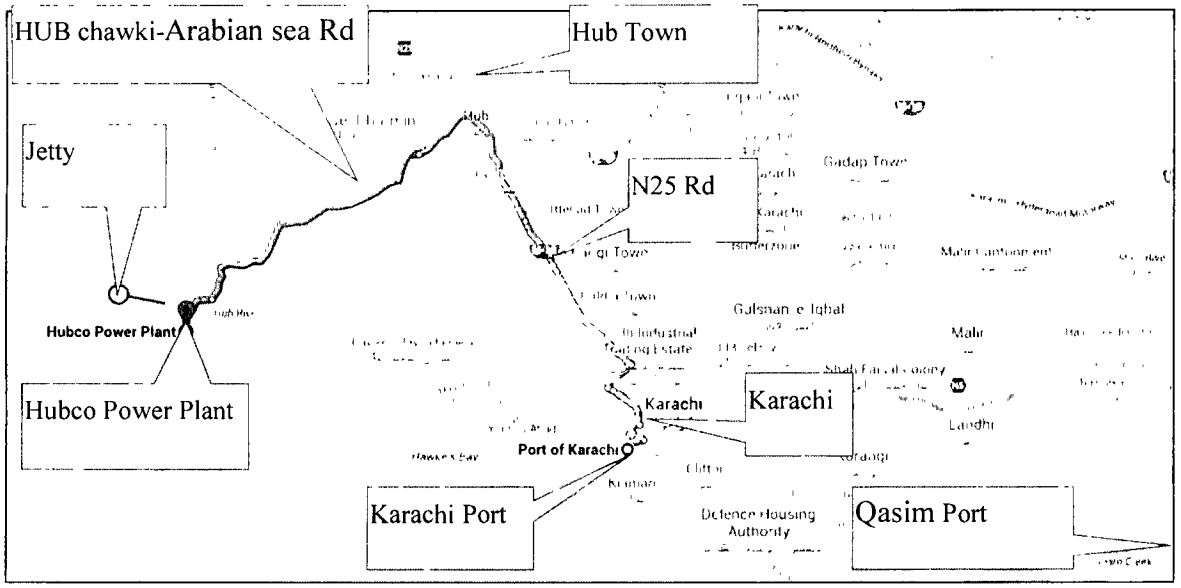
Access road for the 2×660MW units in this phase can be connected to the access road of the existing HUBCO Power Plant.

2) Fuel transport:

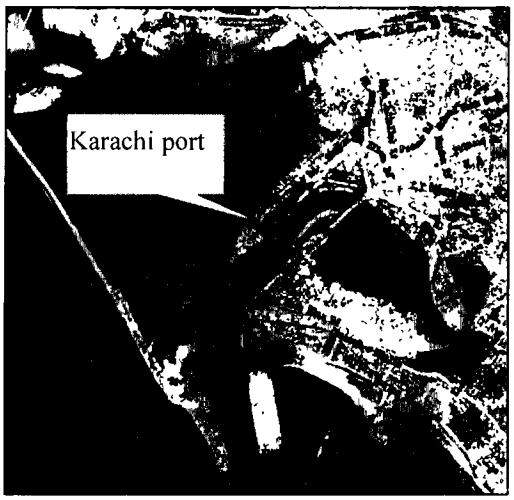
South African coal is transported by sea to the project power plant and the transport distance from Richards Bay Coal Terminal in South Africa to the project site is about 4,300kts. Indonesian coal is transported by sea to the project plant site and the transport distance from Indonesian coal production plate in the southeast Kalimantan to the project site is about 3,900kts.

It is planned that a 100,000DWT bulk carrier offshore coal unloading berth, two tugboat berths are constructed about 5.4km from the plant area coastline, and a temporary large and heavy equipment berth is constructed about 300m from the plant area coastline. The comprehensive downtime of wharf is 65d, and the continuously downtime is about 25d. The berth is provided with 2 ship unloaders of 1500t/h. The jetty is installed with one-way belt conveyer tentatively, with the belt width of 1800mm, rated output of 3600t/h, which supply coal for the power plant 2×660MW units. Details please see FSR for Jetty.

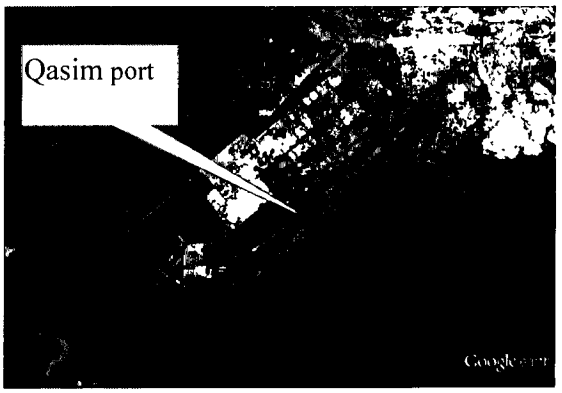
3) Transport of heavy and large equipment: large equipment in the Project mainly includes boiler plate girder, generator stator, rotor and main transformer. The preliminary transport planning is as following: The power plant is provided with temporary heavy equipment dock and in non-monsoon period, heavy equipment is transported by sea to Qasim Port for transfer and after disembarked, it is transported by large flatbed to the plant area or construction and installation area. In monsoon period, the equipment is transported by land from Qasim Port to the power plant. According to the preliminary investigation of port options, Karachi Port is mainly for container handling but Qasim Port has the handling facility for Transporting of heavy and large equipment, therefore, Qasim Port is selected for the Transportation of heavy and large equipment for this phase of the project. The scheme details of large equipment transport will be determinate in Basic Design phase.



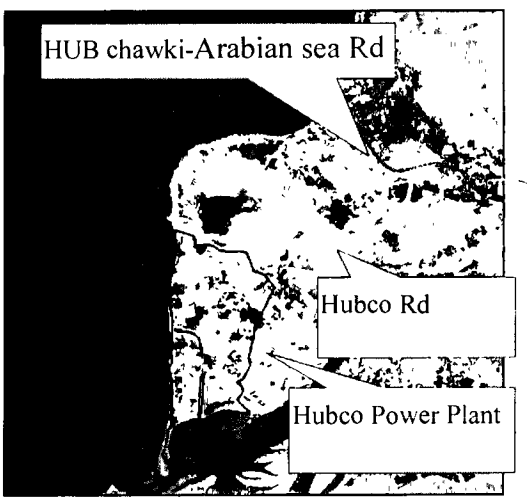
Road Connecting Plant Site and Karachi



Satellite Map of Karachi Port



Satellite Map of Qasim Port



Access Road on Plant Site

4.3 Hydrological & Meteorological Conditions

4.3.1 Meteorological Conditions

1) Climate

The plant site is located in the southwest of coastal Indus River Delta in the south of Pakistan, adjacent to the Arabian Sea. The climate at the plant site is characterized as hot and dry during summer, and mild during winter with heavy, sporadic, rainfall during the monsoon. The southwest monsoon prevails from April to October in the Project area and the Indian Ocean. The monsoon is characterized by a reversal in wind direction during the remaining months; and, heavy rainfall over most of the Indian Subcontinent.

2) Meteorological elements

For wind speed, wind direction, air temperature and relative humidity, the data at the plant location is provided by HUBCO which was acquired from Lakes Environmental (http://www.weblakes.com/services/met_data.html). The data is based on generated synthetic data for a 50 km × 50 km area around the plant site (24.918N, 66.688E), for a period of two years from January, 2012 to December, 2013. The wind direction at the plant site blew from southwest to northeast. This corresponds with the summer season, particularly, the months from May to October. The other predominant wind direction is from the northeast to southwest which occurred for a little over 10 % of the time. This corresponds with the winter season, especially, in the months of January, November and December. See Figure 4.3-1. The statistic results show that the annual mean air temperature, maximum air temperature and minimum air temperature are 25.3℃, 36.9℃ and 6.1℃, respectively. The annual mean relative humidity and minimum relative humidity are 65.9% and 9%. See Table 4.3-1.

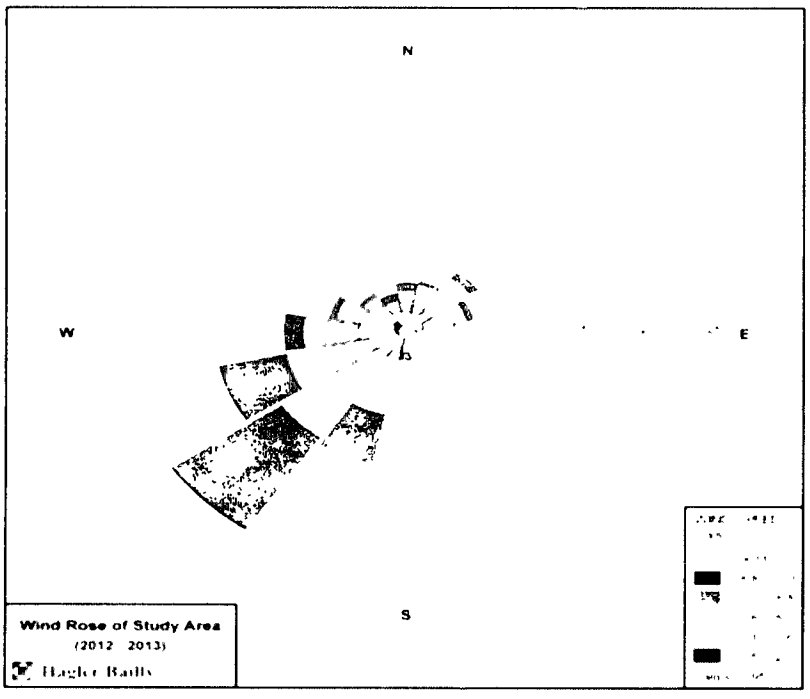


Figure 4.3-1 Annual Wind Direction Rose Map at the plant location

For air pressure, the data at the plant location is provided by HUBCO which was observed from 2009 to 2014. The monthly mean air pressure are also show in Table 4.3-1.

For precipitation and sunlight hours, the data at the plant location is not available. However, the data from Jinnah International Airport meteorological station in Karachi (24°54' N, 67°08' E), which is about 44km east away from the location of this project, could be taken as the regional climatic reference. The statistic results in 1981~2010 is shown in Table 4.3-2.

Table 4.3-1 Annual and Monthly Characteristic Values of Meteorological Elements at the plant location

Item \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean air temperature (°C)	17.4	19	23.8	27.8	29.9	30.3	29.7	28.2	28.7	27.2	23.2	18.5	25.3
Extreme maximum temperature (°C)	25.6	26.6	31.6	33.8	35.4	36.9	33.1	32.1	34.8	34.6	30.6	25	36.9
Extreme minimum temperature (°C)	10	8.6	14.1	22.8	25.4	26.1	26.6	25.2	24.2	20.1	15.1	6.1	6.1
Mean relative humidity (%)	47.2	51.1	62.1	69.2	74.7	77.5	80.6	81.7	78.7	65.5	52.1	50.8	65.9
Extreme minimum relative humidity (%)	17	17	15	12	9	27	52	64	40	21	21	18	9
Mean wind speed (m/s)	3.6	3.9	4.2	5	5.8	5.6	5.8	5.3	4.6	3.3	3.1	3.6	4.5
Predominant wind direction	NE	Variable	W	WSW	SW	SWS	SWS	SWS	SW	SW	NE	NE	SW
Mean air pressure (hPa)	1015.0	1012.7	1010.0	1006.3	1000.7	996.1	994.8	998.0	1001.7	1006.8	1010.5	1012.9	1005.5

Table 4.3-2 Annual and Monthly Characteristic Values of Meteorological Elements at Jinnah International Airport meteorological station in Karachi

Month / Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean rainfall (mm)	11.5	3.6	2.3	0.4	2.5	14	65.9	55	8.7	8.2	0.2	6.2	178.5
Mean sunlight hours (h)	270.7	249.4	271.6	277.4	299.1	231.8	155	147.7	218.8	283.5	273.3	272	2950.3

According to the "Building Code of Pakistan" (BCP SP-2007) (refer to Annexure 10), the project site belongs to Exposure D category and the fastest-mile wind speed is 135km/h. After calculation, the 10min average wind speed at 10m height as specified in national standard GB50009-2012 is 42m/s and the corresponding basic wind pressure with a recurrence interval of 50 years is 1.10 kN/m^2 and the land surface roughness category is Category A.

3) Other Information

The plant site is located adjacent to an active tectonic setting approximately 190 km east of the triple continental junction between the Arabian, Eurasian and Indian plates. Besides, The plant site is in an area of potential tsunami of which there is potential for a tsunami associated with the Makran Subduction Zone (MSZ) or smaller localised tsunamis associated with several smaller thrust faults around Karachi. However, large tsunamigenetic earthquakes have been relatively rare. The tsunami generated along the MSZ in 1945 was responsible for loss of life (approximately 4000 deaths) and destruction along the coast of Pakistan. There is evidence that this tsunami was 1.2 m and the associated earthquake of intensity was 7.2 ML. The earthquake was also associated with eruption of a mud volcano and forming four islands off the Makran Coast. This also caused minor damages in Port Qasim area. The 1945 event was followed by another tsunami-related tidal wave in 1953. The tsunami of December 26, 2004 and March 28, 2005 had little impact on the coastal areas of Gadani and Sonmiani. Both these areas are west of the plant site.

4.3.2 Hydrological Conditions

1) Tide

Tidal observation data is not available at the plant site. According to the " Hydraulic & Hydrographic Survey at Hub River Estuary & Circulating Water Intake Locations" (hereinafter referred to as the "Hydrological Report", refer to annexure 7) for HUBCO 4×323MW Oil Fired Power Plant in 1996, the tidal form factor in this region is 0.94, which is irregular semi-diurnal tide. Statistical characteristic values are given below:

Annual mean high high water level (MHHW) 2.60m (sea chart datum elevation)/1.337m (local elevation)

Annual mean low high water level (MLHW) (local elevation)	2.00m (sea chart datum elevation)/0.737m
Annual mean sea level (MSL) (local elevation)	1.60m (sea chart datum elevation)/0.337m
Annual mean low low water level (MLLW) (local elevation)	0.60m (sea chart datum elevation)/-0.663m
Annual mean high low water level (MHLW) (local elevation)	1.30m (sea chart datum elevation)/0.037m
Highest astronomical tide (HAT) (local elevation)	3.10m (sea chart datum elevation)/1.737m
Lowest astronomical tide (LAT): (local elevation)	-0.40m (sea chart datum elevation)/-1.663m

According to the "Hydrological Report", when affected by summer tropical storm, storm surge set-up at Karachi Port 60km from the plant site can reach 0.8m to the maximum extent.

As related data are not available for the time being, it is tentatively determined in the present phase that 97% low water level is -2m (sea chart datum elevation)/-3.263m (local elevation). At present, annual water level observation for the project site and observation data are less than one year. In the next phase, the 200-year return period high water level and 97% low water level will be calculated from the complete annual water level observation data and the long term water level observation data for nearby ports.

2) Ocean current

Shoreline near the project site extends from northwest to southeast. As a result, the nearshore current direction in flood tide is east while that in ebb tide is southwest. According to short term investigation result in January~February 1996 in this sea area, the tidal nature in this sea area is irregular semi-diurnal tidal current and mode of motion is mostly reciprocating current. In vertical direction, flow speed in the upper layer is higher than the middle layer and flow speed in the middle layer is higher than the lower layer. In horizontal direction, far-shore flow speed is higher than near-shore and maximum flow speed is not more than 1m/s.

3) Wave

No long term wave observation data is available at the plant site. According to the short term investigation result in January~February 1996 in this sea area, sea condition in investigation period is calm and visually observed wave height at the research ship side is not more than 0.3m. But according to research report of mathematical wave models from other projects in the sea area and 10-year wave height and direction data in 1997~2007 from the global wave model of UK Met Office, normal wave direction in this sea area is S to SSW and strong wave direction is SSW to SW, which is consistent with the southwest monsoon direction in summer in this sea area. Maximum significant wave height from open ocean can reach 9~10m and corresponding cycle is 8~10s. Besides, according to NOAA global hindcast wave data, the prevailing wave is from SSW with frequency 41.43%, sub-prevailing wave is from SW with

frequency 37.16%. Strong wave is from SW and the wave period is between 7s and 11s. From May to September, sea conditions are severe. Wave rose is shown in Figure 4.3-2.

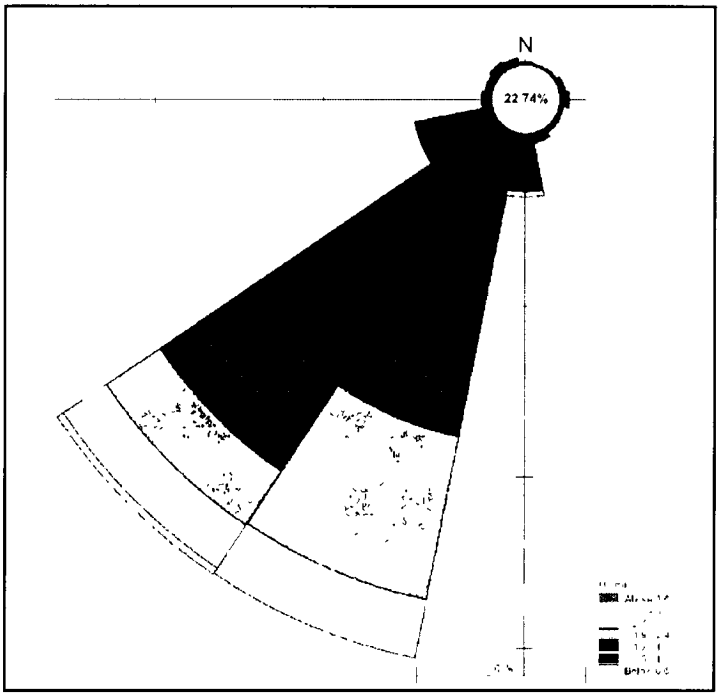


Figure 4.3-2 Wave Rose Map (quoted from FSR for jetty)

4) Water temperature

According to sea surface temperature observation data in 2009~2014 of HUBCO 4×323MW Oil Fired Power Plant south of the plant site, monthly characteristic values of sea surface temperature are obtained as shown in Table 4.3-3. It can be seen that annual mean water temperature of the sea area at the plant site is 27.9°C and seasonal change is significant. Annual water temperature change is single peaked. Water temperature rises in January~May to the highest in June and monthly mean water temperature is 31.6°C; and water temperature falls in July~December to the lowest in January and monthly mean water temperature is 22.4°C. Maximum water temperature in the observation period occurred on June 10, 2009 and reached 34.8°C; minimum water temperature occurred on February 8, 2012 and was 16.0°C.

The three months with highest water temperature in the observation period were May, June and July. Mean water temperature in this time period was 31.4°C and daily mean water temperature with 10% cumulative frequency was 32.4°C.

Table 4.3-3 Monthly Characteristic Values of Sea Surface Temperature at the plant site

Item \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Monthly mean water temperature (°C)	22.4	22.8	25.8	28.9	31.5	31.6	30.9	30.3	29.9	29.2	27.3	24.0	27.9
Monthly maximum water temperature (°C)	26.5	28.0	30.2	33.4	34.5	34.8	34.2	33.8	33.4	32.1	31.4	29.3	34.8
Monthly minimum water temperature (°C)	18.0	16.0	20.8	25.3	28.5	27.2	26.8	22.7	22.8	25.7	22.6	19.1	16.0

5) Sediment and coast stability

For suspended sediment in the sea area where the plant site is located, its concentration variation is associated with the tide variation. Peak concentration of suspended sediment often occurs at fastest flood tide or fastest ebb tide. According to the short term investigation result in January~February 1996 in this sea area, suspended sediment in the middle layer is in the range of 117~392ppm while that in the bottom layer is between 78~519ppm. The average suspended sediment concentration in spring tide and neap tide are 184ppm and 156ppm respectively and ratio of the two is 1.18.

The plant region is sandy coast in wave activity area and sediment activity along the shore is violent. According to the short term investigation result in January~February 1996 in this sea area, near-shore substrate is mostly fine sand.

6) Hydrological conditions of land

The major river in the plant region is Hub River, which is flowing in the southwest direction, falling in the Arabian Sea near Cape Monze. The plant site is located on the right bank of the Hub River and adjacent to the delta of the estuary. After the construction of Hub Dam in 1980, the Hub River Estuary has gone dry and got fresh water only in heavy rainfall and flood season. Affected by rainstorm, for Hub River Estuary, flood may occur once in 2 to 3 years.

4.3.3 Existing problems

The present hydrological and meteorological conditions are mainly quoted from the

"Hydraulic & Hydrographic Survey at Hub River Estuary & Circulating Water Intake Locations" for 4×323MW power plant of HUBCO in 1996 (refer to Annexure 7). This report was completed early, observation of tide and wave is less than one year, hydrographic observation of full tide is limited to winter and substrate sampling point is far from the project sea area. Therefore, near term observation results of tidal level, ocean current, wave, sediment, water temperature and salinity are still not available in the plant sea area. In addition, the effect of Hub River delta storm flood on the project site also needs to be studied.

In order to provide necessary hydrological parameters for power plant warm water discharge model test, sea area use demonstration, environmental impact assessment and flood prevention safety and obtain objective and reliable hydrological and meteorological input data for power plant design and future operation, the following specific studies shall be conducted subsequently in basic design phase :

1) Annual tidal level observation in plant sea area;

2) Full tide hydrological observation in winter and summer;

3) Annual wave observation in plant sea area;

4) Wave element analysis and calculation of site sea area;

5) Sediment and coast stability analysis;

6) Flood analysis assessment.

4.4 Water Sources

Water sources include the one for cooling water system and the one for fresh water.

4.4.1 Cooling water source

The plant is in the southwest of Hub City in Baluchistan Province, with Arabian Sea in its west. The once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

4.4.2 Fresh water source

Fresh water is mainly used as boiler makeup water treatment system, coal yard spray water, flushing water for coal handling system, ash removal water, air conditioner makeup water, fire water, potable water, and drinking water. The fresh water in this phase of project is supplied by seawater desalination system.

4.5 Ash Yard

In this project, ash and slag are separately removed and dry ash and slag handling systems are used. Annual amount of ash and slag discharged by 2×660MW units is about 67.20×10^4t and coal mill reject is about 1.88×10^4t per year. Ash quantity in FSR has been based on design coal RB-3, figure of 18.5% (air dry). Ash and slag volume density is calculated based on 1t/m^3 (There are 90% ash and 10% slag, the density of ash is about 0.7~0.9 t/m^3 and density

of slag is about 0.8~1.0t/m^3, and when the blend under compressing in ash yard, the density would be approximately 1t/m^3), and ash, slag and coal mill reject generated by 2×660MW units every year is about 69.08×$10^4$$m^3$.

A external ash yard is being investigated to cater for 30 years operation ash of the plant. Trucks shall be used to transport the ash to ash yard, that is the normal and economic way for ash transporting.

Plain area in the southeast of the plant is used as emergency ash yard. Underlying soil of the ash yard consists of clay silt, silty clay, sand and gravel etc. The ash yard occupies an area of 30×$10^4$$m^2$. When ash pile reaches 16m high (design maximum height), the volume is about 408×$10^4$$m^3$ and can store ash from the 2×660MW for 5.9 years.

More structure details of emergency ash yard, please see 5.14.

4.6 Earthquake, Geology and Geotechnical Engineering

4.6.1 Areal geology

Located in the northwest of the South Asian Subcontinent and in the collision zone of Eurasian continental plates on the geological structure, Pakistan is a seismically active area. According to "Building Code of Pakistan (Seismic Provisions-2007)(BCP SP-2007)" (refer to Annexure 10), the seismic activity in most parts of Pakistan is moderate to high, which is mainly caused by the collision of the Eurasian continental plates and appears to be the orogenic movement of the Himalayas and other mountain chains. There are mainly four seismic activity tectonic zones in Pakistan: (1) Himalayan seismic tectonic zone in the north; (2) the thrust fold belt of Suleiman -Gilt in the west; (3) transform fault of Chaman-Ornach-Nal and Makran subduction zone; (4) Kutch coastal seismic zone in the southeast. The diversified geological faults constitute the above seismic tectonic activity partition. The main fracture near the site area is the Pab fracture (No. 17) as shown in Figure 4.6-1.

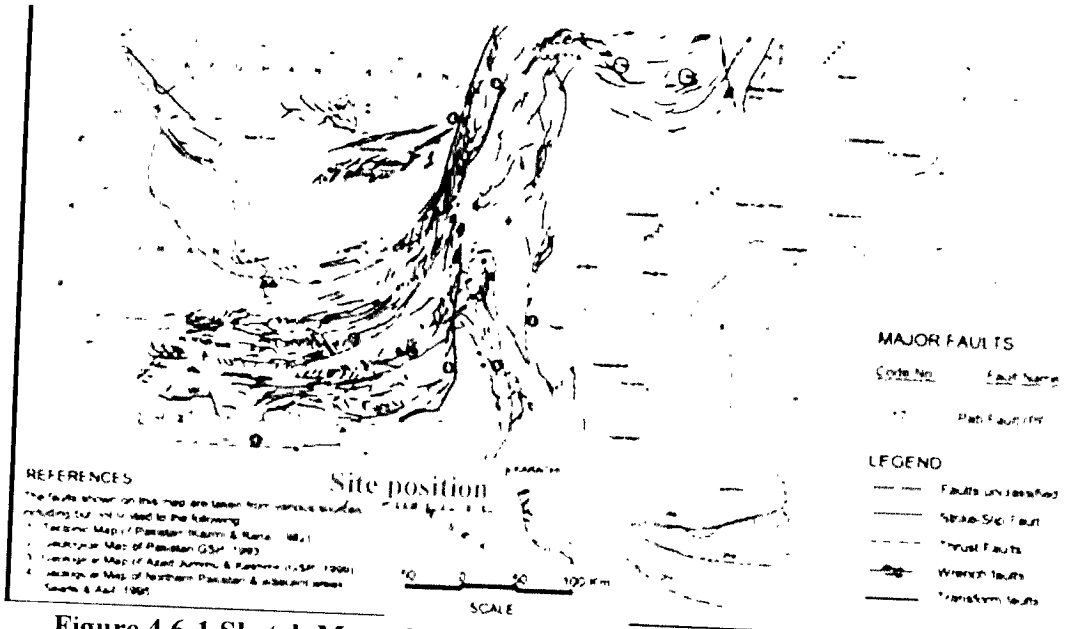


Figure 4.6-1 Sketch Map of Fault Structure near Site Area (BCP SP-2007)

The fracture is about 6 kilometers from the site. The site is located in the famous Chaman fault tectonic zone in Pakistan on the areal geology. Although it is a weak new active fault, the site has good geological conditions, high capacity and very small increase in accumulated ground stress, thus there are few earthquake recorded near the site.

4.6.2 Site Stability Evaluation and Ground Motion Parameters

According to the historical earthquake records, within 50 kilometers of the site, there were four earthquakes recorded with most of the earthquake magnitudes of less than M-S 4.7, and its potential earthquake loss was moderate[1]. According to the conclusion of the survey report of existing HUBCO Oil Fired Power Plant, the site has good geological conditions, high bearing capacity, and very small increase in accumulated ground stress and there are few earthquake recorded near the site; therefore, the site is suitable for construction geologically.

As per the seismic zoning map in BCP SP-2007 (shown as Figure 4.6-2) as well as Table 2-1 and Table 2-2, the site belongs to seismic zone 2B (with the Peak Ground Acceleration range 0.16 to 0.24g), the PGA with exceedance probability of 10% in 50 years of the plant site area is 0.20g (shown as Figure 4.6-3) and the corresponding basic seismic intensity scale is VIII according to Chinese "Code for seismic design of buildings (GB 50011-2010)".

[1] Shahid A. Khan, M Ali Shah, M. Qaisar. Seismic risk analysis of coastal area of Pakistan. Acta Seismologica Sinica. July 2003, Volume 16, Issue 4, pp 382-394

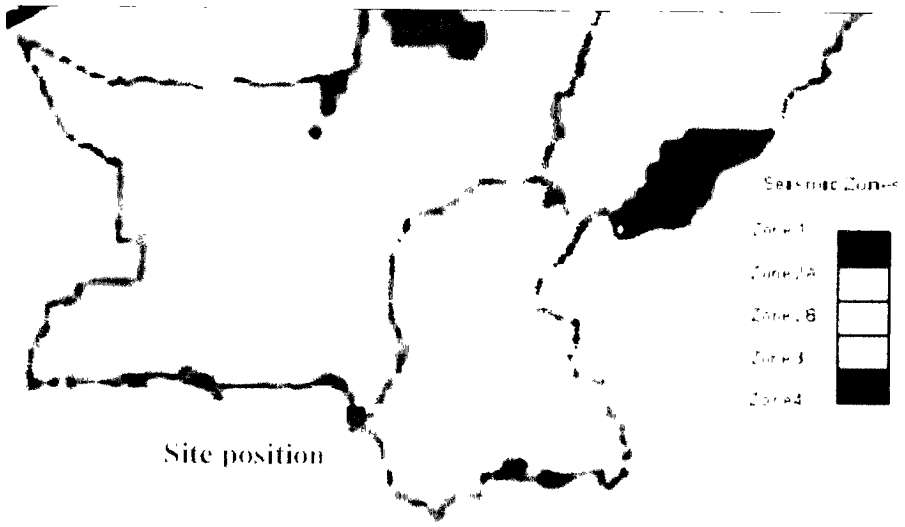


Figure 4.6-2 Seismic Zoning Map of Site (BCP SP-2007)

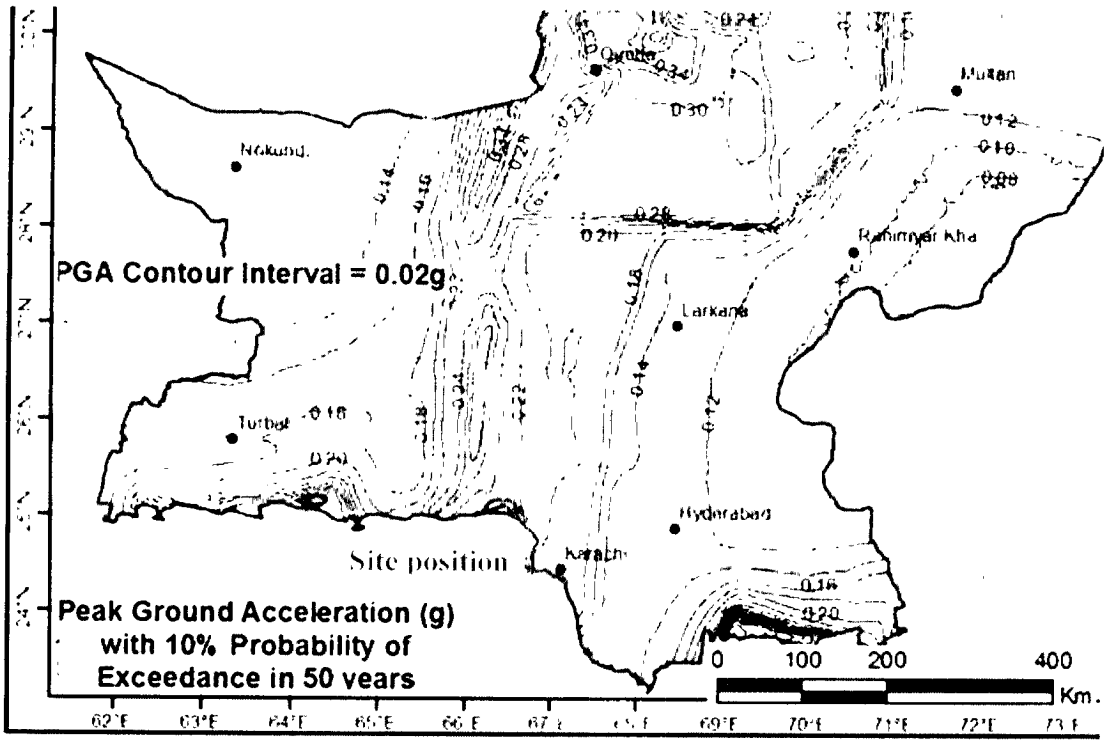


Figure 4.6-3 Basic Earthquake Acceleration Map of Site Area (BCP SP-2007)

As per Munich Re world map of natural hazards (2011 version), the proposed plants site locates in seismic zone 3 corresponding to the probable maximum seismic intensity scale VIII (Modified Mercalli scale) shown as Figure 4.6-4.

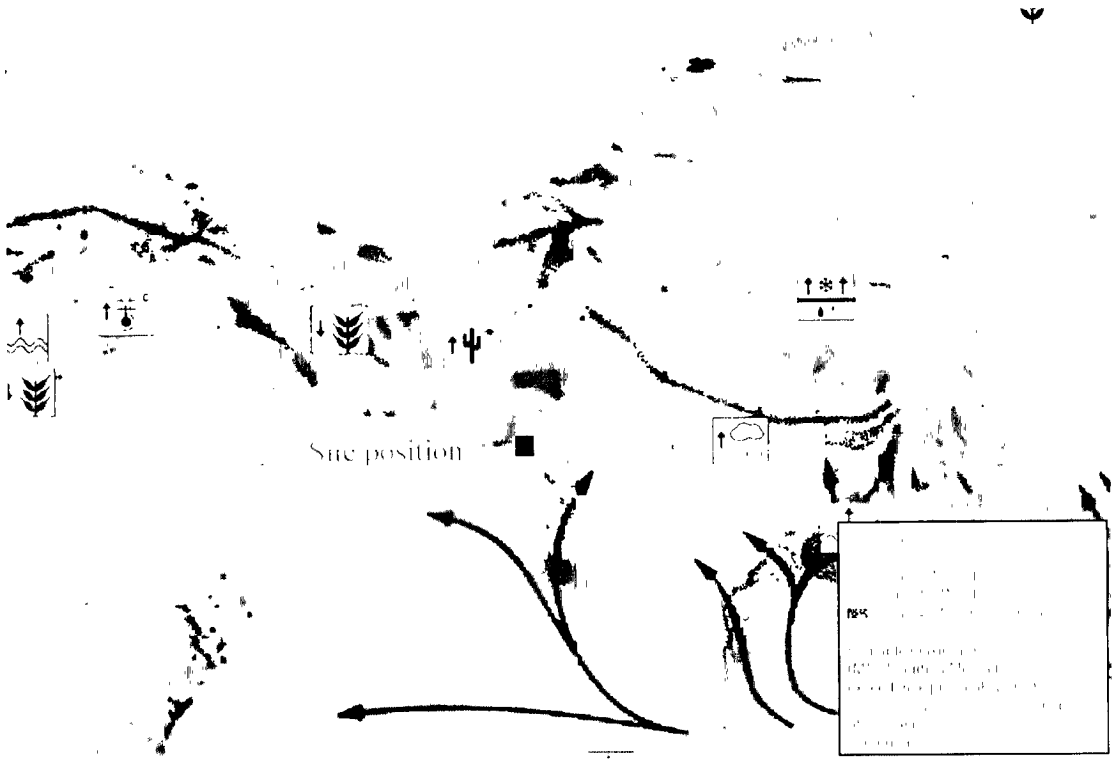


Figure 4.6-4 Seismic intensity scale map of Site Area (Munich Re world map of natural hazards-2011 version)

As per Chinese national code: The Chinese seismic intensity scale (GB/T 17742-2008), seismic intensity of level VIII corresponds to PGA range from 1.78 to 3.53m/s^2 (equal to 0.18~0.36g). And according to Zhang Minzheng[2], Chinese seismic intensity scale and world's other prevailing scales are basically consistent except the Japanese scale (shown as Table 4.6-1).

Table 4.6-1 Relationship between different seismic intensity scales

Scales	Seismic Intensity											
China	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
MSK	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
MM	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
JMA	0	I	II	III	IV	V-	V+	VI-	VI+			

MSK-Modvedev, Spanheuer, Karnik

MM- Modified Mercalli Intenstiy Scale

JMA-Japan Morological Agency

Therefore, in summary, the PGA of 0.2g corresponding to basic seismic intensity of VIII is recommended for this project.

4.6.3 Geotechnical Engineering Conditions

4.6.3.1 Geomorphology

[2] Zhang Minzheng. Seismic Intensity and Intensity Assessment. J.of Institute of Disaster-Prevention Science and Technology. Mar 2010. Vol.12 No.1.

4) Gray to ficelle clay layer, medium plasticity, hard to very hard (CL);

5) Brown gray to gray siltstone, mudstone, intensely weathered to slightly weathered (SiS, CS); uniaxial compressive strength of rocks is 2~10Mpa.

4.6.3.3 Geotechnical engineering condition Evaluation

According to analysis based on the geotechnical engineering survey report (refer to Annexure 6) for the existing HUBCO Power Plant, rock top coverage in the plant area is about 2.7~10m thick and mainly consists of clay silt, silty clay, sand and gravel layers. As revealed by the borehole BH13 with the worst conditions that is closest to the seaside, the upper 2m is silty clay, silty fine sand and coarse sand layers and layer bottom elevation is -0.59m under which is gravel layer filled with clay and sand and under -7.8m are mudstone and siltstone. The foundation has good physical mechanic property and high bearing capacity. According to experience in construction with all natural foundations for HUBCO Power Plant and considering that this project site is adjacent to HUBCO Power Plant, natural foundation can still be used for buildings and structures in most areas of the power plant. Extended foundation is used and in the local areas where bearing stratum is buried slightly deeply, other foundation treatment methods such as replacement or heavy tamping can be used. Compactness of structural backfill needs to reach at least 0.95 and compactness of non-structural backfill needs to reach over 0.90. Even if pile foundation is used, pile length is small.

The plant site is adjacent to seaside and strata have medium water permeability. Groundwater and seawater infiltration is hydraulically related. According to observation in the engineering survey period of HUBCO Power Plant, groundwater level is 0.5~1.0m. As seawater generally is highly corrosive, it is preliminarily judged that groundwater is weakly to medium corrosive and corrosion protection means need to be used. Due to two-way makeup of Hub River and seawater, groundwater level is relatively high and during foundation pit excavation, water level reduction and drainage means need to be considered.

Such unfavorable geologic functions as landslide, avalanche and underground cavern have not been found in and near the site. Valuable cultural relic or exploitable mineral resources has not been found in the site range either.

Because of lack of specific geotechnical investigation data such as in-situ tests or laboratory tests for the new site, some foundation design parameters or sand liquefaction evaluation will be determined by sufficient investigation information in the next phase of design. Therefore some main risks including deep bearing stratum and liquefaction should be considered when doing foundation design at this stage.

4.7 Conclusions

4.7.1 Main conclusions

Technical Conditions of Plant Site are shown in the table below

Table of Technical Conditions on the Plant Site

No.	Item	Technical Conditions for 2×660MW Units in this Phase	Remarks
1	Geographic position of plant site	The plant site is situated in the southwest of Hub Town, Baluchistan Province (N 24°54'9", E 66°41'31") and about 20km from the center of Hub City.	
2	Relationship with urban planning and industrial and mining enterprises	The plant site is about 20km from the center of HUB Town to the northeast. The plant site is adjacent to the existing BYCO refinery to the east, and its north is the other enterprises' undeveloped land. The plant site is about 10km from Karachi Nuclear Power Plant in southeast.	
3	Topography	The construction site slopes from north to south and from west to east, with flat and broad landform on the plant site. The ground elevation is generally about 2.5~6.0m. There are small dunes in some places, with sparse vegetation on the ground surface.	
4	Construction site	The land acquired in Phase I meets the demand for construction of 6×660MW units. The 2×660MW units to be built in this phase will occupy an area of about 43.4hm^2, and 6×660MW units will require an area of about 115.50hm^2.	
5	Demolition	Basically no demolition.	
6	Transport conditions	Airline: Jinnah International Airport in Karachi is about 45km from the plant site, from which you can fly to everywhere in the world with regular flights. Port: Karachi port is the largest port in Pakistan and it is about 30km from the plant site. The oil terminal allows berthing of oil tankers up to 75,000DWT. Qasim Port is a deep-water seaport in Karachi, Sindh, Pakistan, on the coastline of the Arabian Sea and is 65km from the plant site. Road: you can travel from Karachi to HUB plant site by taking No. 25 national highway, shifting to HUB chawki-Arabian sea Rd. in HUB town and then the access road of the plant.	
7	Fuel transport method	Water transport is used. It is planned that a 100,000DWT bulk carrier offshore coal unloading	

No.	Item	Technical Conditions for 2×660MW Units in this Phase	Remarks
		berth, two tugboat berths are constructed about 5.4km from the plant area coastline, and a temporary large and heavy equipment berth is constructed about 300m from the plant area coastline.	
8	Coal storage and conveying facility in the plant	One strip-shaped open air coal yard with bucket wheel machine will be provided in the power plant, the coal yard has total 3 coal stockpiles of A, B, and C, width of coal stockpiles A and C is 50mm, width of coal stockpile B is 90m, the coal stockpile length is 455m, the coal stockpile height is 15m. The total coal storage capacity of the 3 coal stockpiles is 72.6×10^4t, meeting the coal demands of 60d of the power plant of 2 units (design coal). The coal yard is installed with 2 reentrant type cantilever bucket wheel stackers/reclaimers, with the cantilever length of 50m, the stacking output of 3600t/h, reclaiming output of 1000/h, the coal stacking capacity matches with the coal unloading system conveying capacity, and the coal reclaiming capacity matches with the coal handling system output. One belt conveyer with belt width of 1800mm, output of 3600t/h is arranged respectively at bottom of the bucket wheel machine.	
9	Water supply	The once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water. Fresh water is mainly used as boiler makeup water treatment system, coal yard spray water, flushing water for coal handling system, ash removal water, air conditioner makeup water, fire water, potable water, and drinking water.	
10	Conditions for emergency ash yard	Plain area in the southeast of the plant is used as emergency ash yard. Underlying soil of the ash yard consists of clay silt, silty clay, sand and gravel etc. The ash yard occupies an area of $30\times10^4m^2$. When ash pile reaches 16m high (design maximum height), the volume is about $408\times10^4m^3$ and can store ash from the 2×660MW for 5.9 years.	

No.	Item	Technical Conditions for 2×660MW Units in this Phase	Remarks
		A 2000m ash transport road will be built from the plant area to the emergency ash yard.	
11	Outgoing lines from the plant	A 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station	
12	Flood control conditions	According to 4.3.14 of the "Code for Design of Fossil Fired Power Plant" (GB 50660-2011), protection for the power plant is designed for 200-year return period flood and effect of flood discharge water level of the upstream Hub reservoir needs to be considered. At present related data is not available and 200-year return period flood level and Hub reservoir flood discharge level remain to be further determined. These related data will influence the determining of the outdoor ground level and will be determined after flood analysis assessment is completed in basic design phase.	About 55km from Hub Reservoir.
13	Earthquake and geology	According to historical earthquake records, four earthquakes have been recorded in the 50km range around the plant site. Earthquake magnitude is less than 4.7th degree and it belongs to area with moderate potential earthquake loss. According to HUBCO power plant survey report conclusions, foundation conditions of plant site are good, carrying capacity is high, accumulated earth stress increase is very small and recorded earthquakes near the plant site are very few. Therefore, the site is suitable for construction. As per the seismic zoning map in the "Building Code of Pakistan (Seismic Provisions-2007)" (BCP SP-2007) (refer to Annexure 10) (shown as Figure 4.6-2) as well as Table 2-1 and Table 2-2, the site belongs to the seismic zone 2B (with the Peak Horizontal Ground Acceleration range from 0.16 to 0.24g), the peak ground acceleration with exceedance probability of 10% in 50 years is 0.20g (shown as Figure 4.6-3) and the corresponding	

No.	Item	Technical Conditions for 2×660MW Units in this Phase	Remarks
		seismic basic intensity scale is VIII according to Chinese "Code for seismic design of buildings (GB 50011-2010)".	
14	Cultural relics, minerals, military facility and airport	No cultural relics or underground mineral resources have been found within the plant site. The plant site is about 8km from the southwest Churna Island (navy firing field) and navy's approval documents may need to be obtained for construction of dock and maritime facilities. The plant site is about 45km from the east Jinnah International Airport and approval from aviation authorities will be required before the commencement of construction work.	
15	Environmental protection	Desulfurization units are built concurrently and seawater desulfurization process is tentatively adopted; conditions for installation of the denitrification unit are allowed. There is no centralized residential area around the plant site, and the nearest village is about 2km from the plant site.	
16	Construction conditions	The construction site is broad and under favorable conditions. Construction water is proposed to be purchased, and construction power shall be supplied by diesel generators.	
17	Earthwork quantities	The elevation of outdoor ground of the plant area is temporarily determined to be 4.80m. Excavated volume is about 842,000m^3 and fill amount is about 460,000m^3. The remaining earthwork can be used to build dams for the ash yard or fill in the low ground in the range of land acquisition for the plant area. Spoil transport distance is 1km~2.5km.	To be checked after flood level is determined
18	Foundation conditions	According to geologic report of the nearby HUBCO Power Plant (refer to Annexure 6), foundation conditions in the plant area are good and the majority of main building foundations are natural foundation. In some places where load is high, pile	

No.	Item	Technical Conditions for 2×660MW Units in this Phase	Remarks
		foundation is used and for other appurtenant works, natural foundation is used.	

From the above analysis on conditions of the plant site, the site has flat landform, spacious construction area, convenient transportation, sufficient water source and favorable outgoing line conditions, which are suitable for construction of the plant. In conclusion, the site meets the requirements for construction of 2×660MW supercritical units in this phase, as well as conditions for future expansion of 4×660MW supercritical units.

4.7.2 Suggestions

1) In order to provide necessary hydrological parameters for power plant warm water discharge model test, sea area use demonstration, environmental impact assessment and flood prevention safety and obtain objective and reliable hydrological and meteorological input data for power plant design and future operation, the following specific studies shall be conducted subsequently in basic design phase :

(a) Annual tidal level observation in plant sea area;

(b) Full tide hydrological observation in winter and summer;

(c) Annual wave observation in plant sea area;

(d) Wave element analysis and calculation of site sea area;

(e) Sediment and coast stability analysis;

(f) Flood analysis assessment.

2) According to 4.3.14 of the "Code for Design of Fossil Fired Power Plant" (GB 50660-2011), protection for the power plant is designed for 200-year return period flood and effect of flood discharge water level of the upstream Hub reservoir needs to be considered. At present, related data is not available and further confirmation is needed. This affects the determination of vertical elevation of the plant site and earth and stone work amount in the plant area. These related data will be determined after food analysis assessment is completed in basic design phase.

5. Engineering proposals

5.1 General Plan of the Power Plant and General Layout Plan of Plant Area

5.1.1 General Plan of the Power Plant

1) General planning principle

a) In this project, 2×660MW supercritical units are built, and land for expansion of 4×660MW units is reserved. The BOP (balance of plant) shall be constructed according to 2×660MW units in principle. Only seawater intake channel is designed for 6 units to provide assistance in construction phase of future projects, however, all the other facilities are designed for 2 units;

b) By adhering to the principle of optimal construction at this phase and rational long-term planning, costs for construction at this phase shall be minimized;

c) Overall planning shall be conducted by considering surrounding environment of the plant site in order to comply with local urban construction planning;

d) With the plant as the center, rational processes inside and outside the plant shall be achieved, and pipelines shall be arranged to be as short as possible;

e) Coordination between inside the plant and outside the plant, between production and living, and between production and construction;

f) Rational planning of transport inside and outside the plant;

g) Coordination between units to be built at this phase and the existing oil-fired units shall be made in order to minimize impacts on those existing units and facilities.

2) Plant area and construction land for the plant

This section is based on the recommended Scheme I (refer to 44-FC08931K-A02-Z02 and 44-FC08931K-A02-Z03), Details comparison of three schemes refer to 5.1.4.

In this project, 2×660MW supercritical units are built, and land for expansion of 4×660MW units is reserved. The BOP (balance of plant) shall be constructed according to 2×660MW units in principle, with simultaneous construction of desulfurization units which are tentatively determined to adopt the seawater desulfurization process, and conditions for installation of the denitrification unit shall be allowed for. The main powerhouse is located in the north of the plant area, with the fixed end facing the southwest. The plant shall be expanded towards the northeast, with units 1~6 installed from southwest to northeast. A-row columns of the main powerhouse face the northwest.

Area of the land inside enclosure walls in the plant area is 43.4hm^2.

3) Supply and transport of fuel

Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3.

South Africa has rich coal resource in the world with reserve of about 2057×10^{8}t, making up

2/3 total coal reserve in the whole Africa. The explored reserve is 587×10^8t. At present, South Africa produces hard coal of about 2.87×10^8t annually, in the first place in Africa and ranking the seventh in the world. In 2014, the total export was 76×10^6t, accounting for 25% of the total coal production. It is the world's fifth largest coal export country and most of its coal is exported to India, Pakistan, Middle East and EU.

At present, Indonesia is the world's fifth largest coal producer and also the biggest coal exporter. Asian region is the main export destination of Indonesian coal, including China, South Korea, Japan, India and Taiwan etc, making up more than 70% of the total export, and Europe and America follow.

The transport distance is about 4300 kts from Port of Richards Bay of South Africa to the project site and about 3900 kts from southeast part of Kalimantan Island – Indonesian coal mine to the project site.

It is planned that a 100,000DWT bulk carrier offshore coal unloading berth, two tugboat berths are constructed about 5.4km from the plant area coastline, and a temporary large and heavy equipment berth is constructed about 300m from the plant area coastline. The comprehensive downtime of wharf is 65d, and the continuously downtime is about 25d. The berth is provided with 2 ship unloaders of 1500t/h. The jetty is installed with one-way belt conveyer tentatively, with the belt width of 1800mm, rated output of 3600t/h, which supply coal for the power plant 2×660MW units. Details please see FSR for Jetty.

Light diesel oil is used for ignition and combustion of the boiler, and temporary is transported by truck to the power plant.

4) Plant water source

The once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

Fresh water is mainly used as boiler makeup water treatment system, coal yard spray water, flushing water for coal handling system, ash removal water, air conditioner makeup water, fire water, potable water, and drinking water. The fresh water in this phase of project is supplied by seawater desalination system.

5) Outgoing line corridor

A 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station (refer to Annexure 1).

6) Ash yard

In this project, ash and slag are separately removed and dry ash and slag handling systems are used. Annual amount of ash and slag discharged by 2×660MW units is about 67.20×10^4t and coal mill reject is about 1.88×10^4t per year. Ash quantity in FSR has been based on design coal RB-3, figure of 18.5% (air dry), ash and slag volume density is calculated based on 1t/m^3, and ash, slag and coal mill reject generated by 2×660MW units every year is about 69.08×10^4m^3.

A external ash yard is being investigated to cater for 30 years operation ash of the plant.

Plain area in the southeast of the plant is used as emergency ash yard. Underlying soil of the ash yard consists of clay silt, silty clay, sand and gravel etc. The ash yard occupies an area of $30\times10^4m^2$. When ash pile reaches 16m high (design maximum height), the volume is about $408\times10^4m^3$ and can store ash from the 2×660MW for 5.9 years.

A 2000m ash transport road will be built from the plant area to the emergency ash yard.

7) Flood control planning within the plant area

According to 4.3.14 of *Code for design of fossil fired power plant* (GB 50660-2011), the plant flood control shall be planned based on a return period of 200 years and shall take impact of flood discharge level of the upstream HUB reservoir into consideration. At present, relevant information is not available and information of tide level with a return period of 200 years and HUB reservoir flood discharge level needs to be confirmed. These related data will be determined after food analysis assessment is completed in basic design phase.

According to 4.3.15 of *Code for design of fossil fired power plant* (GB 50660-2011), when the site elevation is lower than the design high water (tide) level or the site elevation is higher than the design high water (tide) level but the site is still affected by waves, waterbreaks shall be provided or other flood control measures shall be taken. For coastal thermal power plants, top elevation of the waterbreaks (or wave walls) shall be determined based on design high water (tide) level plus wave train with a return period of 50 years, wave run-up with an accumulative frequency of 1% and safe superelevation of 0.5m.

In this project, about half retaining wall of the plant area is near sea and faces main waves. Therefore, wave walls need to be provided. Considering importance of the project and complexity of wave calculation, structural form of wave walls and top elevations can be finalized after observation of waves and physical model test of waves and retaining wall sections.

8) Road outside the plant and entrance to the plant area

2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant.

Construction of main access road about 1600m long, secondary access road about 1200m long and ash transport road about 2000m long shall be required.

9) Construction area and construction living area

The construction area shall be mainly located in the east and in the north of the plant area, and it will occupy an area of $20hm^2$, including about $4hm^2$ for the construction living area.

10) Environmental protection

Desulfurization units which are tentatively determined to adopt the seawater desulfurization process shall be also constructed in the Project, and conditions for installation of the denitrification unit shall be allowed.

11) Plant living area

Plant living area of the Project shall be arranged within the land acquired for the plant area and to the northwest of the access road for HUBCO Power Plant. Living area of the jetty area and safety and security personnel shall be arranged together with the plant living area.

5.1.2 General Layout Plan of Plant Area

The consideration of the general layout of the plant mainly include land use condition, entrance road condition, CCW intake and discharge condition, outgoing line corridor condition, coal yard location condition and surrounding environment condition, etc. There are three general layout plan schemes, details are as following:

5.1.2.1 General Layout Plan of Plant Area (Scheme I)

In this scheme (refer to 44-FC08931K-A02-Z03), the main powerhouse shall be provided in the northern part of the plant area, with A-row columns facing the northwest and fixed end facing the southwest. Expansion shall be made towards the northeast, with units 1~6 provided from southwest to northeast.

1) Main powerhouse area

The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler house, forced draft fan, ESP, induced draft fan provided from northwest to southeast, and the central control building shall be provided between two boilers.

Four-row arrangement of "steam turbine house - deaerator bay - coal bunker bay - boiler house" shall be adopted for the main powerhouse.

2) Power distribution device

500kV indoor GIS shall be provided in front of A-row columns of the steam turbine house to facilitate the overhead line to the main transformer.

3) Cooling facility

The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel.

The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the length and bottom altitude of this open channel is 720m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulphurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling

water is discharged, via two 4.6m×3.6m culverts, to the sea area northwest to plant site. The total length of the culverts is 3000m.

4) Coal yard and coal conveying system

The coal yard shall be a separate area in the Project, and it shall be provided in the southeast of the plant area.

In this scheme, an open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 455m long and 15m high. The 3 coal stockpiles can store 72.6×10^4t coal and meet the demand of 60 days (for design coal) for the 2 units. 2 cantilever bucket-wheel stackers/reclaimers shall be installed on the coal storage yard, which shall have a 50m cantilever and the stacking output of 3600t/h and reclaiming output of 1000t/h. The coal stacking capacity shall match with the conveying capacity of the coal unloading system and the reclaiming capacity shall match with the coal charging system output. A belt conveyor with belt width of 1800mm and capacity of 3600t/h shall be provided at the bottom of each bucket-wheel stacker/reclaimer (refer to 5.7 for details).

5) Auxiliary production area

Other auxiliary workshops in the power plant shall be mainly provided on the fixed end of the main powerhouse and in the area behind the chimney, and such shops include seawater desalination station, boiler feedwater and makeup treatment station, central wastewater treatment plant, aeration tank, seawater desulfurization facility area, industrial fire water basin, portable and drinking water tank, comprehensive water pump house, fire pump house, oil tank area, auxiliary boiler, hydrogen generator station, circulating water pump house and reserved ammonia area, etc.

The ash silo and the aeration fan room shall be provided immediately behind the chimney, and the coal bulldozer house and coal wastewater treatment plant, etc. shall be provided near the coal yard.

6) Building zone of the frontage area

Mainly including the production office building, etc.

7) Entrances to the plant area

2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant.

The main entrance is located at northeast side of the plant area with the main access road about 1600m long; the secondary entrance is located at southwest side of the plant area with the secondary access road about 1200m long.

5.1.2.2 General Layout Plan of Plant Area (Scheme II)

In this scheme (refer to 44-FC08931K-A02-Z04), the main powerhouse shall be provided in the southern part of the plant area, with A-row columns facing the southeast and fixed end

facing the southwest. Expansion shall be made towards the northeast, with units 1~6 provided from southwest to northeast.

1) Main powerhouse area

The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler room, forced draft fan, ESP, induced draft fan provided from northwest to southeast, and the central control building shall be provided between two boilers.

Four-row arrangement of "steam turbine house - deaerator bay - coal bunker bay - boiler house" shall be adopted for the main powerhouse.

2) Power distribution device

500kV indoor GIS shall be provided in front of A-row columns of the steam turbine house to facilitate the overhead line to the main transformer.

3) Cooling facility

The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel.

The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the length and bottom altitude of this open channel is 450m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulphurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two 4.6m×3.6m culverts, to the sea area northwest to plant site. The total length of the culverts is 4600m.

4) Coal yard and coal conveying system

The coal yard shall be a separate area in the Project, and it shall be provided to the northwest of the plant area, that is, on the opposite of the plant area with the open water channel in the middle.

In this scheme, an open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 660m long and 15m high. The 3 coal stockpiles can store 109×10^4t coal and meet the demand of 90 days (for design coal) for the 2 units. 2 cantilever bucket-wheel stackers/reclaimers shall be installed on the coal storage yard, which shall have a 50m cantilever and the stacking output of 3000t/h and

reclaiming output of 1000t/h. The coal stacking capacity shall match with the conveying capacity of the coal unloading system and the reclaiming capacity shall match with the coal charging system output. A belt conveyor with belt width of 1800mm and capacity of 3000t/h shall be provided at the bottom of each bucket-wheel stacker/reclaimer (refer to 5.7 for details).

5) Auxiliary production area

Other auxiliary workshops in the power plant shall be mainly provided on the fixed end of the main powerhouse and in the area behind the chimney, and such shops include seawater desalination station, boiler feed water treatment station, central wastewater treatment plant, aeration tank, seawater desulfurization facility area, industrial fire water basin, portable and drinking water tank, comprehensive water pump house, fire pump house, oil tank area, auxiliary boiler, hydrogen generator station, circulating water pump house and reserved ammonia area, etc.

The ash silo and the aeration fan room shall be provided immediately behind the chimney, and the coal bulldozer house and coal wastewater treatment plant, etc. shall be provided near the coal yard.

6) Building zone of frontage area

Mainly including the production office building, etc.

7) Entrances to the plant area

2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant.

The main entrance is located at south side of the plant area with the main access road about 900m long; the secondary entrance is located at northeast side of the plant area with the secondary access road about 1200m long.

5.1.2.3 General Layout Plan of Plant Area (Scheme III)

In this scheme (refer to 44-FC08931K-A02-Z05), the main powerhouse shall be provided in the northern part of the plant area, with A-row columns facing the northeast and fixed end facing the southeast. Expansion shall be made towards the northwest, with units 1~6 provided from southeast to northwest.

1) Main powerhouse area

The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler room, forced draft fan, ESP, induced draft fan provided from northeast to southwest, and the central control building shall be provided between two boilers.

Four-row arrangement of "steam turbine house - deaerator bay - coal bunker bay - boiler room" shall be adopted for the main powerhouse.

2) Power distribution device

500kV indoor GIS shall be provided in front of A-row columns of the steam turbine house to facilitate the overhead line to the main transformer.

3) Cooling facility

The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel.

The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the length and bottom altitude of this open channel is 1100m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulfurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two 4.6m×3.6m culverts, to the sea area northwest to plant site. The total length of the culverts is 5200m.

4) Coal yard and coal conveying system

The coal yard shall be a separate area in the Project, and it shall be provided to the northwest of the plant area, that is, on the opposite of the plant area with the open water channel in the middle.

In this scheme, an open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 455m long and 15m high. The 3 coal stockpiles can store 72.6×10^4t coal and meet the demand of 60 days (for design coal) for the 2 units. 2 cantilever bucket-wheel stackers/reclaimers shall be installed on the coal storage yard, which shall have a 50m cantilever and the stacking output of 3600t/h and reclaiming output of 1000t/h. The coal stacking capacity shall match with the conveying capacity of the coal unloading system and the reclaiming capacity shall match with the coal charging system output. A belt conveyor with belt width of 1800mm and capacity of 3600t/h shall be provided at the bottom of each bucket-wheel stacker/reclaimer (refer to 5.7 for details).

5) Auxiliary production area

Other auxiliary workshops in the power plant shall be mainly provided on the fixed end of the main powerhouse and in the area behind the chimney, and such shops include seawater desalination station, boiler feed water treatment station, central wastewater treatment plant, aeration tank, seawater desulfurization facility area, industrial fire water basin, portable and drinking water tank, comprehensive water pump house, fire pump house, oil tank area,

auxiliary boiler, hydrogen generator station, circulating water pump house and reserved ammonia area, etc.

The ash silo and the aeration fan room shall be provided immediately behind the chimney, and the coal bulldozer house and coal wastewater treatment plant, etc. shall be provided near the coal yard.

6) Building zone of frontage area

Mainly including the production office building, etc.

7) Entrances to the plant area

2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant.

The main entrance is located at east side of the plant area with the main access road about 255m long; the secondary entrance is located at northeast side of the plant area with the secondary access road about 550m long.

5.1.3 Vertical planning of the plant area

According to 4.3.14 of *Code for design of fossil fired power plant* (GB 50660-2011), the plant flood control shall be planned based on a return period of 200 years and shall take impact of flood discharge level of the upstream HUB reservoir into consideration. At present, relevant information is not available and information of tide level with a return period of 200 years and HUB reservoir flood discharge level needs to be confirmed. These related data will be determined after flood analysis assessment is completed in basic design phase.

For this phase of project, we determine the outdoor ground level referring to the top level of the flood control dike of the existing Hubco Power Plant and the existing Hubco Power Plant has not been flooded since the flood control dike has been built.

The elevation of outdoor ground of the existing Hubco Power Plant is about 3.80m and the flood control dike about 1m high is provided around the plant area with top elevation of about 4.80m. At present, the elevation of outdoor ground of the plant area is determined to be 4.80m by referring to top elevation of the water breaks for the existing plant. The final outdoor ground elevation would be determinate in basic design phase.

5.1.3.1 General Layout Plan of Plant Area (scheme I)

The plant adopts gentle slope vertical layout with outdoor ground elevation of 4.80m and indoor ground elevation of 5.10m.

The excavation for the plant area is about 84.2×10^4 m^3 and filling is about 46×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km.

5.1.3.2 General Layout Plan of Plant Area (scheme II)

The plant adopts gentle slope vertical layout with outdoor ground elevation of 4.80m and indoor ground elevation of 5.10m.

The excavation for the plant area is about 94.8×10^4 m^3 and filling is about 48×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km.

5.1.3.3 General Layout Plan of Plant Area (scheme III)

The plant adopts gentle slope vertical layout with outdoor ground elevation of 4.80m and indoor ground elevation of 5.10m.

The excavation for the plant area is about 68.5×10^4 m^3 and filling is about 54×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km.

5.1.4 Conclusion of general layout scheme recommendations

This section is concern about techno-economic comparison among three general layout schemes and gives the recommended scheme.

5.1.4.1 Comparison of technical conditions for the plant area general layout

The consideration of the general layout of the plant mainly include land use condition, entrance road condition, CCW intake and discharge condition, outgoing line corridor condition, coal yard location condition and surrounding environment condition, etc. There are three general layout plan schemes, details are as following:

Comparison of technical conditions for the plant area general layout

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
1	Plant area general layout	In this scheme, A-row columns of the main powerhouse face the northwest and fixed end faces the southwest. Expansion shall be made towards the northeast, with units 1~6 provided from southwest to northeast. Land area within the plant area enclosing wall is about 43.4hm^2	In this scheme, A-row columns of the main powerhouse face the southeast and fixed end faces the southwest. Expansion shall be made towards the northeast, with units 1~6 provided from southwest to northeast. Land area within the plant area enclosing wall is about 50.5hm^2	In this scheme, A-row columns of the main powerhouse face the northeast and fixed end faces the southeast. Expansion shall be made towards the northwest, with units 1~6 provided from southeast to northwest. Land area within the plant area enclosing wall is about 44.2hm^2
2	Main powerhouse	The main powerhouse shall be provided in the northern part of the plant area. The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler house, forced draft fan, ESP, induced draft fan provided from northwest to southeast, and the central control building shall be	The main powerhouse shall be provided in the southern part of the plant area. The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler room, forced draft fan, ESP, induced draft fan provided from northwest to southeast, and the central control building shall be	The main powerhouse shall be provided in the northern part of the plant area. The main powerhouse shall be arranged according to parallel coal bunker scheme, with transformer zone, steam turbine house, deaerator bay, coal bunker bay, boiler room, forced draft fan, ESP, induced draft fan provided from northeast to southwest, and the central control building shall be

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		provided between two boilers.	provided between two boilers.	provided between two boilers.
3	Desulphurization facility	Sea water desulphurization process is adopted. The desulphurization lift pump house and absorption tower are arranged behind the chimney and aeration tank and aeration fan house are close to the steam turbine house. Water drainage pipelines are smooth.	Sea water desulphurization process is adopted. The desulphurization lift pump house and absorption tower are arranged behind the chimney and aeration tank and aeration fan house are close to the steam turbine house. Water drainage pipelines are smooth.	Sea water desulphurization process is adopted. The desulphurization lift pump house, absorption tower, aeration tank and aeration fan house are arranged behind the chimney. Water drainage pipelines are smooth.
4	Power distribution device and incoming and outgoing line	500kV indoor GIS shall be provided at the northeast side of the plant area. In this phase, 2×500kV lines are built and go out towards northeast smoothly. It occupies less land (about 1.3hm^2)	500kV indoor GIS shall be provided at the northeast side of the plant area. In this phase, 2×500kV lines are built and go out towards northwest smoothly. The outgoing line corridor is located between phase I and Phase II coal yards. It occupies more land (about 14hm^2)	500kV indoor GIS shall be provided at the northeast side of the plant area. In this phase, 2×500kV lines are built and go out towards northeast. The outgoing line corridor is located between phase I and Phase II coal yards. It occupies more land (about 16.5hm^2)
5	Cooling facility and circulating water pipeline	The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the	The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the	The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		source of cooling water. The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel. The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the	source of cooling water. The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel. The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the	source of cooling water. The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m (local elevation) and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel. The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		length and bottom altitude of this open channel is 720m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulphurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two 4.6m×3.6 culverts, to the sea area northwest to plant site. The total length of the culverts is 3000m.	length and bottom altitude of this open channel is 450m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulphurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two 4.6m×3.6 culverts, to the sea area northwest to plant site. The total length of the culverts is 4600m.	length and bottom altitude of this open channel is 1100m and -7.863m (local elevation), respectively. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulfurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two 4.6m×3.6 culverts, to the sea area northwest to plant site. The total length of the culverts is 5200m.
6	Coal yard and coal conveying system	In this scheme, a turn-back strip coal yard is adopted with the coal gallery connected from the fixed end to the coal bunker bay. The coal gallery is about 1650m long. The plant is	In this scheme, a turn-back strip coal yard is adopted with the coal gallery connected from the fixed end to the coal bunker bay. The coal gallery is about 2200m long. The plant is	In this scheme, a turn-back strip coal yard is adopted with the coal gallery connected from the fixed end to the coal bunker bay. The coal gallery is about 1950m long. The plant is

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		provided with one open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 455m long and 15m high. The 3 coal stockpiles can store 72.6×10^4t coal and meet the demand of 60 days (for design coal) for the 2 units. Wind-break is provided around the coal yard, about 1450m	provided with one open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 660m long and 15m high. The 3 coal stockpiles can store 109×10^4t coal and meet the demand of 90 days (for design coal) for the 2 units. Wind-break is provided around the coal yard, about 1850m	provided with one open-air strip coal yard with bucket-wheel stacker/reclaimer shall be provided. The coal yard shall be composed of coal stockpiles A, B and C. Stockpiles A and C are 50m wide, and stockpile B is 90m wide. The stockpiles are 455m long and 15m high. The 3 coal stockpiles can store 72.6×10^4t coal and meet the demand of 60 days (for design coal) for the 2 units. Wind-break is provided around the coal yard, about 1450m
7	Auxiliary production area	Other auxiliary workshops in the power plant shall be mainly provided on the fixed end of the main powerhouse and in the area behind the chimney	Same with scheme I	Same with scheme I
8	Building zone of the frontage area	Located at the northwest side of the plant area, close to the sea with good visual effect	Located at the central but a little bit west of the plant area, close to sea. But it faces the coal yard across the	Located at the southeast side of the plant area, facing the intake open canal and far from the sea with good visual

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
			intake open canal, the visual effect is not so good	effect
9	Entrances to the plant area	2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant. The main entrance is located at northeast side of the plant area with the main access road about 1600m long; the secondary entrance is located at southwest side of the plant area with the secondary access road about 1200m long.	2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant. The main entrance is located at south side of the plant area with the main access road about 900m long; the secondary entrance is located at northeast side of the plant area with the secondary access road about 1200m long.	2 entrances shall be provided in the plant area, both of which shall be connected to the existing access road built for HUBCO Power Plant. The main entrance is located at east side of the plant area with the main access road about 255m long; the secondary entrance is located at northeast side of the plant area with the secondary access road about 550m long.
10	Impact on surrounding environment	The plant area is located at the northwest side of the land acquired for the old plant, faces the sea at the west, and undeveloped land for other enterprises at the north, about 2km from the village at the northeast side of the plant area. At the south and east sides, there is land acquired for the old	Same with scheme I	Same with scheme I

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		plant. Have minor impact on surrounding environment.		
11	Earthwork and stonework quantities	The excavation for the plant area is about 84.2×10^4 m^3 and filling is about 46×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km.	The excavation for the plant area is about 94.8×10^4 m^3 and filling is about 48×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km	The excavation for the plant area is about 68.5×10^4 m^3 and filling is about 54×10^4 m^3. Surplus earthwork can be used for building dam on emergency ash yard or filled in the low-lying area in the land acquisition area of the plant. Transport distance of the spoil is about 1km~2.5km.
12	Expansion condition	Good expansion condition	Same with scheme I	Same with scheme I
13	Construction condition	Spacious construction land, good construction and installation condition with construction area of about 20hm^2.	The turbine house is about 100m from the 2×500kV outgoing lines of the old plant. The construction and installation site is in shortage and construction difficulty is large. Total construction land is about 19.5hm^2	Spacious construction land, good construction and installation condition with construction area of about 20.5 hm^2.
14	Demolition and relocation	In this phase, the 2×500kV outgoing lines of the old plant will not be relocated. There is almost no	Same with scheme I	In this phase, the 2×500kV outgoing lines of the old plant need to be relocated. In addition, living

S/N	Item	Scheme I (44-FC08931K-A02-Z03)	Scheme II (44-FC08931K-A02-Z04)	Scheme III (44-FC08931K-A02-Z05)
		relocation work within the construction site.		area of the old plant needs to be relocated.

5.1.4.2 Comparison of economic conditions for the plant general plan

Comparison of economic conditions for the plant general plan

S/N	Item	Unit	Scheme I	Scheme II	Scheme III	Remarks
1	Coal yard	Type	Strip coal yard for 60 days' use	Strip coal yard for 90 days' use	Strip coal yard for 60 days' use	
		10,000 yuan	±0	+1080	0	
2	Wind-break	Length	1450	1850	1450	
		10,000 yuan	±0	+560	0	
3	Intake open canal	m	720	450	1100	
		10,000 yuan	±0	-3483	+4902	
4	Drainage culvert	m	1500	2300	2600	
		10,000 yuan	±0	+5440	+7480	
5	Retaining wall	m	1500	1750	700	
		10,000 yuan	±0	+3175	-10160	
6	Coal gallery	m	1650	2200	1950	
		10,000 yuan	±0	+1595	+870	
7	Access road	m	2800	2100	805	
		10,000 yuan	±0	-58.8	-167.6	
8	Bridge over the open canal	10,000 yuan	±0	+300	+300	

S/N	Item		Unit	Scheme I	Scheme II	Scheme III	Remarks
9	Plant earthwork and stonework quantities	Excavation	10,000 m^3	84.2	94.8	68.5	
		Filling	10,000 m^3	46	48	54	
		Cost	10,000 yuan	±0	+212	-314	
10	Relocation		10,000 yuan	±0	0	+6130	
11	Total		10,000 yuan	±0	+8820.2	+9040.4	

Note: the above table is just comparison between investments for comparable part in the 3 general plans. The relative investment comparison is based on scheme I (±0), and "+"represents investment increase and "-" represents investment decrease.

5.1.4.3 Conclusion on comparison of the General Layout Plan

From the above technical and economic comparison, the scheme I has lower relative investment, and also has the advantage of reasonable general layout, smooth process flow, smooth 500kV outgoing lines, less land occupation, short coal gallery, good environment for frontage area, small earthwork and stonework quantities, good construction condition, no need for relocation of facilities of the old plant etc. Therefore, in this stage, scheme I will be used as the recommended scheme and design work will be conducted based on it.

5.2 Selection of Project Installation scheme

5.2.1 Experience of Coal fired Units in China

At present, Chinese 600MW coal-fired units which have long operation performance and are well-proven basically include four types:

1) Imported subcritical unit;

2) Domestic licensed subcritical unit;

3) Imported supercritical unit;

4) Domestic supercritical unit;

Since obtaining license of subcritical 600MW unit technology from CE Company in the 1980s, China has designed, manufactured and installed a dozen of subcritical 600MW units by itself. In operation of all domestic subcritical units, the in-service domestic subcritical units are always keeping good operation state. But subcritical 600MW pure condensing turbines gradually fade into history and have very little market due to general application of

efficient supercritical 600MW turbines. With rapid industrial development, increasing energy consumption, demanding environmental requirements and more mature supercritical unit technology, 660MW supercritical units are becoming main force in China's thermal power generation in recent years.

China began to import and develop supercritical units from the 1990s. The first supercritical unit is 60MW supercritical unit imported by Shanghai Shidongkou Second Power Plant. By taking technology, economics and unit materials into overall consideration, the unit parameters are determined to be 24.2MPa/538℃/566℃. Later, China imported a batch of 300MW and above supercritical units from former Soviet Union and Japan, such as Huaneng Nanjing Power Plant 2×300MW, HuanengYingkou Power Plant 2×300MW, Panshan Power Plant 2×500MW, Yimin Power Plant 2×500MW and Zhangzhou Houshi 2×600MW. Main parameters of the units are as follows:

Plant	Manufacturer	Power (MW)	Parameter (MPa/℃/℃)
Shidongkou Second Power Plant	ABB/CE SULZER	600	24.2/538/566
Panshan Power Plant	Soviet Union	500	23.54/540/540
Huaneng Nanjing Power Plant	Soviet Union	320	23.54/540/540
Waigaoqiao Phase III	Siemens/ABB ALSTHOM	900	23.53/538/566
Yingkou Power Plant	Soviet Union	300	25.01/545/545
Yimin Power Plant	Soviet Union	500	25.0/545/545
Suizhong Power Plant	Soviet Union	800	25.0/545/545
Zhangzhou Houshi Power Plant	Mitsubishi	600	25.4/542/569

In April 2000, China determined Henan Qinbei Power Plant (2×600MW) project as the pioneer unit for localization of 600MW supercritical units. In 2004, Henan Qinbei Power Plant 2×600MW units were put into operation successfully. It indicates general level of China's power industrial leapfrog development. Qinbei Power Plant adopted DG1900/25.4—II1 manufactured by Dongfang Boiler Co., Ltd under license of Japanese Babcock-Hitachi. Turbine generator adopts CLN600-24.2/566/566 turbine generator manufactured by Harbin Turbine Company Limited under license of Japanese Mitsubishi. Unit parameters are24.2MPa/566℃/566℃and design coal consumption is 297.3g/KW.h. After being put into operation of Qinbei Power Plant, a batch of localized 600MW supercritical units were put into operation subsequently, such as Units 1~5 in Taishan Power Plant Phase I, Datang Guangdong Chaozhou Power Plant 2×600MW units, Huarun Zhenjiang Power Plant 2×600MW units, Shanxi LujinWangqu Power Plant Phase I, HuarunChangshu Power Plant Unit 3 and 4, CPI Pingwei Power Plant Phase II. Except a few units put into operation early with parameters of 24.2MPa/538℃/566℃, most of the units are 24.2MPa/566℃/566℃.

As of the end of 2011, 125×600MW supercritical units from five power generation groups have been put into operation. 600MW supercritical units have realized full localization. Thermal economics, peak-load regulation capacity and automation level of domestic units are not lower than the imported supercritical parameter units. In the aspect of auxiliaries, China also has strong manufacture capability and strong design, manufacturing, installation, commissioning, operation and management capability.

5.2.2 Subcritical Vs Supercritical

Compared with subcritical units, domestic 600MW supercritical units have the following advantages or favorable conditions:

1) Economics

Rankine cycle decides that steam parameter is the leading factor which affects thermal efficiency of power plant. It's impossible to further increase thermal efficiency of units without increasing unit parameters to supercritical. A large quantity of foreign and domestic theoretic calculations and practice data clearly show that increasing steam parameter can increase internal efficiency of units, reduce heat rate and thus increase thermal efficiency of the entire plant and reduce coal consumption.

The latest domestic and foreign study results show impact of the following steam parameters on power plant heat rate as given in table 5.2-1.

Table 5.2-1 steam parameter and power heat rate chart

S/N	Steam pressure MPa(a)	Steam temperature ℃	Change rate of plant heat rate
1	16.7 (subcritical)	538/538	Baseline
2	24.2	538/538	-1.6~-2.0%
3	24.2	538/566	-2.3~-2.8%
4	24.2	566/566	-3.1~-3.6%
5	24.2	538/552/566	~-5%
6	31.5~35	570~650/570~595/570~595	~-7.5%

From statistical data of supercritical units operation in the world, published by China Electricity Council (http://www.cec.org.cn)standard coal consumption of supercritical units is about 310~329 g/kWh power supply to grid and advanced supercritical units can reach 300 g/kWh power supply to grid. The economic benefits are quite obvious. But it should be pointed out that increasing economic benefits comes at a price. According to relevant domestic and foreign documents and company quotation, total investment of supercritical unit is 2%~4% higher than subcritical unit with the same capacity. From statistic data of supercritical units operation in the world, standard coal consumption of supercritical units is about 310~329 g/kWh and advanced supercritical units can reach 300 g/kWh. The economic

benefits are quite obvious. But it should be pointed out that increasing economic benefits comes at a price. According to relevant domestic and foreign documents and company quotation, total investment of supercritical unit is 2%~4% higher than subcritical unit with the same capacity.

2) Reliability

Reliability of supercritical units has great impact on economic efficiency. Unit availability is related with design and manufacturing level, installation and construction quality and operation management level. According to statistics published by China Electricity Council (http://www.cec.org.cn), availability of foreign supercritical and subcritical units with the same capacity can be about 90%.

3) Environmental benefits

In power generation equipment, fossil fuel power generation causes the most serious air pollution, receives wide attention from international community and is one important factor that affects China's long-term sustainable development. To reduce emission of SO2, CO2, NOx and other pollutants, the country develops Environmental Protection Law. Under this circumstance, supercritical units are used as main power generation equipment to reduce coal consumption. When a large amount of coal is saved, environmental pollution will be reduced. Therefore, from environmental benefit, energy saving is environmental protection.

4) Unit peak load regulation performance

Supercritical units are characterized by quick startup, good peak regulation performance and stability during low load operation.

At present, many domestic manufacturers have strong capability to produce supercritical units and have performance in several projects in China.

To sum up, domestic supercritical 660MW unit technology adopted in the project is mature and has good economic benefits and environmental benefits.

Domestic 600MW supercritical turbine has two types: three-cylinder-four-extraction and four-cylinder-four-extraction. Three-cylinder-four-extraction turbine has fewer bearings and gland seals, reduction of 4m in length compared with four-cylinder-four-extraction turbine, reduced civil cost, lower equipment cost, installation cost and operation and maintenance cost; combined HIP cylinder and steam flow in reverse direction can balance axial thrust; highest temperature work areas of rotor concentrate at middle part. Cylinder temperature reduces gradually towards both ends and thermal stress is reduced. HIP cylinder of four-cylinder-four-extraction turbine set has higher thermal efficiency and lower heat rate than three-cylinder-four-extraction. Because domestic manufacturers have most performance and most mature technology in three-cylinder-four-extraction turbines, this project tentatively adopts three-cylinder-four-extraction supercritical turbine.

In summary, the project installations scheme is proposed as follows:

Supercritical parameter variable-pressure once-through boiler, single furnace, one reheat cycle, tangential combustion, balanced draft, outdoor arrangement, dry bottom furnace, full steel

frame, full suspension structure Π-type boiler; 2×660MW supercritical, one reheat cycle, three-cylinder-four-extraction, tandem compound, condensing turbine generator set.

5.3 Technical conditions for main equipment

5.3.1 Boiler

Type: supercritical once-through pulverized coal boiler, corner tangential combustion, one reheat cycle, single furnace balanced draft, ∏ arrangement, dry bottom furnace, all steel frame suspension structure and tri-sector rotary air preheater. Positive pressure primary cold air direct blowing pulverization system.

For the tower boiler, the flue gas flow upwards, and the furnace is relatively high, the fly ash velocity is lower than "Π" boiler. The fly ash abrasion is lower. So tower boiler is more suitable for the high ash content coal, The coal ash content of HUB project is low, the technical advantages of tower boiler cannot give full play. "Π" boiler due to the low roof height, in the wind pressure high, high seismic intensity region, can reduce the boiler architecture investment. Therefore recommends the "Π" type boiler.

Main parameters (BMCR condition)

1) Superheating steam outlet flow: 2078t/h

2) Superheating steam outlet pressure: 25.4MPa.a

3) Superheating steam outlet temperature: 571°C

4) Reheat steam outlet temperature: 568°C

5) Economizer inlet feedwater temperature: 296.1°C

6) Exhaust smoke temperature (after correction): 110.7°C

7) Guaranteed boiler fuel efficiency (ASME, PTC4, LHV): 93.3%

8) Boiler outlet NO_X concentration: $<350mg/Nm^3$

The boiler steam condition should coordinate with turbine condition.

5.3.2 Turbine

Type: supercritical, one reheat cycle, tandem compound, three-casing-four-flow, condensing turbine.

Reheat system: three HP heater stages, four LP heater stage, and one deaeration stage.

Main technical parameters of turbine are as follows:

Item	Unit	TMCR condition	VWO condition	Average water temperature condition in Summer
Main steam flow	t/h	1943.2	2078	1994

Steam pressure before MSV	MPa(a)	24.2	24.2	24.2
Steam temperature before MSV	℃	566	566	566
Reheat steam flow	t/h	1595.695	1699.985	1624.532
HP cylinder exhaust pressure	MPa(a)	5.408	5.754	5.499
HP cylinder exhaust temperature	℃	336.3	348.2	339.8
Steam pressure before CRV	MPa(a)	4.975	5.293	5.059
Steam temperature before CRV	℃	566	566	566
Final feedwater temperature	℃	291.5	296.1	293.0
Circulating water temperature	℃	27.9 (annual mean water temperature)	27.9 (annual mean water temperature)	31.4+0.5 (Mean water temperature in summer plus estimated return water temperature rise)
Exhaust backpressure	KPa（a）	6.4	6.4	7.6
Generation power	MW	660.017	689.3	660.056
Heat rate	kJ/kW.h	7670	7712	7710

The parameter of main equipments mentioned above are the typical 600MW grade parameters as per GB/T 754-2007 "Parameter series of steam turbines for power plant", and many units under such parameters have been operated safety and efficiency in China.

More details of the chosen or calculation parameters of boiler and turbine, as well as the plant efficiency, please see Annexure 9.

5.3.3 Generator

Type: under rated power factor and rated hydrogen pressure condition, rated power of generator matches output under rated condition of turbine. Maximum continuous output power of generator matches with maximum continuous output of turbine.

Main parameters:

1) Rated capacity:	776.47 MVA
2) Rated power:	660 MW
3) Rated voltage:	20~26 kV
4) Rated power factor:	0.85 (lag)
5) Rated speed:	3000r/min
6) Rated frequency:	50 Hz
7) Cooling:	water-hydrogen-hydrogen
8) Rated hydrogen pressure:	0.45MPa(g)
9) Full-load efficiency:	＞99%
10) Excitation:	static self-shunt excitation

5.4 Thermal system

The system includes principle thermal system for the project, mainly including main steam system, bypass system, startup drain system, reheat steam system, feedwater system, condensate system, feedwater reheat system, extraction system, cooling water system and vacuum extraction system, and selection of all main auxiliary equipment in the principle thermal system.

5.4.1 Main steam and reheat system systems adopt unitized system

Main steam adopts unitized system. Main steam pipes adopt 2-1-2 arrangement, i.e. two pipes at boiler superheater outlet, combined into one piece and divided into two pipes before coming into turbine. It can simplify pipe arrangement, save pipe investment, help eliminate thermal deviation of steam due to boiler and pressure deviation caused by different pipe resistance.

Cold reheat steam pipes and hot reheat steam pipes adopt 2-1-2 arrangement. Two cold reheat steam pipes are connected from HP cylinder exhaust, combined into one pipe, divided into two pipes again at boiler side and connected to inlet header at both sides of reheater respectively. Hot reheat steam pipes are connected from both sides of boiler reheater outlet header, combined into one pipe, divided into two pipes before turbine and connected to CRV at left and right sides of turbine. Cold reheat steam pipes supply steam to #2 HP heater and are also used as one of steam sources for auxiliary steam system. One pipe is connected from main steam pipe as backup steam source for turbine for boiler feedwater pump during unit startup and low load operation.

5.4.2 Turbine bypass

Main functions of bypass system:

1) Improve unit start performance, quicken unit start speed and reduce life loss of turbine;

2) Protect reheater during startup, shutdown and load rejection;

3) Deal with residual steam under unit load transient condition, and improve stability of boiler operation;

4) Recycle steam and reduce noise;

Configuration and capacity of bypass system is related with boiler minimum once-through load and unit startup. Bypass based on series connection of high and low pressure is temporarily set. Bypass capacity is temporarily 40% of boiler maximum continuous rating (BMCR) to meet quick start requirement of the units. Considering the impact of unit trip due to grid instability, it's necessary to make closely coordination with the manufacturer to finally determine bypass capacity. Considering the impact of unit trip due to possible grid failure, after main equipment is subsequently determined, it's necessary to make closely coordination with the manufacturer to finally determine bypass capacity. High pressure bypass is connected from main steam pipe, reduces pressure and temperature and then is connected to reheat (cold leg) steam pipe. HP bypass desuperheating water comes from feedwater system at discharge of turbine-driven feedwater pump. LP bypass desuperheating water comes from condensate system at outlet of condensate polishing equipment. HP and LP bypasses include steam control valve, desuperheating control valve and shutoff valve and control devices.

5.4.3 Reheat extraction system

Turbine has eight non-regulated extraction stages. Stage 1, 2 3 extractions are supplied to three HP heaters; stage 4 extraction is supplied to deaerator, boiler feedwater pump turbine and auxiliary steam system; stage 5, 6, 7 and 8 extractions are supplied to #5, 6, 7 and 8 LP heaters respectively; steam cooler is provided before #3 HP heater.

To prevent turbine overspeed and water ingress, except stage 7 and 8 extraction pipes, all other extraction pipes are provided with pneumatic check valve and electric isolation valve.

All branches from turbine extraction pipes to steam consumers are also provided with check valve.

Heater drain flows by gravity stage by stage. HP drain flows to deaerator and LP drain flows to condenser.

To prevent water ingress to turbine, the system designs perfect drain system according to ASME TDP-1.

5.4.4 Feedwater system

Feedwater system is provided with 2×50%B-MCR turbine-driven speed-regulating feedwater pump. Every unit is provided with 1×50% startup and standby motor-driven feedwater pump. Both turbine-driven pump and motor-driven pump are provided with booster pump.

Feedwater system adopts unit system and is provided with 3 HP heaters and one #3 HP heater steam cooler. Feedwater overall bypass is adopted to simplify the system, reduce equipment investment and facilitate pipe arrangement. When any one of the three HP heaters and #3 HP heater steam cooler fails, HP bypass will automatically start and supply water direct to economizer.

Feedwater pump turbine has automatic steam source changeover device. Normal working

steam source comes from stage 4 extraction of main turbine and can come from HP steam source during startup and low load condition: main steam (or HP cylinder exhaust) or auxiliary steam from adjacent unit.

Feedwater system supplies water to economizer and also provides desuperheating water to boiler superheating steam desuperheater, reheat steam emergency desuperheater and turbine HP bypass desuperheater.

5.4.5 Condensate system

The system sends condensate in condenser hotwell to deaerator via IP condensate polishing equipment, gland steam condenser and LP heater, In addition, it also provides desuperheating water to turbine proper drain flash tank and LP desuperheater. The system is provided with 2×100% vertical condensate pumps (without variable-frequency regulation), 4 LP heaters (#5, 6, 7 and 8), 1 gland steam condenser, 1 deaerator and feedwater box, 1×300m^{3}condensate makeup water tank and two condensate transport pumps.

Deaerator water tank has an effective volume of 180m^3, equal to 5min boiler maximum feedwater flow.

Condensate pipeline at inlet of #7 and 8 LP heaters is provided with main and auxiliary regulation valves to regulate water level of deaerator.

Condensate makeup tank is provided with one condensate transport pump which charges water to the system during unit startup and boiler. When unit operates normally, water is made up to condenser via condensate transport pump bypass pipe under negative pressure of condenser. One regulation device is provided on the condenser makeup pipe to regulate condenser hotwell level.

3 LP heater stages are provided. LP heaters adopt feedwater individual bypass system.

5.4.6 Vacuum extraction system

In this Phase, every unit is provided with 3×50% water-ring vacuum pumps for normal operation condition. During normal operation, two pumps are in operation and one is on standby. When vacuum extraction starts, 3 vacuum pumps operate at the same time to quickly establish vacuum and shorten startup time of units.

One water chamber vacuum pump for every unit is also provided at water side of condenser to continuously extract and remove air in water chamber of condenser so as to ensure siphon of circulating water and increase heat exchange efficiency.

One vacuum breaker is connected at shell side of every condenser to break vacuum under emergency condition, increase condenser backpressure and shorten idle time of turbine.

5.4.7 Auxiliary steam system

Auxiliary steam system provides public steam source for the power plant. In this phase, every unit is provided with 1 auxiliary steam header and interconnecting header is provided between two units. The system supplies steam for deaerator startup, boiler feedwater pump turbine commissioning, turbine gland seal and coal mill fire protection etc. It provides steam for air

preheater soot blowing during startup.

During normal operation of units, auxiliary steam source comes from stage 4 extraction of turbine and comes from cold reheat steam system at low load.

Steam supply capacity of auxiliary steam system is considered based on sum of steam when one unit starts and the other unit works normally.

It is a new project and will not use any facility of the old plant. For feasibility stage, 1×35t/h oil startup boiler is considered to supply steam to auxiliary steam system. Final capacity of startup boiler will be determined in basic design phase, based on the amount of steam and startup time required for startup.

Startup boiler steam is enough for normal startup for 1 unit. Consider the particularity of Pakistan, if 2 units need to start at the same time, startup boiler capacity shall increase according to actual conditions.

5.4.8 Cooling water system

It is a coastal power plant with shortage of fresh water resource. If sea water is directly used for equipment cooling, all coolers shall adopt titanium which is very expensive. Based on the principle of saving fresh water and reducing equipment investment and taking materials of water consumers into consideration, condenser and closed cooling water heat exchanger adopt sea water cooling which is open cooling water system, and all other equipment adopts closed circulating cooling water system (unitized system).

Primary water is sea water and secondary water is demineralized water. Closed industrial cooling water system is provided with 2×100% closed circulating cooling water pumps (1 in operation and 1 on standby), 2×water-water heat exchangers with 100% heat exchange area (operating water flow) and full titanium (1 in operation and 1 on standby) and 1 elevated buffer water tank. The capacity of water-water heat exchanges meet cooling water requirement under all loads from startup to normal operation and have certain margin. Start filling of secondary water comes from demineralized water at outlet of makeup water tank. The makeup water is condensate.

5.4.9 Configuration and specification of main auxiliary equipment for thermal system (for one unit)

No.	Equipment	Specification and code	Number
1	Turbine-driven feedwater pump	50% capacity (provided with 50% capacity booster pump)	2
2	Startup and standby motor-driven feedwater pump	50% capacity, horizontal, centrifugal pump (provided with 50% capacity booster pump)	1
3	Embedded deaerator	Horizontal, sliding pressure operation	1
4	Condensate water pump	Vertical, drum, 100% capacity	2

No.	Equipment	Specification and code	Number
5	Water-ring vacuum pump	Mechanical	3
6	Condenser	Double backpressure, single flow path and surface type	1
7	1# HP heater	Horizontal	1
8	2# HP heater	Horizontal	1
9	3# HP heater	Horizontal	1
10	5# LP heater	Horizontal	1
11	6# LP heater	Horizontal	1
12	7# LP heater	Horizontal	2
13	8# LP heater	Horizontal	2
14	#3 HP heater steam cooler	Horizontal	1

5.5 Combustion coal pulverization system

5.5.1 Fuel

Design coal for this project is South African RB-3 and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3. See details of coal quality in Table 3.1.3-1.

Light diesel is used as fuel for boiler startup and auxiliary boiler.

5.5.2 Coal consumption

Calculation principle for boiler coal consumption (single supercritical boiler) is:

1) Coal consumption is calculated based on BMCR condition.

2) Annual utilization hours of boiler are calculated based on 7446h.

3) Daily utilization hours of boiler are calculated based on 24h.

4) Boiler fuel efficiency is 93.3% (corresponding to net caloric value)

Boiler coal consumption for design coal and check coal is as follows:

Unit capacity / Item	Value	1×660MW		2×660MW	
		Design coal	Check coal	Design coal	Check coal
Hourly coal consumption	t/h	252.22	270.79	504.44	541.58
Daily coal	t/d	6053.28	6498.99	12106.56	12997.98

consumption					
Annual coal consumption	10^4t/a	187.80	201.63	375.61	403.26

5.5.3 Combustion coal pulverization system

According to "Technical condition of coal used for pulverized coal-fired boiler for power generation" (GB/T 7562-1998), RB3 coal is bituminous coal and NAR4700 coal is sub-bituminous for the project.

Selection of coal pulverization system is determined mainly based on requirement of boiler combustion on coal quality. According to practice experience in China and "Guide for type selection for pulverizes and pulverizing systems of power station" (DL/T 466-2004) and based on coal characteristics, coal pulverization system better selects medium speed bowl-mill primary air positive pressure direct blowing system.

5.5.4 Selection of combustion and coal pulverization system equipment

1) Medium speed coal mill

Every boiler is provided with six (preliminary) medium speed coal mills. Under both design and check coal conditions at BMCR, 5 mills will be in operations while 1 remains standby. Output of coal mill shall be considered based on 115% fuel coal consumption under BMCR. At the outlet of every mill, pulverized coal is divided into four paths through pulverized coal distributor. There are totally 24 pulverized coal delivery pipes to connect with boiler burner. Final selection of mills will be determined in basic design phase.

The recommended scheme is temporarily designed based on HP1163 medium speed coal mill. To adapt to the characteristics of bituminous coal used in the project, pulverized grain of design coal is R90=21.83% and air temperature at outlet of coal mill is 65~77℃.

2) Raw coal bunker

Every coal mill corresponds to one raw coal bunker, so there are six coal bunkers in all, 5 operations and 1 standby. Since coal handling system works in three shifts. Five coal hoppers shall meet design coal consumption for 10h under BMCR condition. At this moment, every coal hopper shall have a volume above 666m^3 (filling coefficient for the hopper takes 0.85 and calculated specific gravity of raw coal is 0.95).

3) Electronic weighing belt coal feeder

Every boiler is provided with 6 electronic weighing belt coal feeders. Feeding capacity of every coal feeder shall guarantee 110% maximum output at single side of single coal mill.

4) Centrifugal sealing air fan

Coal pulverization system of every boiler is provided with 2×100% centrifugal booster sealing air fans, 1 operating and 1 on standby.

5.5.5 Flue gas and air system

Flue gas and air system adopts balanced draft and tri-sector rotary regenerative air preheater.

1) Primary air system and equipment

Every boiler is provided with 2×50% adjustable moving vane axial primary cooling fans.

2) Secondary air system and equipment

Every boiler is provided with 2×50% adjustable moving vane axial forced draft fans.

3) Flue gas system and equipment

Flue gas out of air preheater goes through ESP (after comparison between ESP and Fabric Filter, ESP is recommended, refer to 7.2.1), induced draft fan and desulphurization system and is exhausted to atmosphere from stack.

According to environmental protection requirement, the ESP efficiency shall be $\eta \geq 99.775\%$. Considering the adoption of ESP, every unit is temporarily provided with 2 two-chamber-five-field ESPs.

In this project, every boiler is provided with 2×50% adjustable movable vane axial induced draft fans.

Two boilers share one 210.0m high sleeved double-cylinder stack with outlet diameter of 2×Φ6.4m (preliminary).

5.5.6 Fuel oil system

In this project, 2×500m^3 oil tanks and 2×100% oil unloading pumps and two coarse oil strainers; oil supply system is provided with 3×50% oil supply pumps and 3 fine strainers. Boiler ignition adopts micro-oil ignition and reserves conventional oil system.

5.6 Electrical part

5.6.1 General

This project will construct two 2×660MW supercritical coal-fired units, the land for the long-term four units will be reserved, and the BOP will be constructed based on 2×660MW units. The power plant will be connected into the power grid with 500kV voltage class. Each generator of this project is connected to the 500kV switchyard through a Generator Step-up Transformer (GST) as a generator-transformer unit. Two transmission lines, approx.220km long, connected to Matiari Switching/Convertor Station, will be considered, the specific connection mode will be finally determined by National Transmission and Despatch Co. Ltd. (NTDC). The 500kV switchgear is only considered based on 2 units and 2 outgoing line circuits of this phase, the plant-grid terminal point is at the power plant 500kV distribution device outgoing line gantry.

5.6.2 Electrical main connection

The electrical main connection scheme of this phase project is considered as the follows:

5.6.2.1 Generator main circuit and auxiliary power system

Each generator of this project is connected to the 500kV switchyard through a Generator Step-up Transformer (GST) as a generator-transformer unit. One unit auxiliary transformer will be installed between the main transformer LV side and the generator for each unit. The auxiliary power can be supplied by the unit auxiliary transformer under normal operation.

As Pakistan local power grid fluctuation range is ±10%, the main transformer is proposed to use three –phase two-winding transformer with on load tap changer.

Two scheme of the unit auxiliary power system will be consider:

Scheme I: The generator circuit breaker (GCB) is not installed at the generator outlet. One station transformer, connected from the 500kV bus bar, with the capacity equal to or greater than one unit's full load plus all common load. The unit can be startup by power transmission from power grid through this station transformer. Also, this transformer can be standby power for each unit. The single line diagram drawing can refer to SINGLE LINE DIAGRAM OF AUXILIARY POWER SYSTEM (SCHEME I).

Scheme II: The generator circuit breaker (GCB) is installed at the generator outlet. Station transformer is not installed. The unit can be startup by power transmission from power grid through the GST and the unit auxiliary transformer. Also, the two unit auxiliary transformers can be backup power for each other. The single line diagram drawing can refer to SINGLE LINE DIAGRAM OF AUXILIARY POWER SYSTEM (SCHEME II).

From the experience of the similar plant, generally, the cost of scheme I is higher than scheme II, but considering the Scheme II will have such phenomenon that when the one unit is fault or under maintenance, another unit will lose its backup power supply in actual operation, and the fault of the GCB will shut down the unit, for feasibility phase, Scheme I is considered due to high operational flexibility over Scheme II. Whether GCB shall be installed shall be determined after the grid interconnection study is received and confirmed.

5.6.2.2 500kV switchgear

The 500kV switchgear is only considered based on 2 units and 2 outgoing line circuits of this phase. If the 500kV switchgear is considered to be installed for 6 units, the rated current shall be more than 5kA, the short circuit level may be higher, so the cost will be increased, and the equipment selection will be more difficult.

Detailed salt deposit density data are not obtained at present at this stage, by referring to the corrosion situation of the existing power plant near the plant site, the salt deposit density is considered to be >0.25~0.35 tentatively, the pollution class is considered to be the maximum class IV tentatively.

Considering the prevailing wind is southwest, blowing from the sea to the land, and the annual mean relative humidity is 85%, also the annual mean rainfall is 178mm, salt spray can easily accumulate on the surface of the insulator, bushing, etc. This can cause pollution flashover, and do harm to the safety operation of the plant. So air insulated switchgear (AIS) is not considered because the insulator should be cleaned regularly due to the environmental factors. And GIS shall be used to increase the reliability of the plant. Both GIS indoor and outdoor can meet the requirement of reliability and safety, considering the convenience of

maintenance, GIS indoor is proposed.

Both breaker and half with two busbar scheme (refer to the electrical SINGLE LINE DIAGRAM OF POWER PLANT (SCHEME I) and double busbar scheme (refer to the electrical SINGLE LINE DIAGRAM OF POWER PLANT (SCHEME II) can be used to ensure the reliability of 500kV switchgear. If breaker and half with two busbar scheme is used, the startup/standby transformer, which is out of use at normal operation, is considered to be connected to the 500kV busbar with one circuit breaker due to the high reliability of GIS. The simple technique and economy comparison of the two schemes are as follows:

SCHEME / ITEM COMPARED	Breaker and half with two busbar scheme	Double busbar scheme
Reliability	Each circuit breaker can be overhauled easily. When one circuit breaker or one busbar has to be overhualed,, no ingoing or outgoing circuit will be out of use. When one circuit breaker or one busbar is overhualed, 1 ingoing or outgoing circuit at most will be out of use if other breaker or busbar is breakdown.	When one circuit breaker or one busbar has to be overhualed,, 1 ingoing or outgoing circuit at most will be out of use. When one circuit breaker or one busbar is overhualed, 0 to 4 ingoing or outgoing circuit will be out of use if other breaker or busbar is breakdown.
Economy	Seven 500kV circuit breakers are used, the cost is higher.	Six 500kV circuit breakers are used.

In summary, considering the importance of the plant in the power grid, breaker and half with two busbar scheme is proposed as the 500kV switchgear. However, NTDC will determine which scheme shall be used.

5.6.3 Auxiliary power distribution system

Two voltages (10kV and 400V) will be used in the auxiliary power distribution system. The neutral point of the 10kV power distribution system shall be ungrounded or grounded via resistance. The neutral point of the 400V power distribution system shall be directly grounded (or grounded via resistance), the auxiliary workshop 400V auxiliary power system, lighting and maintenance power shall adopt neutral point directly grounded mode. The neutral point grounding mode will be defined in preliminary design.

Both 6kV and 10kV auxiliary power system can be used for 600MW class unit. Considering the case of this project, 10kV system is more suitable, the reasons are following:

1) Auxiliary power capacity of this project is higher than normal due to the large common facilities such as jetty and seawater desalination system. So if 6kV system is adopted, two auxiliary transformers for each unit are required for limitation of the short circuit current. If 10kV system is adopted, only one auxiliary transformer for each unit is required, so that, the connection of auxiliary power system can be more simple and reliable.

2) According to Chinese design standard, capacity of startup/standby transformer would be as same as the largest auxiliary transformer. If 6kV system is adopted, the capacity of startup/standby transformer can be smaller (based on unit load only), however, considering that the grid is very unstable in Pakistan and the case of full stop happened often, the capacity of startup/standby transformer should cover all common load, so this advantage is not exist.

3) Focus on the cost, if 10kv system is adopted, the insulation lever must be higher, but the conductor will be saved due to the lower current, generally, the cost will be similar to 6kV system.

Two 10kV unit busbar, arranged in single bus configuration, with the working power supply from the unit auxiliary transformer, the backup power supply from the standby transformer, shall be installed. The unit loads are connected respectively to 10kV unit busbar of the respective unit, and the common loads are connected to the 10kV common busbar of the two units.

LV power distribution system adopts PC—MCC connection, each area is provided with mutually backup paired LV transformers based on the load functions and areas.

5.6.4 Emergency power supply, AC uninterrupted power supply (UPS) and DC system configuration

1) Emergency power supply

In order to guarantee safe shutdown of the unit in case of AC auxiliary power distribution fault, diesel generator unit is installed as the AC emergency power supply.

Each unit plans to provide one diesel generator as the emergency power supply, with two emergency sections provided; during normal operation, the power is supplied by the LV working section of each unit. In case of power-off due to accident, the diesel generator unit will start rapidly and automatically to supply power to the emergency section loads.

2) AC uninterrupted power supply (UPS)

Each unit is provided with two sets of AC uninterrupted power supply device (UPS), each set of UPS is composed of rectifier and inverter, single bypass system, feeder panel, etc., each UPS operates independently. The unit UPS system mainly supplies power to the loads such as the unit distributed control system (DCS), I&C automatic regulation and monitoring equipment, important Motor Operated Valves (MOVs) electrical protection panel and measurement transmitter panel, and the plant electrical control and management system. UPS has its own battery set and can serves DCS and its loads for 4 hours.

3) DC system

Each unit is provided with one set of DC system to supply power to the unit DC power and

control loads. One set is 220V DC power used as the unit power, mainly supplies power to the DC power loads, such as UPS, DC oil pump motor, emergency lighting and emergency MOV; the other set is 110V DC power used for unit control, mainly supplies power to the DC control loads, such as protection, control, and signal.

Battery of the unit DC system adopts valve controlled sealed maintenance free lead-acid battery, the charging device adopts HF switching power supply module mode, the charging device selects the module quantity according to backup of N+1 (N+2); the battery charging mode includes floating charge and equalizing charge. DC system is configured with microcomputer-based monitoring unit, which forms the monitoring system together with the insulation monitoring and measuring device, busbar measuring device, battery data acquisition device, etc.

Busbar voltage of the power DC system is 220V. Power DC system of each unit is provided with 1 battery pack and 2 sets of charging devices. The power DC system of each unit adopts single busbar section.

Busbar voltage of the control DC system is 110V. Control DC system of each unit is provided with 2 battery packs and 2 sets of charging devices. The control DC system of each unit adopts single busbar sectionalized connection, the two battery packs are connected on two bus sections respectively, and tie-switch is provided between the two bus sections.

5.6.5 Selection and arrangement of main equipment

1) Selection of GST and HV unit transformer, and HV station transformer

This project 660MW generator, with COSΦ=0.85, the maximum continuous rating of 776.47MVA, the accurate parameters will be justified and determined at the next stage.

GST is proposed to select forced oil circulating air-cooled three-phase double winding transformer with on-load tap changer. One unit auxiliary transformers for each unit, is proposed to select three-phase fan-cooled split winding transformer with on-load tap changer One station transformer for the two units is proposed to select three-phase fan-cooled split transformer with on-load tap changer.

2) Selection of HV distribution device equipment

The 500kV switchgear is to adopt indoor GIS, according to the provision of NTDC "the Grid Code" and with consideration of the grid development, the parameters are as follows: bus rated current: 3150A; breaker, isolating switch rated current: 3150A; breaking current: 50kA (effective value); dynamic steady current: 125kA (peak value); thermal steady current: 50kA (effective value), 3S. Accurate parameters will be justified and determined from short-circuit study.

3) Selection of isolated phase enclosed busbar, common enclosure busbar

Generator leading-out line and the unit power branch HV side leading-out line plans to adopt isolated phase enclosed busbar. The unit power branch LV side leading-out line plans to adopt common enclosure busbar or pouring insulation busbar.

4) Arrangement of main equipment

The main transformer, HV unit auxiliary transformer and HV standby transformer of this project are arranged outside the main plant building column A. Gas insulated metal enclosure busbar or overhead line is planned to use from the main transformer, standby transformer to the 500kV distribution device equipment. Considering the environment condition and the reliability, Gas insulated metal enclosure busbar is proposed.

500kV distribution device adopts indoor GIS equipment, which is arranged outside the main plant building A row columns. Outgoing transmission line of the 500kV distribution device adopt overhead line.

5.6.6 Control system

1) Unit control system

This project plans to adopt turbine-boiler-generator centralized control mode. The electrical and thermal cycle I&C share one microcomputer-based distributed control system (DCS) to realize boiler, turbine and generator integrated control.

Main electrical equipment of the unit shall adopt DCS and ECMS monitoring and control. Normal startup and shutdown of the unit realize sequential control by DCS completed with the control system of gas turbine unit, or carry out manual one-to-one control through man-machine interface. The generator - transformer group, auxiliary power system monitoring all enter electrical control and management system (ECMS), and important signals are connected to DCS by hard wiring; data communication connection is made between ECMS and DCS, the units realize total CRT control, which can increase automation level, save large quantity of control cables and computer cables, and reduce the project construction cost.

In order to guarantee safe shutdown of the unit, necessary backup hard manual operation devices (generator emergency stop button, magnetic blow-out switch emergency trip button, diesel generator emergency start button) are provided for the unit emergency shutdown. Simple heavy-current control is provided on the local equipment, so as to meet the needs of commissioning and maintenance.

2) Electrical control and management system

Electrical control and management system (ECMS) is provided for this project to make monitoring, relay protection, data storage and management of the unit and the public electrical equipment operation conditions, and it can also be used as backup of DCS to operate and control the unit and the public electrical equipment, however, the control function will be disabled during operation time.

ECMS adopts hierarchical distributed microcomputer-based network structure, the whole system is divided into the station control level and bay level, and the networking mode may adopt Ethernet and field bus. ECMS main equipment includes: host/operator workstation, Ethernet switch, bay level 10kV and 400V microcomputer-based integrated protection measuring and control device, etc.

Main functions of ECMS are: 10kV and 400V auxiliary power equipment relay protection,

data acquisition and processing, monitoring and alarm, operation control, man-machine interface and management, data statistics calculation, data record and statement printing, system self-diagnosis and maintenance, data communication connection with other systems/equipment (including DCS, generator transformer group protection device, fault recording device, DC system, UPS equipment, generator excitation system, synchronization device, 10kV auxiliary power quick switchover, diesel generator control equipment, NCS, etc.)

3) Switchyard network control system

One set of 500kV switchyard network control system (NCS) is provided for this project to make monitoring, control and telecontrol information transmission of the electrical equipment and the generator-transformer group related operation within the switchyard scope. NCS control scope mainly includes 500kV circuit breaker, 500kV isolating switch and grounding switch, system protection (including relay protection of 500kV line, busbar, bus-tie breaker, etc.), measurement, switchyard DC system, generator-transformer group related electricity quantity and operation status quantity, etc.

NCS adopts open type, hierarchical distributed network structure, the whole system is divided into the station control level and bay level, the network structure adopts redundant double-star 100M Ethernet. NCS main equipment includes: host/operator workstation, engineer workstation, shift supervisor workstation, telecontrol workstation, five-prevention workstation, Ethernet switch equipment, bay level measuring and control device and communication controller, synchronization switching device, etc.

5.6.7 Lightning and earthing protection

The lightning protection will be designed complying to NFPA. And the earthing protection will be designed complying to IEEE 80-2000.

5.6.8 Power factor improvement

According to the Pakistan local requirement, the power factor of the plant shall be higher than 0.9, checked by NTDC each month. Considering that the tariff measuring point is at the 500kV outgoing line, whether power factor improvement devices shall be installed will be determined in next stage. If installed, capacitor may be installed on the 10kV busbar or 400V busbar.

5.6.9 Auxiliary power calculation (just for reference)

According to the Pakistan local requirement, the rate of auxiliary power shall be below 8% (about 7.93%) when the generator is full power output. The following table shows the preliminary auxiliary power calculation, in which the kind, the capacity, and the quantity of the loads just for reference. The exact data and calculation shall be done in the detail design stage.

No.	Item Description	Rated Power (kW)	Power Factor	Rated Capacity (kVA)	Total No.	No. in operation				Demand Factor	Calculated Power (kW)	Remarks
						Total	#1	#2	Common			
1	Circulating Water Pump	2800	0.9	3111	6	6			6	1	16800	
2	Fire Pump	261	0.85	307	1	1			1	0	0	spare
3	Condensate Pump	2000	0.9	2222	4	2	1	1		1	4000	
4	Boiler Feed Pump	12000	0.9	13333	2	2	1	1		0	0	used for start-up and standby
5	Boiler Feedwater Booster pump	560	0.85	659	4	4	2	2		0.85	1904	
6	Closed Cycle Cooling Water Pump	500	0.85	588	4	2	1	1		0.85	850	
7	Medium Speed Mill	560	0.85	659	12	10	5	5		0.85	4760	
8	Secondary Air Fan	1120	0.9	1244	4	4	2	2		0.85	3808	
9	Primary Air Fan	2400	0.9	2667	4	4	2	2		0.85	8160	
10	Draft Fan	6150	0.9	6833	4	4	2	2		0.85	20910	
11	Air compressor	250	0.85	294	12	10	5	5		0.85	2125	
12	Seawater reverse osmosis high-pressure pump	335	0.85	394	3	2			2	0.85	569.5	
13	Areation PumpA	900	0.85	1059	2	2			2	0.85	1530	spare
14	Areation PumpB	1100	0.9	1222	2	2			2	0.85	1870	
15	Areation PumpC	1200	0.9	1333	2	2			2	0.85	2040	
16	Areation Fan	1400	0.9	1556	6	4			4	0.85	4760	
17	Coal reclaimer	470	0.85	553	2	2	1	1		0.85	799	
18	Coal crusher	450	0.85	529	2	2			2	0.85	765	
19	C1A(B) Tape converyer	315	0.85	371	1	1			1	0.85	268	
20	C2A(B) Tape converyer	315	0.85	371	2	2			2	0.85	536	
21	C3A(B) Tape converyer	400	0.85	471	2	2			2	0.85	680	
22	C4A(B) Tape converyer	200	0.85	235	2	2			2	0.85	340	
23	C5A(B) Tape converyer	280	0.85	329	2	2			2	0.85	476	

No.	Item Description	Rated Power (kW)	Power Factor	Rated Capacity (kVA)	Total No.	No. in operation				Demand Factor	Calculated Power (kW)	Remarks
						Total	#1	#2	Common			
24	Jetty ship unloader	1260	0.9	1400	2	2			2	0.85	2142	
24	Jetty conveyor	765	0.85	900	4	4			4	0.85	2601	
24	Jetty 400V	1164	0.75	1552	2	1			1	0.7	815	
25	Turbine 400V	2000	0.75	2667	4	2	1	1		0.7	2800	
26	Boiler 400V	2500	0.75	3333	4	2	1	1		0.7	3500	
27	ESP 400V	2000	0.75	2667	6	4	2	2		0.7	5600	
28	Lighting 400V	500	0.75	667	2	1			1	0.7	350	
29	Maintenance 400V	500	0.75	667	2	1			1	0.5	250	
30	Desulfurization 400V	800	0.75	1067	2	1			1	0.7	560	
31	Coal Handling 400V	1250	0.75	1667	2	1			1	0.7	875	
32	Chemical water treatment 400V	1600	0.75	2133	2	1			1	0.7	1120	
33	Desalination 400V	1000	0.75	1333	2	1			1	0.7	700	
34	Ash 400V	1000	0.75	1333	2	1			1	0.7	700	
35	Office 400V	1600	0.75	2133	2	1			1	0.5	800	
36	Loss of transformer and other electric equipment	2000			2	2	1	1		1	4000	
Total load of 2 units (kW)											104763	
Total load of 1 units (kW)											52381	
Generator active power (kW)											660000	
Auxiliary power consumption rate (%)											~7.93	

5.6.10 Conclusion of electrical part

i) Each generator of this project is connected to the 500kV switchyard through a Generator Step-up Transformer (GST) as a generator-transformer unit. One unit auxiliary transformer for each unit will be installed to supply power for the auxiliary load under normal operation.

ii) The scheme of not installing generator circuit breaker at the generator outlet is proposed. One station transformer will be installed for the two units. The unit can be startup by power transmission from power grid through this station transformer. Also, this transformer can be standby power for each unit. Whether GCB shall be installed shall be determined after the grid interconnection study is received and confirmed.

iii) Breaker and half with two busbar scheme is proposed for the 500kV switchgear. The exact scheme shall be determined after the grid interconnection study is received and confirmed.

iv) Two voltages (10kV and 400V) will be used in the auxiliary power distribution system.

v) One diesel generator for each unit will be installed as the emergency power supply.

vi) Each unit is provided with two sets of AC uninterrupted power supply device (UPS)

vii) Each unit is provided with one set of DC system to supply power to the unit DC loads, and one set of DC system to supply power to the control loads.

viii) Turbine-boiler-generator centralized control mode is proposed to be used. Main electrical equipment of the unit shall adopt distributed control system (DCS) and electrical control and management system (ECMS) monitoring and control.

ix) The lightning protection will be designed complying to NFPA. And the earthing protection will be designed complying to IEEE 80-2000.

x) Whether power factor improvement devices shall be installed will be determined in next stage.

xi) The preliminary auxiliary power calculation shows that the rate of auxiliary power is below 8%. However, the exact data and calculation shall be done in the detail design stage.

5.7 Coal handling system

5.7.1 Assumption of this phase project scheme

Coal handling system of this project is designed based on 2×660MW units. Stacker/Reclaimer is the battery limit for the jetty and plant respectively as per Terminal Point mentioned in 1.5.2. Upstream of the stacker is the scope of jetty, including the ship unloaders, conveyors, transfer towers, etc. Downstream of the reclaimer is the scope of power plant, including the

coal yard, conveyors, crushers, screens, transfer towers, etc.

5.7.2 Coal unloading system

With consideration of the site coast natural conditions and impact of the 4 months monsoon period, the wharf part is considered based on 2 schemes.

Scheme I:

One 100,000DWT bulk carrier offshore coal jetty is planned to be constructed at the place about 5.4km away from the plant area coastline. The comprehensive downtime of jetty is 65d, and the continuously downtime is about 25d after protected by the breakwater. The jetty is provided with 2 ship unloaders of 1500t/h. The jetty is installed with one-way belt conveyer tentatively, with the belt width of 1800mm, rated output of 3600t/h, which supply coal for the power plant 2×660MW units.

Scheme II:

One 10,000t barge offshore coal jetty is planned to be constructed. During the non-monsoon period, the coal is transferred to barges at the open sea by an offshore lighterage station, and then transferred to the barge jetty for unloading. The comprehensive downtime of jetty is 85d, and the continuously downtime is about 45d after protected by the breakwater. The jetty is provided with 2 ship unloaders with output of 1250t/h. The jetty is installed with one-way belt conveyer, with the belt width of 1800mm, rated output of 3000t/h, which supply coal for the power plant 2×660MW units.

For details of the coal unloading system, please see FSR for Jetty.

5.7.3 Coal yard and coal yard equipment

For matching with the 2 jetty schemes, 2 schemes are also considered for the coal yard capacity, namely, the 60-day coal yard scheme (corresponding to the jetty scheme I Mother vessel jetty) and the 90-day coal yard scheme (corresponding to the jetty scheme II Barging jetty). Details please see FSR for Jetty.

Scheme I:

One strip-shaped open air coal yard with bucket wheel machine will be provided in the power plant, the coal yard has total 3 coal stockpiles of A, B, and C, width of coal stockpiles A and C is 50mm, width of coal stockpile B is 90m, the coal stockpile length is 455m, the coal stockpile height is 15m. The total coal storage capacity of the 3 coal stockpiles is 72.6×10^4t, meeting the coal demands of 60d of the power plant of 2 units (design coal). The coal yard is installed with 2 reentrant type cantilever bucket wheel stackers/reclaimers, with the cantilever length of 50m, the stacking output of 3600t/h, reclaiming output of 1000/h, the coal stacking capacity matches with the coal unloading system conveying capacity, and the coal reclaiming capacity matches with the coal handling system output. One belt conveyer with belt width of 1800mm, output of 3600t/h is arranged respectively at bottom of the bucket wheel machine.

Scheme II:

One strip-shaped open air coal yard with bucket wheel machine will be provided in the power plant, the coal yard has total 3 coal stockpiles of A, B, and C, width of coal stockpiles A and C is 50mm, width of coal stockpile B is 90m, the coal stockpile length is 660m, the coal stockpile height is 15m. The total coal storage capacity of the 3 coal stockpiles is 109×10^4t, meeting the coal demands of 90d of the power plant of 2 units (design coal). The coal yard is installed with 2 reentrant type cantilever bucket wheel stackers/reclaimers, with the cantilever length of 50m, stacking output of 3000t/h, reclaiming output of 1000t/h, the coal stacking capacity matches with the conveying capacity of the coal unloading system, the coal reclaiming capacity matches with the output of the coal handing system. 1 belt conveyer with belt width of 1800mm and output of 3000t/h is provided respectively at bottom of the bucket wheel machine.

The coal yard of the two schemes is provided with 2 coal bulldozers, 2 loading machines, and 1 excavator for supporting operation. With consideration of environmental protection requirement and the local windy environment, the coal yard is provided with wind dust network. Coal yard spray facilities are also provided. Drainage trenches shall be provided around the coal pile for water run-off.

The check coal is blended coal by two coals. As a result of high volatile matter and high moisture, it will cause large fire risk and coal block problem if the Indonesian NAR4700 is stored in silos. So the coal silos are not fit to be the coal blending facilities in this project. According to the characteristics and coal yard type of the power plant, it is fit to adopt the method of blending coal in the coal yard by stacker-reclaimers. Besides, because only the check coal shall be blend and it won't frequently happen, there is no need to install additional reclaimer in the coal yard. The two stacker-reclaimers shall be used to blend the coal. When the power plant needs to burn the check coal, the two coals shall be stored separate coal piles along the longitude direction of the coal yard. Botn the two stacker-reclaimers will be used to blend the coal, one reclaiming coal from RB-3 at 50% capacity and another reclaiming coal from NAR4700 at 50% capacity. When the coal arrives coal bunkers, it has already been blended.

5.7.4 Belt conveyer system

The unloading system from the jetty to the coal yard selects belt conveyor with belt width of 1800mm and output of 3600t/h tentatively (3000t/h for scheme II), single conveyer arrangement. The coal handling system after the coal yard to the main plant building selects the belt conveyor with the belt width of 1200mm, output of 1000t/h, two-belt conveyor arrangement, one on operation, one on standby.

T0 transfer tower is an interface transfer tower with the jetty belt conveyer, and arranged with physical goods calibration device. C1 belt conveyer can be switched to C3AB belt conveyer or coal yard C2A belt conveyer through T1 transfer tower. C3AB belt conveyer can be switched to C4AB belt conveyer or coal yard C2B belt conveyer through T2 transfer tower. Distribution Tee-way in T2 transfer tower can realize direct passing function from the jetty

coal to the coal bunker bay raw coal bunker.

The coal handling system will operate based on three-shift operation system, 6h operation per shift.

Above-ground trestle of the belt conveyer adopts the type of open air trestle + belt conveyer rain cover.

The coal bunker bay belt conveyer adopts electric double side unloader to distribute coal to the raw coal bunker.

5.7.5 Screening and crushing system

One stage screening and one stage crushing are adopted to crush the raw coal to meet the pulverized coal requirement of ≤ 30mm; two ring hammer crushers are provided, with the output of 700t/h, the crushed coal grain size smaller than 30mm; the screen plans to select roller screen, with output of 1000t/h.

5.7.6 Auxiliary facilities

4 stages magnetic separator are provided before entering the coal yard, at the coal yard outlet belt, before and after the coal crusher in the system. As-fired coal mechanical sample taking and preparing device and electronic belt scale are provided on the belt conveyer after the coal crusher and before the coal bunker floor, both adopts dynamic chain code check device for checking. Coal handling system is provided with as-received coal physical check device at T0 transfer tower, and as-received coal electronic belt scale is provided at C1 belt conveyer. As-received coal mechanical sample taking and preparing device, iron removal device are provided on the jetty belt conveyer; for details, see the FSR for jetty.

Belt conveyor safety protection device is provided for coal handling system as required by the relevant standard.

Corresponding water flushing facilities and coal yard spray facilities are provided for the coal handling system.

Lifting facilities are provided in each coal transfer tower, coal crusher room, coal bunker bay and coal bulldozer house, etc. for equipment lifting.

The facilities, such as lighting, communication, fire-fighting, ventilation, and dedusting are provided in the coal handling system.

The auxiliary buildings such as program logic controlled room, maintenance room, distribution room are provided for the coal handling system as required.

5.8 Ash handling system

5.8.1 General description of ash handling system

5.8.1.1 Ash handling mode

The ash handling system of this project 2×660MW units is designed based on 1 system for 1 unit (of which, the ash silo and ash silo fluidizing blower house are shared by two boilers). The system design follows the principle of being safe, reliable, economic and rational; give full consideration to water saving, and less floor area.

The ash handling system inside the plant plans to adopt the ash and slag separate handling mode. Considering the local ash and slag reuse level is low, all the ash and slag are transported to the external ash yard by truck for storage, and also could be transported to the emergency ash yard in plant in case of emergency. The ash handling system is composed of the following three parts:

1) Fly ash part: the fly ash of economizer ash hopper and the ESP ash hopper adopt dry ash dense phase pneumatic conveying system to convey the fly ash to 2 ash silos. The design scope is from the economizer ash hopper and the ESP ash hopper flange outlet to the ash silo outlet dry, wet ash loading onto the truck and transported to ash pond.

2) Boiler bottom slag part: considering this power plant is lack of fresh water resources, the fresh water is obtained by sea water desalination, for saving water, the slag handling adopts dry slag handling mode. Each boiler is provided with one set dry slag removal equipment, which is composed of slag pit, bottom slag removal device (i.e., hydraulic shut-off valve or large slag pre-crushing device), steel belt slag conveyor, slag crusher, bucket elevator, slag silo and truck loading equipment. The design scope is from the boiler slag discharging port to the slag silo outlet to load onto the truck and transport to outside.

3) Pyrites part: starting from the coal mill rejects (pyrites) outlet lower flange as the design boundary line to the mobile pyrites hopper under the surge pyrites hopper outlet, and the battery fork lift truck transports to the truck loading point for transporting to ash pond. Each boiler is considered based on 1 unit.

5.8.1.2 Ash, slag quantity

For ash, slag quantity of this project, see Table 5.8.1-1.

Table 5.8.1-1 Ash, slag, pyrites quantity

Item \ Unit capacity / Value		1 × 660MW		2× 660MW	
		Design coal	Check coal	Design coal	Check coal
Ash/slag quantity/h	t/h	45.13	31.28	90.25	62.55
Ash quantity/h	〃	40.61	28.15	81.23	56.30
Slag quantity/h	〃	4.51	3.13	9.03	6.26

Item \ Value \ Unit capacity		1 × 660MW		2× 660MW	
		Design coal	Check coal	Design coal	Check coal
Pyrites quantity/h	〃	1.26	1.35	2.52	2.71
Total	〃	46.39	32.63	92.78	65.26
Ash/slag quantity/d	t/d	1083.05	750.63	2166.10	1501.25
Ash quantity/d	〃	974.75	675.56	1949.49	1351.13
Slag quantity/d	〃	108.31	75.06	216.61	150.13
Pyrites quantity /d	〃	30.27	32.47	60.53	64.94
Total	〃	1113.32	783.10	2226.64	1566.20
Ash/slag quantity/a	10^4t/a	33.60	23.29	67.20	46.58
Ash quantity/a	〃	30.24	20.96	60.48	41.92
Slag quantity/a	〃	3.36	2.33	6.72	4.66
Pyrites quantity/a	〃	0.94	1.01	1.88	2.01
Total	〃	34.54	24.30	69.08	48.59

Note: the above values are calculated based on the following principle:

1) Daily availability hours are based on 24h; annual availability hours are based on 7446h.

2) Ash quantity is based on 90% of the total ash/slag.

3) Slag quantity is based on 10% of the total ash/slag.

4) Pyrites quantity is based on 0.5% of the boiler coal consumption.

5.8.2 Selection of ash/slag handling system

5.8.2.1 Ash handling system

Ash handling system adopts positive pressure pneumatic conveying system to centralize the fly ash discharged from ESP and economizer ash hopper to the ash silo.

Design output of the pneumatic ash handling system is 65t/h (meeting the allowance of not lower than 50% when discharging ash from firing design coal, and the allowance of not lower than 20% when discharging ash from firing check coal). The ash discharged from the economizer and ESP adopts positive pressure pneumatic conveying system conveying method to convey the fly ash to the ash silo. Ash conveying transmitter is installed under the economizer and ESP ash hopper, compressed air is provided by air compressor at beginning of each branch pipe, and the ash in each ash hopper is conveyed to the ash silo through the material level switch procedure control of the transmitter.

Two boilers in this project share 2 ash silos and 1 ash silo aeration fan room, another fly ash silo place is reserved for future utilization. The ash silo adopts reinforced concrete structure for the time being, with the effective volume of each ash silo of about 1500m^3, two ash silos shall store about 24h ash volume of 2 boilers firing design coal. Three aeration fans are installed in the ash silo aeration fan room, 2 on operation and 1 on standby; besides, each ash silo is provided with 1 electric heater to supply hot air to the ash silo. Each silo top is provided with bag-filter. Each ash silo unloading device is configured with 2 humidifying mixers with output of 200t/h and 1 dry ash loading machine of 200t/h. Trucks with 30t capacity are considered to be used. So, about 94 trucks per day will run for ash transportation, which means about 8 trucks per hour (12h operation per day). Truck transport method is adopted for transport to ash yard, after humidifying and mixing, the ash is sent to the ash yard by enclosed self-dumping truck. The compressed air for ash handling system conveying and the compressed air for instrument control are provided in a unified way by the thermo-dynamic discipline.

5.8.2.2 Slag handling system

For dry slag removal system, each boiler is provided with 1 system, air-cooled mechanical slag removal equipment is adopted; the bottom slag falls onto the bottom slag removal device from the slag hopper. Large slag blocks fall onto the conveyer steel belt after being crushed by large slag crushing device after completely fired. High temperature slag is conveyed out by slag conveyer steel belt, the slag after air cooled is discharged into the slag silo after being crushed. The slag silo adopts mechanical sealing. Design output of the steel belt slag conveyer is not lower than 250% of the slag discharge capacity of B-MCR when firing the design coal, the design output is 15t/h, its output is adjustable.

Slag enters the slag silo from the slag conveyer outlet for storage, then the slag inside the slag silo is loaded onto the truck through unloading device and transported to outside for comprehensive utilization or transported to the ash yard to be rolled for storage. The slag silo effective volume is 150m^3, shall store the design coal slag for about 24h. The slag, after being humidified, is sent to ash yard by truck. Each boiler is provided with 1 steel belt slag conveyor, 1 slag crusher, 2 bucket elevators, 1 slag silo, 1 dry slag loading machine and 1 humidifying mixer.

5.8.2.3 Pyrites system

Pyrites discharged from medium speed mill enters surge hopper first, both inlet and outlet of the surge hopper is provided with pneumatic valve. The pyrites discharged from the surge hopper is transported to the self-dumping truck parked near the slag silo by battery fork lift truck, and then is transported to the ash yard.

5.8.2.4 Ground flushing, drain system

The dry slag extractor and the slag silo ground, ash silo area, of the two boilers are provided with flushing and drain facilities, the sewage after ground flushing is pumped to the sedimentation tank of the hydraulic engineering discipline for unified treatment by the sewage pump respectively, the treated water is delivered to each flushing water consuming point of the ash handling discipline by the hydraulic engineering discipline for recycle use.

5.8.2.5 Others

Transport of ash, slag and pyrites to the ash yard adopts truck for transportation; truck transportation considers using the local social carrying capacity, this project does not provide the transport trucks for the time being.

The ash, slag and pyrites handling system adopt programmed logic control. The system equipment can be controlled in the control room, and can be operated locally as well.

Necessary maintenance lifting facilities are provided for the ash handling system.

5.9 Chemical part

5.9.1 Water source and water quality

The power plant water takes from sea water; sea water desalination water is used as the fresh water source. Three samples of the sea water quality reports are refer to Annexure 8, 8a.

Note: Since BOD and COD value provided by Annexure 8 in too much higher than the usually value of seawater, and also much higher than the value mentioned in ESIA, BOD and COD get retest and the value list in Annexure 8a is equivalent with ESIA. So Annexure 10 is the seawater quality basis except BOD and COD, while BOD and COD basis value as per Annexure 8a.

At present stage, this analysis report is used as the design inputs of the project.

5.9.2 Water steam quality standard

For the boiler feedwater quality requirement of this project, see Table 5.9-4 (quoted from GB/T12145-2008 Quality criterion of water and steam for generating unit and steam power equipment).

Table 5.9-4 Boiler feedwater quality standard

S/No.	Description		Unit	Standard value
1	pH(25℃)	Volatile treatment (copper-free		9.2~9.6

S/No.	Description		Unit	Standard value
		system)		
		Oxygenation treatment (copper-free system)		8.0~9.0
2	Dissolved oxygen	Volatile treatment	μg/L	≤7
		Oxygenation treatment		30～150
3	Hydrazine	Volatile treatment	μg/L	≤30
		Oxygenation treatment		—
4	Conductivity (after H-ion exchange, 25℃)		μS/cm	<0.15
5	Silicon oxide		μg/L	≤10
6	Iron		μg/L	≤5
7	Copper		μg/L	≤2
8	Sodium		μg/L	≤3
9	TOC		μg/L	≤200

5.9.3 Power plant normal water steam losses

For the normal water steam losses of this project 2×660MW units, see Table 5.9-5.

Table 5.9-5 Normal water steam loss of the power plant

S/No.	Type of losses	Losses (t/h)
1	Water-steam circulation losses	64
2	Other losses	6
3	Total	70

5.9.4 Sea water desalination system

5.9.4.1 Construction scale

Sea water desalination system is constructed based on 2×660MW units.

5.9.4.2 System process flow

Water produced by sea water desalination system is mainly used as the source of industrial water, living water and boiler make-up water.

The main process flow of sea water desalination system is as follows:

Seawater feedwater pump →reaction and sedimentation tank →clear seawater tank →seawater UF feedwater pump →seawater UF cartridge filter →seawater UF equipment →seawater UF water tank→ SWRO feedwater pump → SWRO cartridge filter→ SWRO high pressure pump → SWRO equipment (with energy recovery device) →SWRO water tank →BWRO feedwater pump →BWRO cartridge filter →BWRO high pressure pump →SWRO equipment →pre-demineralized water tank →each consumer.

Note: UF—Ultra Filtration; SWRO—Seawater Reverse Osmosis; BWRO—Brackish Water Reverse Osmosis.

Besides, three samples of the seawater quality reports are not sufficient for design of sea water desalination system, more seawater analysis need to be carried out.

5.9.4.3 System output

The capacity of SWRO is 3×117t/h, 2 on operation, and 1 on standby. The capacity of BWRO is 3×99t/h, 2 on operation, and 1 on standby.

5.9.4.4 System effluent quality

1) SWRO equipment effluent quality is:

TDS: 300~500mg/L

2) BWRO equipment effluent quality is:

TDS: ≤15mg/L

Boron: ≤0.5mg/L

5.9.5 Boiler make-up water treatment system

5.9.5.1 Construction scale

Boiler make-up water treatment system is constructed based on 2×660MW units.

5.9.5.2 System process flow

The boiler make-up water treatment system plans to use the following process flow:

Seawater desalination water →counter-flow regeneration cation exchanger →counter-flow regeneration anion exchanger →mixed bed ion exchanger →demineralized water tank →demineralized water pump for operation → main plant building

5.9.5.3 System design output

According to the water-steam losses and auxiliary water ratio, the capacity of boiler make-up water treatment system is 2×78t/h, 1 on operation, and 1 on standby.

5.9.5.4 System effluent quality

Conductivity（25℃）： ≤0.15μS/cm

Silicon oxide: ≤10μg/L

TOC: ≤200μg/L

5.9.6 Condensate polishing system

Full flow medium pressure condensate polishing system shall be provided for this project, adopting "prefilter + mixed bed" process scheme and external regeneration mixed bed mode. Condensate polishing system is mainly configured with the following equipment:

2×50% prefilter for each unit, without standby;

3×50% high speed mixed bed for each unit, 2 on operation, and 1 on standby.

Two units share one set mixed bed external regeneration equipment and one set prefilter backwash equipment.

5.9.7 Chemical dosing system

5.9.7.1 Condensate, feedwater ammonia dosing system

Ammonia dosing can increase the condensate and the feedwater pH value, which plays a significant role in protecting the thermal-dynamic system equipment. Ammonia dosing control standard: the controlled feedwater pH under AVT (All Volatile Treatment) operating condition to be 9.2~9.6; the controlled feedwater pH under OT (Oxygenated Treatment) operating condition to be 8.0~9.0.

Two units of this project is provided with 1 ammonia dosing device, including 2 ammonia solution tanks, 3 feedwater ammonia dosing metering pumps (2 on operation, 1 on standby) and 3 condensate ammonia dosing pumps (2 on operation, 1 on standby).

5.9.7.2 Condensate, feedwater oxygen dosing system

When adopting OT operating condition, it is necessary to add oxygen in the condensate and feedwater, the oxygen content is controlled at 30~150μg/L.

Two units of this project is provided with 1 set condensate oxygen dosing device and 1 set feedwater oxygen dosing device; the oxygen dosing point is set on the outlet main pipe of the condensate polishing system and the deaerator downcomer respectively.

5.9.7.3 Closed cooling water chemical dosing system

To add NaOH to the closed cooling water to maintain the water pH value to certain value. The NaOH dosing control standard: in all-iron system, control the closed cooling water to be pH≥9.5; in copper contained system, control the closed cooling water to be pH=8.0~9.2.

Two units of this project is provided with 1 set closed cooling water NaOH dosing device, the dosing point is set on the closed cooling water pump outlet main pipe.

5.9.8 Water-steam sampling system

In order to supervise the water-steam quality of the thermal-dynamic system, guarantee safe and economic operation of the unit, each unit is provided with 1 set centralized water-steam sampling analysis device. The water steam sampling and analysis system includes high

temperature frame and instrument panel (including manual sampling part); sample water adopts the closed cooling water. Design of the sampling system meets the requirements of "ASME PTC 19.11 Part-II". The lowest sampling points and the instrument configuration are as shown in Table 5.9-6.

Table 5.9-6 Sampling points and instrument configuration

S/No.	Location	Instrument
1	Make-up water	Specific conductivity
2	Condenser hot well	Cation conductivity (both sides)
3	C.E.P. Discharge	pH, Specific conductivity, Cation conductivity, Dissolved oxygen , Sodium ion
4	Condensate polisher outlet	pH, Specific conductivity, Cation conductivity, Sodium ion Silica Dissolved oxygen
5	Deaerator outlet	Dissolved oxygen
6	Economizer inlet	pH, Specific conductivity, Cation conductivity, Dissolved oxygen
7	Saturated steam	pH, Specific conductivity, Cation conductivity,
8	Main steam	pH, Specific conductivity, Cation conductivity, Sodium
9	Condenser cooling water	pH,

		Specific conductivity

5.9.9 Hydrogenation system

For this project, the generator cooling method adopts "water - hydrogen - hydrogen". The hydrogen generation system design output is $2\times5Nm^3$, which meets the requirement of hydrogen filling and hydrogen replenishing during 2×660MW unit generator startup and normal operation. The hydrogen from hydrogen station will be transferred directly into generators by pipe. CO_2 cylinders are provided for purging of generator.

5.9.10 Circulating water treatment system

In order to prevent adhesion and growth of marine organism in the cooling water system, and further affect through-flow area of the cooling system, reduce heat transfer efficiency of the condenser and produce corrosion, the cooling water has to be sterilized. In this project design, sodium hypochlorite produced by direct electrolysis of sea water is used for sterilization and algae removal.

Seawater electrochlorination system design output is 2×120kg/h, the process flow is: circulating water pump outlet main pipe seawater → seawater prefilter → seawater booster pump →automatic rinsing filter →sodium hypochlorite generator →sodium hypochlorite storage tank→ circulating water pump house forebay. Sodium hypochlorite solution in the storage tank flows to the circulating water pump house forebay by gravity.

In addition, one set of dosing system using purchased sodium hypochlorite solution is provided as the backup for the electrolyzed sea water chlorination system.

5.9.11 Industrial wastewater treatment system

5.9.11.1 Construction scale

Industrial wastewater treatment system is constructed based on 2×660MW class units, with the treatment capacity designed based on $50m^3/h$.

5.9.11.2 Effluent requirement

Effluent of the industrial wastewater treatment system can be discharged only when the quality meets the national environmental quality standard (NEQS) of Pakistan. For details of the water quality, see Table 5.9-7.

Table 5.9-7 NEQS for Municipal and Liquid Industrial Effluent (mg/l, unless otherwise defined)

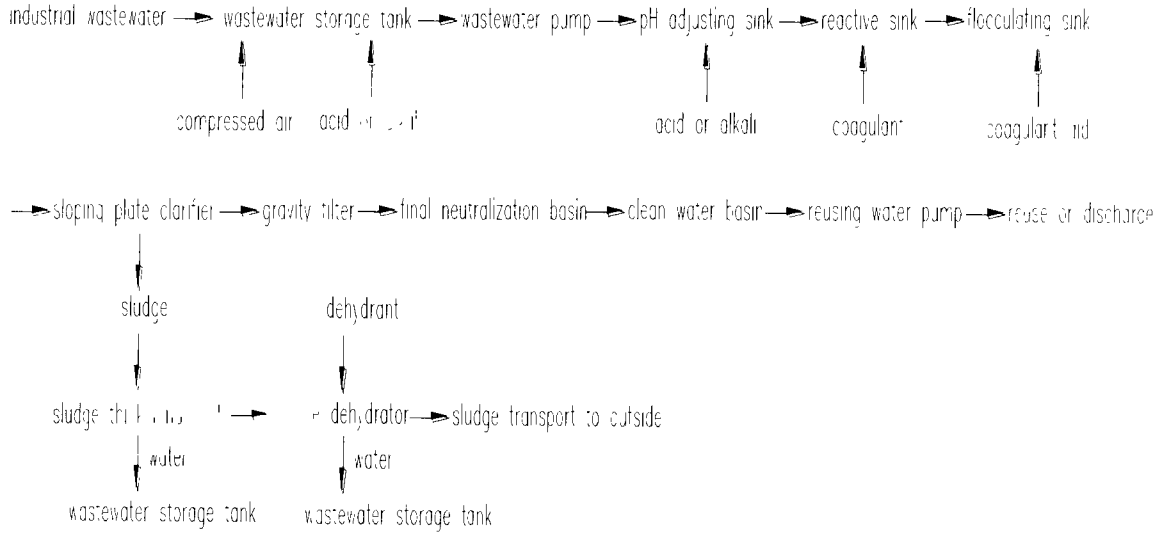
No.	*Parameter*	*Standards*		
		Into Inland Waters	*Into Sewage Treatment*[1]	*Into Sea*[2]
1.	Temperature increase[3]	=<3°C	=<3°C	=<3°C

No.	*Parameter*	*Standards*		
		Into Inland Waters	*Into Sewage Treatment*[1]	*Into Sea*[2]
2.	pH value	6 to 9	6 to 9	6 to 9
3.	Five-day bio-chemical oxygen demand $(BOD)_5$ at 20°C[4]	80	250	80[5]
4.	Chemical oxygen demand (COD)[1]	150	400	400
5.	Total suspended solids (TSS)	200	400	200
6.	Total dissolved solids (TDS)	3,500	3,500	3,500
7.	Grease and oil	10	10	10
8.	Phenolic compounds (as phenol)	0.1	0.3	0.3
9.	Chlorides (as Cl')	1,000	1,000	SC[6]
10.	Fluorides (as F')	10	10	10
11.	Cyanide total (as CN')	1.0	1.0	1.0
12.	Anionic detergents (as MBAS)[7]	20	20	20
13.	Sulfates (SO_4)	600	1,000	SC[6]
14.	Sulfides (s')	1.0	1.0	1.0
15.	Ammonia (NH_3)	40	40	40
16.	Pesticides[8]	0.15	0.15	0.15
17.	Cadmium[9]	0.1	0.1	0.1
18.	Chromium (trivalent and hexavalent)[9]	1.0	1.0	1.0
19.	Copper[9]	1.0	1.0	1.0
20.	Lead[9]	0.5	0.5	0.5
21.	Mercury[9]	0.01	0.01	0.01
22.	Selenium[9]	0.5	0.5	0.5
23.	Nickel[9]	1.0	1.0	1.0
24.	Silver[9]	1.0	1.0	1.0
25.	Total toxic metals	2.0	2.0	2.0
26.	Zinc	5.0	5.0	5.0
27.	Arsenic[9]	1.0	1.0	1.0

No.	Parameter	Standards		
		Into Inland Waters	Into Sewage Treatment[1]	Into Sea[2]
28.	Barium[9]	1.5	1.5	1.5
29.	Iron	8.0	8.0	8.0
30.	Manganese	1.5	1.5	1.5
31.	Boron[9]	6.0	6.0	6.0
32.	Chlorine	1.0	1.0	1.0

5.9.11.3 System process flow

Industrial wastewater treatment system process flow is as follows, and fresh water balance diagram refer to 44-FC08931K-A02-S01.



5.9.12 Transformer oil purification

One set portable transformer oil purification facility shall be provided for this project to make purification treatment of the transformer oil.

5.9.13 Laboratory and instruments

The complete set of water, oil and coal laboratory and instrumentation shall be provided.

5.10 I&C automation part

This project is planned to construct 2×660MW supercritical coal-fired power plant and the corresponding auxiliary facilities. I&C design of this project is based on the consideration of 2×660M units and various auxiliary production workshops.

5.10.1 Automation level

1) This project plans to adopt turbine, boiler, generator and auxiliary workshops central control mode. The two units share one central control room, with an area of about 150m2, the central control room is planned to be arranged between the two boilers or at the fixed end of the main plant building. The unit control room is arranged the unit monitoring console, network control console, auxiliary production system monitoring console, shift supervisor console, fire alarm panel, etc.

2) Each unit is provided with a set of DCS system. DCS control following systems: boiler proper and auxiliary systems, turbine proper and auxiliary systems, generator proper and auxiliary system, chemical sampling, and condensate polishing, etc. Each unit is monitored by on-duty operator through operator station, with assistants to complete the startup and shutdown operation, monitoring of normal operation and emergency handling of the unit. The backup control panel only retains a small number of necessary backup conventional instruments and operating equipment. Each unit is planned to be equipped with several operator stations and LCD display (arranged on the backup panel).

The backup control panel, which separated form DCS, is configured to ensure operators safety shutdown unit when DCS fail. The backup control panel include following: Main Fuel Trip (MFT), Turbine Emergency Trip, Generator Trip, PCV, DC lube oil pump and so on. Those output signal of the backup control panel will be sent to equipment directly by using hardwire connections.

3) The common control network is configured in the following manner:

The common control network will be connected to both unit DCS control networks, So operators can use either of the unit DCS to monitor and control the common equipment that is monitored by the common control network. Corresponding protecting measures are adopted to ensure that only the operation instructions sent from the distributed control system (DCS) of one unit can be received, so as to avoid direct coupling of DCS of the two units. Design of each controller of the equipment under common control network gives full consideration to assist with the equipment maintenance. The function of the common control system includes the common auxiliary power system, compressed air system, chemical dosing system, condensate polishing regeneration part, and central air conditioning.

4) The auxiliary systems of the power plant, such as the water systems, ash systems, and coal systems, are all controlled in the central control room in the main plant building; it is planned to set up several operator workstations; each BOP workshop will also have a maintenance workstation, each BOP workshop can be controlled and maintained locally as well as from central control room. All auxiliary systems adopt the same type of monitoring equipment (programmable logic controller (PLC) or DCS); and the whole plant will adopt the same type of monitoring equipment as far as possible, which can not only reduce the varieties and quantities of spare parts and equipment, but also facilitate the maintenance management.

5) The coverage of distributed control system (DCS) functions should be as wide as possible, so as to share the information, reduce spare parts, and facilitate maintenance and management; the functions include:

- Data acquisition system (DAS)
- Mimic control system (MCS)
- Sequence control system (SCS)
- Boiler burner management system (BMS)
- Turbine bypass control system (TBPC)
- Generator-transformer unit and auxiliary power system (ECS)
- Soot blowing system
- Turbine electro-hydraulic control system (DEH)/turbine emergency trip system (ETS) is realized by using the same type of distributed control system to facilitate operation management, maintenance and repair of the power plant.
- Feedwater pump turbine electro-hydraulic control system (MEH)/feedwater pump turbine emergency trip system (METS) is realized by using the same type of distributed control system.

Of which, turbine electro-hydraulic control system (DEH)/turbine emergency trip system (ETS), turbine proper supervisory instrument (TSI), feedwater pump turbine electro-hydraulic control system (MEH), feedwater pump turbine proper supervisory instrument system, feedwater pump turbine emergency trip system, boiler FSSS local equipment, furnace flame monitoring TV, etc. shall be supplied together with the main and auxiliary equipment in principle.

6) DCS will satisfied following requirement: DCS will adhere to the principle of 'Fail Safe'. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. DCS shall have redundant controllers, communications and power supplies.

In order to guarantee the safe operation of boiler and turbine, Burner management system (BMS) and turbine Emergency Trip System (ETS) will use the safety instrument system. The following measures will be adopted to ensure reliability of safety instrument system:

1. Signals, which are able to characterize the safe status of boiler/turbine, these are regarded as the key protection signal. Those key protection signals will be triple redundant.
2. Redundant key protection signals are sent to different IO module of control system.
3. Redundant key protection signals processed by 2 out 3 principle.
4. Control system of safety instrument system will be set up one pair (one duty and one standby) separate controller.
5. The logic of safety instrument system design will use the fail safe principle.9) Selection of

main control equipment

(a) The principle of selecting the distributed control system (DCS) should be: select the products that have successful application experience on the fossil fuel power plant, with reasonable performance and price, and give full consideration to the special requirements of the fossil fuel power plant for the control system, such as, the reliability, environmental adaptability and application software and control strategies of complicated control systems. Give priority to use the products of cooperative companies who have the capabilities of undertaking the power plant project - including the system design, hardware configuration, application software design and commissioning, perfect quality assurance system and after-sale services such as training, maintenance and supply of spare parts. This is the basis to ensure the distributed control system can be used in the power plant for long-term and can achieve good results. It will be required that supplier must guarantee 10 year support.

(b) The instruments and control devices supplied by the main/auxiliary equipment manufacturers in complete set mainly include:

Turbine electro-hydraulic control system (DEH)

Turbine emergency trip system (ETS)

Turbine proper supervisory instrument (TSI)

Feedwater pump turbine electro-hydraulic control system (MEH)

Feedwater pump turbine emergency trip system (METS)

Feedwater pump turbine proper supervisory instrument system (MTSI)

Furnace flue gas temperature monitoring device

Furnace flame monitoring industrial TV

Power distribution device of soot blowing system

(c) Other I&C systems and equipment, such as distributed control system (DCS), programmable logic controller (PLC), I&C instrument, the products of famous manufacturers and having the similar project performance shall be selected, final selection will be determined by tendering.

5.10.2 Control mode

1) I&C automation level will be designed according to the characteristics of the units, so as to meet the requirement of safe and economical operation of the units and to reduce the maintenance cost.

2) The turbine, boiler, generator centrally controlled power plant has high automation level; the on-duty operator completes the control in the control room:

- To realize startup and shutdown of the unit with coordination of a few local

operations and patrol inspections;

- To monitor and control unit under normal operating condition;
- To realize unit shutdown and accident handling under abnormal operating condition.

3) High-level control program will be used, which use FGC (functional group control) Drive based control hierarchy. It will light labor intensity of the operators during the unit startup and shutdown, prevent maloperation, short the startup time, and raise the automation level of the power plant.

4) Circulation pump house, fuel oil pump house, and desulfurization adopt DCS remote I/O station, monitored in the unit control room; other applications (such as steam turbine, generator, and boiler proper detection) also adopt remote I/O station. Most of remote I/O stations will be installed in equipment room; others I/O stations will use high protect level enclosures.

5) All auxiliary workshops can be operated and controlled in the central control room; Control systems of every auxiliary workshop are connected together by networks and servers to form the control networks of auxiliary workshops; set up display operating terminals of BOP networks in the unit control room to realize monitoring and control of each auxiliary system; and the auxiliary systems realize unmanned automatic operation.

6) This project is to set up a plant-level information management system (MIS); unit DCS, common DCS and BOP communicate with the plant-level information management system through redundant switches; unit DCS, common DCS and BOP send the plant's parameters and equipment condition information to the plant-level information management system. The plant-level information management system mainly includes the following functions: plant-level production process monitoring and management, plant-level performance calculation and analysis, optimization, ERP, Running Hour Data and so on.

7) This project has plant Local Area Network (LAN). All authorized PC can connect to LAN and share information. The local area network and the plant-level information management system of this project adopt integrated wiring.

8) There are two sets of CCTV system are configured for this project. One set system is used for monitoring key plant equipment such as boiler, turbine and generator and so on. Another set system is used for site access security, monitoring area including gates, fence and road. CCTV system includes data storage system, which is used to record historical data at least one week.

9) One I&C automation laboratory equipment is set up, which is used to inspect and maintain I&C equipment. I&C automation laboratory will following Chinese standard DL/T 5004 Design standard of I&C laboratory for fossil power plant.

10) One set Machine Management System (MMS) will be supplied. MMS is used to receive, process and analysis vibration signal of key equipment including turbine, generator, ID fans, FD fans, PA fans, CEPs, BFPs. MMS help operators and maintainers to know status of key

equipment.

11) This project plans to set up simulator system. Simulation system simulates the whole control system, and it is used to train operators and test control program.

12) This project plans to set up access control system, to control access and prevent unauthorized person enter into key protected area. Authorized person can enter into protected area by using access cards.

13) "Coding standard of identification system in power plant"(GB/T 50549-2010) is suggested to use as coding principle in this project.

14) All control system, MIS and electrical protect system will to be synchronized with GPS clock. This will ensure all systems have some time base. More detailed information about GPS, please refer to electrical description.

5.11 Layout of main plant building

5.11.1 General

1) Project overview

The Pakistan Hubco 6×660MW coal-fired generating project is to construct new 2×660MW supercritical units; land space for 4×660MW units is reserved for future expansion; the BOP is constructed based on 2×660MW units in principle.

2) Scope of design

Including the turbine hall, deaerator bay, coal bunker bay, boiler house and the FD fan, ESP, and ID fan rooms between the boiler tail and the chimney, chimney inlet horizontal gas duct and chimney plot plan;

Including the cross sections of the above contents;

Make general layout in coordination with the plot plan and transportation discipline.

3) Layout of the main plant building: Adopt a four-row layout pattern of turbine hall, deaerator bay, coal bunker bay and boiler house.

4) Arrangement of boiler rear area: make in-line arrangement of FD fan room—ESP –-ID fan room—chimney—desulfurization island.

5) The desulfurization island is arranged in front of the chimney. For selection and arrangement of the desulfurization system, see the section of environmental protection.

5.11.2 Arrangement of the turbine hall and deaerator bay

The turbine-generator unit arrangement is crosswise in-line arrangement, with the machine head toward fixed end; the distance from the centerline of the turbine-generator to the centerline of A row columns is 15.3m, the span of the turbine hall is 30.6m, the column-column space is 10m; each unit covers 9 column spaces; between the

two turbines is reserved a 10m maintenance ground and a 1.5m expansion joint; the total length of the two turbines is 171.5m; and the span of the deaerator bay is 9.8m.

The height of the turbine hall is determined according to the requirement of lifting height of the LP upper casing.

The turbine hall is divided into three floors: 0m (ground floor), 6.4m (intermediate floor), and 13.7m (operation floor). The operation floor of the turbine hall adopts large platform structure.

Two turbine-driven feedwater pumps are arranged on the operation floor; the centerline is 4.7m to the centerline of row B column. The feedwater pump turbine heads are opposite, and the exhaust steam is downward connected into the main condenser. The turbine-driven feedwater pumps are arranged on the turbine hall operation floor, compared with the arrangement on the turbine hall ground floor, it has the following advantages:

The operation and maintenance environment of the turbine-driven feedwater pumps and the turbines is improved;

With the feedwater pump turbine exhausted downward, when opening it for maintenance, it is not necessary to remove the exhaust pipe.

With the feedwater pump turbine arranged at high position and the steam exhausted downward, the probability of water damage to the feedwater pump turbine is reduced, favorable for safe operation;

The space of the turbine hall operation floor and the intermediate floor can be fully utilized.

Turbine hall ground (0m) floor: The steam turbine head section is arranged the condensate polishing plant, main turbine oil system equipment, and liquid ring vacuum pump. The generator end is arranged the generator's oil, hydrogen and water equipment, condensate pump, and closed circulating cooling water pump. Under the feedwater pump turbine pedestal is arranged the feedwater pump turbine oil system equipment. The water-water heat exchanger and condensate water storage tank are arranged on outer side of the turbine hall ground (0m) floor A row columns.

The turbine hall 6.4m floor is mainly arranged the piping. The turbine head is arranged equipment such as the HP bypass device, turbine oil system equipment, gland seal steam supply and gland steam condenser; at A row columns side is arranged the turbine LP bypass device, etc.

On 0m floor of the deaerator bay is arranged the booster pumps of the two turbine-driven feedwater pumps and so on. #5 LP heater and #6 LP heater are arranged on the intermediate floor of the deaerator bay. #1, #2 and #3 HP heaters are arranged on the operation floor of the deaerator bay; #3 HP heater steam cooler is arranged on the operation floor column C side, on the 26m deaerator floor is arranged the deaerator and water tank and buffer tank of the closed service (industrial) water system.

5.11.3 Arrangement of coal bunker bay and boiler house

The coal bunker bay has 0.00m floor, 17.00m coal feed floor and 42.0m belt conveyor floor.

On the coal bunker bay 0.00m floor is arranged 12 medium speed mills, each mill occupies one column space; the column space is 12m.

On the coal bunker bay 17.00m coal feeder floor is arranged 12 electronic weighing coal feeders, with 12 raw coal bunkers arranged above the 12 coal feeders correspondingly.

The coal bunker bay 42.0m floor is the belt conveyer floor, arranged with the coal conveyer belt. It adopts fixed end coal handling scheme.

The boiler house and the bunker bay are separated, with low seal provided in front of the boiler. On the boiler house ground floor is arranged such equipment as the slag removal equipment, and seal air fan.

At rear of the boiler house is arranged in the order of the fan room—ESP—ID fan room—chimney—desulfurization island in-line arrangement.

The primary air fan and FD fan in parallel to the boiler centerline is arranged on the fan room 0m floor, and on upper part of the fan room is arranged the gas duct.

The ID fan vertical to the boiler centerline is horizontally arranged on the ID fan room 0m floor, and on upper part of the ID fan room is arranged the gas duct.

5.11.4 Main indexes of the main plant building

Description	Unit	Project parameters of this phase
Span of the turbine hall	m	30.6
Length of the turbine hall	m	171.5
Turbine hall operation floor elevation	m	13.7
Overhead crane rail top elevation	m	25.6
Turbine hall roof truss lower chord elevation	m	30.5
Span of coal bunker bay	m	12.5
Belt conveyer floor elevation	m	42.0
Coal feeder floor elevation	m	17.0
Space between the boiler first row column and the coal bunker bay column	m	7.0
Space between A row columns and rear row columns of the ID fan room	m	131.3
A row to chimney centerline	m	214.1

5.11.5 Arrangement of other auxiliary workshops

This project plans to construct the auxiliary workshops of 1×35t/h oil startup boiler, air compressor room, fuel tank farm and the associated fuel oil pump house. And the corresponding turbine-boiler maintenance workshop and metal test laboratories will be constructed in accordance with the requirements of "Guide for furnishing test apparatus, maintenance device, and architectural area of fossil fuel power plant" (DL/T5001-2010).

5.12 Civil works part

5.12.1 Architectural part

1) Architectural design of main plant building

The main building adopts four-row arrangement pattern, that is, the turbine hall, deaerator bay, coal bunker bay and boiler house. Two-turbine-boiler central control mode is adopted, with the central control building arranged in between the two boilers.

In the turbine hall, the turbines are arranged longitudinally, with the equipment lifting maintenance ground provided in between the two units. In addition to the turbine auxiliary facilities on the turbine hall 0.000m floor, excitation transformer room and excitation panels are arranged. On the 6.400m floor is arranged the 10kV working section, and 220/380V turbine emergency section. The turbine operation floor is at 13.700m. In the turbine hall is equipped two overhead bridge cranes, the overhead crane rail top elevation is 25.600m.

On the deaerator bay ±0.000m floor is arranged the feedwater pump and condensate polishing regeneration plant; on 6.400m floor is arranged the LP heaters; on 13.700m floor is arranged the HP heaters, etc.; and the deaerator is arranged on 26.200m floor. In addition, the main staircases are arranged in the deaerator bay.

On the coal bunker bay ±0.000m floor is arranged coal mills; the 17.00m floor is the coal feeder floor, each boiler is provided with associated facility; the belt conveyer floor elevation is 42.0m.

The boiler is of all steel frame structure, outdoor island arrangement. Each boiler is equipped with 1 passenger-cargo elevator of 2000kg carrying capacity and 2m/s speed, which stops at each floor main working area of the boiler.

B row columns of the main plant building near the deaerator bay side is the main longitudinal passageway, with both ends corresponding to the building entrance and exit; on A row columns side there is the secondary longitudinal maintenance passageway. Lateral passageway is between the two units, which can connect the main working floors of the turbine hall, the coal bunker bay and the boiler house. Equipment lifting and maintenance ground is provided in between two units.

On C row columns side is arranged two main staircases, located at the fixed end and the central part of the building respectively, and at the expansion end is arranged one outdoor steel staircase. All the three staircases can reach all floors of the turbine hall and the deaerator

and coal bunker bay; and the staircase at the fixed end can reach the roof directly, which is the main vertical passageway of the main plant building.

On turbine hall A row columns side is also arranged the steel staircases that can reach all floors of the turbine hall, one staircase for each unit.

Through the above organization, a smooth passage network is formed for the main plant building:

Personnel pass-through: people can reach each floor and working platform through the staircase in the turbine hall and the deaerator bay and the ladders and elevators in the boiler island, and reach each working area through the horizontal passageways on each floor, quickly and easily.

Equipment transportation: large parts can be transported to the desired floor through lifting load hole, and small parts can be transported through stairways and elevators.

The horizontal and vertical passages and entrances of the main plant building are set strictly in accordance with the fire protection code, so as to ensure safe evacuation of the production and operation personnel in case of fire.

The part above 1.200m of the main plant building turbine hall is enclosed with single layer colored aluminum zinc coated profiled steel sheet; the partition walls and outer walls of the deaerator bay and the coal bunker bay adopt hollow-brick masonry, and the other walls adopt lightweight brick wall; the boiler elevator shaft adopts profiled steel sheet as the enclosure; the elevator machine room outer enclosure adopts composite panel. The roofing adopts insulation layer, grade II waterproofing, with organized water drainage.

2) Architectural design of the central control building

(a) The central control building is arranged in between the two boilers.

(b) The structural form of the central control building is of steel frame structure.

3) Other main production buildings

They are designed according to the requirements of the production process, with corresponding architectural treatment according to different characteristics of the production systems; some production buildings of close correlation are arranged in a combined way to reduce the building scale.

Exterior-protected construction of other main production buildings adopts hollow brick wall, or lightweight blocks according to their different structures; the roof waterproofing will use grade II or grade III waterproofing design according to their service nature, and thermal insulation or heat insulation layer will be provided for all the roofing.

4) Auxiliary buildings and ancillary buildings

The auxiliary buildings and ancillary buildings mainly include the production and administrative buildings, material storehouses and repair and maintenance buildings, etc.

5.12.2 Structural design

5.12.2.1 Design basis data

Basic wind pressure: 1.10kPa

Ground motion peak acceleration: 0.2g

Seismic resistance intensity: 8 degree

5.12.2.2 Main plant building structure system and structure type selection

The turbine hall, deaerator bay and coal bunker bay form a lateral rigid connection steel frame - supporting structure, form a longitudinal rigid connection steel frame - supporting structure or hinged connection steel frame - supporting structure system of each row. The platform frame of each floor of the turbine hall adopts steel structure; floors of the main plant building mainly use concrete slabs paved on the steel sub-beams. The turbine hall roof forms space structure by trapezoidal roof truss and supporting system, on the steel purlins are laid the double-layer insulation profiled steel sheets as the lightweight roof. Most of the main plant building foundation use natural foundation, with pile foundation used for some positions with heavy loads.

The turbine-generator pedestals use cast-in-place reinforced concrete frame structure, using raft slab foundation, natural foundation.

The central control building is independently arranged in between the two boilers, of the steel frame structure, using natural foundation.

The boiler structure adopts steel structure, designed and supplied by the manufacturer. The boiler foundation uses natural foundation.

5.12.2.3 Other main production buildings (structures)

1) Chimney, dust, slag handling buildings (structures)

(a) Chimney

The two units share one chimney. Height of the chimney is 210m, in the form of double steel inner cylinder - reinforced concrete outer cylinder chimney, with steel inner cylinder diameter of 6.4m, lined with titanium alloy plates. The chimney foundation adopts reinforced concrete raft foundation, with the natural ground as the ground foundation.

(b) The FD fan frame, ID fan frame and gas duct support

They adopt steel frame structure, natural foundation.

(c) ESP, slag silo

The civil works only designs the foundation of ESP and slag silo frame, using natural ground as the foundation; the superstructures are supplied by the manufacturer.

(d) Ash silo

This project is to construct two cylindrical ash silos, of the reinforced concrete silo structure, with natural ground as the foundation.

2) Fuel buildings

(a) Transfer tower

The coal transfer towers adopt steel frame structure, with natural ground as the foundation.

(b) Coal conveyor trestle

The coal conveyor trestles are of the outdoor arrangement, the trestles of small span and low height adopt steel structure, portal rigid frame is used longitudinally; the overhead trestles of large span and high height adopt steel column supports, steel truss structure is used longitudinally. The underground parts adopt reinforced concrete box structure, using natural ground as the foundation.

(c) Oil pump house and oil tank farm

The oil pump house uses steel frame structure, using independent foundation of natural foundation.

The foundation of steel oil tanks uses round raft foundation on the natural foundation, and asphaltic sand is paved on the sand-gravel cushion as an insulating layer. The firewall of the oil tank farm uses reinforced concrete structure.

3) Electrical buildings

(a) 500kV GIS distribution device uses steel frame structure, using the foundation of natural foundation.

(b) The main transformer, unit auxiliary transformer, startup/standby transformer are arranged outdoors, using natural foundation.

(c) 500kV outdoor distribution device: the frame uses herringbone structural columns assembled with steel pipes, and the cross beams use triangular steel trusses; all the steel structures are treated by hot dip galvanizing or spray galvanizing. The foundation is independent reinforced concrete cup foundation.

4) Chemical water buildings

The sea water desalination system, boiler make-up water treatment system, cooling water treatment plant and hydrogen generation plant adopt steel frame structure, using natural ground as the foundation.

5) Desulfurization system buildings (structures)

The flue gas desulfurization of this project uses sea water desulphurization process, the desulphurization system buildings (structures) mainly includes absorber, GGH frame, and aeration fan room, etc.

(a) The absorber adopts steel structure; the foundation adopts reinforced

concrete raft foundation.

(b) The GGH frame adopts steel structure; the foundation adopts independent foundation.

(c) The aeration fan room adopts steel structure, independent foundation.

6) Ancillary and auxiliary production buildings

(a) The comprehensive material storehouse and maintenance workshop (including the turbine boiler maintenance workshop, metal test labs and material storehouses) use steel structure, natural foundation of independent substructure.

(b) The startup boiler house and CEMS flue gas monitoring cabin use steel structure, natural foundation of independent substructure.

(c) The integrated pipe rack uses steel structure, natural ground of independent substructure.

It should be noted that as only the geological report nearby HUBCO power plant is available (see Annexure 6) but the geological report on this project plant site location is not available at present (in process), selection of each building and structure foundation type is temporary estimated, there may be different from the reality. So cost estimate of the foundation shall take that into account, and the building and structure foundation type selection would be modified according to the final geological report.

5.13 Cooling water system and cooling facilities

5.13.1 Cooling water supply system

The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water.

Cooling water can be taken from Arabian Sea via two methods, open channel or box culvert. Both of these two options are able to meet the requirements of CW intake for the plant. CW intake open channel can be constructed with the capacity for all the planned 6×660MW units at one time, such arrangement can provide significant convenience for the construction of further planned 4×660MW units. CW intake box culvert shall be constructed with the capacity for 2×660MW units.

However, the construction costs of these two options are similar. The CW intake open channel option has relatively lower water head loss and is relatively more convenient for siltation cleaning comparing to The CW intake box culvert option. On the other hand, both of these two CW intake options are able to meet the requirements of environmental protection. The CW intake open channel can prevent the entrainment of marine lives by its low flow velocity. The CW intake box culvert option can prevent the entrainment of marine lives by controlling its flow velocity and the use of additional screening bars. By considering all the techno/economic as well as environmental protection needs, CW intake open channel option is recommended.

After heat exchange in plant, the heated cooling water will be discharged back to Arabian Sea. Basing on the NEQS requirements, the temperature of the discharged water will not be more than 3° C higher than the existing seawater temperature, at 100 m from the outfall location into the sea. Basing on the investigation presented in ESIA, this can be achieved only if the CW outfall is completely submerged into water at all times. Therefore, box culvert is recommended to be used for CW discharge.

The further modelling shall be 3D, which includes computer and physical modelling, taking into account thermal discharge, sediment, and wave effects. The modelling will cover thermal recirculation and will take into account the impact of the existing Hubco plant and also the future expansion of the site for 6x660MW units.

It should be noted that, the CW intake/discharge scheme proposed above is basing on the preliminary information currently available. Further studies (including further surveys and modellings) need to be done to determine and optimized the cooling water design concept. Further description of the proposed CW intake/discharge scheme is presented as follow:

1) Cooling water supply method

The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows, through the sea cooling water intake open channel, to the land cooling water intake open channel.

The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The cooling water flows, through the land cooling water intake open channel, into the cooling water pump house. Then it is pressurized and flows through condenser and desulphurization aeration basin sequentially for heat exchange. Afterwards, the heated cooling water is discharged, via two culverts, to the sea area northwest to plant site.

2) Process of cooling water system

The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project. Each unit equips with 3 cooling pumps (3×33.33%). The total capacity of the 3 cooling water pumps shall be able to provide the maximum design volume of cooling water for one unit. The cooling water from Arabian Sea flows through sea cooling water intake open channel, land cooling water intake open channel, cooling water forebay, then into cooling water pump house. The cooling water is then pressurized and flow through condensers, siphon wells, desulphurization aeration basin sequentially. Afterwards, the heated cooling water is discharge via 2×4.6m×3.6m culverts to the sea area northwest to plant site. The process of cooling water system is described as:

Cooling water intake Sea cooling water intake open channel → land cooling water intake open channel → cooling water pump house forebay → cooling water pump house → condenser→siphon well → desulfurization aeration basin → discharge culvert

3) Cooling water volume

The volume of cooling water is presented in Table 5.13.1-1.

Table 5.13.1-1 Cooling water capacity of the unit

S/No.	Unit capacity (MW)	Rated condensation capacity (t/h)	Circulating cooling water demand (m^3/h)			Water demand (m^3/s)	Remarks
			Condenser	Other cooling water	Total circulating water amount		
1	1×660	1204. 49	115300	3500	118800	33	
2	2×660	2408. 98	230600	7000	237600	66	

Note: After heat exchange, the temperature rise of cooling water is 7.5°C. The effects of the discharge of this heated cooling water on Arabian Sea will need to be validated by the 3D modelling.

4) Main equipment of cooling water system

The equipment of cooling water system is mainly located in cooling water pump house. The pump house is hypaethral in this phase of the project. The details of the equipment of cooling water system are presented in Table 5.13.1-2.

Table 5.13.1-2 Main equipment of the circulating water pump house (2×660MW)

S/No.	Description	Specification	Unit	Qty	Remarks
1	Cooling water pump	Vertical mixed-flow pump, Q=39600m^3/h, H=19.0m n=295rpm	Set	6	Sea water
2	Circulating water pump motor (outdoor arrangement)	N=2800kW U=6000V	Set	6	Seawater
3	Rotary band screen (side-inflow)	B=2.6m，H=16.3m	Set	6	Seawater
4	Trash rack	B=4.1m，H=16.3m	Set	6	Seawater
5	Trash cleaner	Mobile	Set	1	Seawater
6	Flat plate steel gate	4.1m×4m	Piece	6	Seawater
7	Hydraulic-controlled butterfly valve	DN2400	Piece	8	Seawater

S/No.	Description	Specification	Unit	Qty	Remarks
8	Gantry crane (double hook)	Lifting weight 40t/10t, Lk=32m	Set	1	

5) Main structures of cooling water system

(a) Cooling water intake

The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site. The altitude and width of the bottom of the gate of the open channel is -5.96m （local elevation system） and 210m, respectively. The capacity of this open channel is sufficient for 6×660MW units. The cooling water from Arabian Sea flows by gravity, through the sea cooling water intake open channel, to the land cooling water intake open channel.. The deep water diversion channel is planned to adopt the construction of underwater excavation of foundation trench, random filling rock blocks on water surface for protective covering.

(b) Land cooling water intake open channel

The capacity of the land cooling water intake open channel is sufficient for 6×660MW units. The bottom width and top width of this open channel is 22m and 63m, respectively. And the length and bottom altitude of this open channel is 720m and -7.863m (local elevation), respectively. The design low water level at 97% frequency is defined to be -3.263 tentatively. At this water level, the flow velocity in land cooling water intake open channel for 2×660MW units or 6×660MW units is 0.5 m/s or 1.49 m/s, respectively. The side slope of the water intake open channel from bottom to surface are: 600-thick crushed stone reversed filter course, 400-thick rock block cushion course, and 150-thick plain concrete surface course.

When constructing the future 4×660MW units, the further land intake open channel can be constructed separately in the reserved position and connected to the land intake open channel of the first 2×660MW units. This arrangement will not disturb the operation of the first 2×660MW units when constructing the future units.

(c) Inlet culvert

The land cooling water intake open channel and cooling water pump house is connected by 4×4m×4m reinforced concrete culverts. The length of each culvert is 45m. The bottom altitude of the culvert inlet is -7.863m (local elevation system). The box culvert adopts cast-in-place reinforced concrete structure, using heavy excavation construction scheme.

(d) Cooling water pump house and its forebay (including screen room, and water pump room)

The cooling water pump house is considered based on the capacity of 2×660MW units. The cooling water pump house and the land cooling water intake open channel flow direction are arranged in 90°. To make a good connection between the water intake open channel and the cooling water pump house and maintain a good flow pattern, a forebay is arranged in between them. A screening system, including bar screen and rotating band screen, will be

deployed to prevent solid suspensions entering the CW pump house. Trash racks & rake will be deployed to clean the screening system of CW pump house regularly.

Upper part of the cooling water pump house is considered to be outdoor arrangement: length (water flow direction) × width = 38m×57m (taking into account the 12m-wide maintenance ground). The forebay plane arrangement adopts rectangular arrangement, with geometrical dimensions: the forebay water inlet side short side length of the cooling water pump house is 38m; the long side length is 45m, with a width of 14.2m, and a depth of 16m. The length × width × clearance depth of the cooling water pump house and the forebay along the water inlet direction is 54.2m × 45m × 16.0m.

The cooling water pump house and the forebay adopt cast-in-place reinforced concrete structure, using heavy excavation construction scheme.

(e) Pressure supply pipes

The cooling water pump house and turbine hall is connection by 2×DN4100 carbon steel pipes. Each unit has one of these pipes. The flow velocity in pipe is 2.50 m/s. The CW pipes will include suitable lining for corrosion/erosion protection.

(f) Siphon wells

Each unit is provided with 1 siphon well, totally 2 siphon wells; the geometrical dimension of each siphon well is: length (parallel flow direction) × width (vertical flow direction) × depth = 26.2m×16.6m×10.3m. Adopt heavy excavation construction, cast-in-place reinforced concrete box-type structure.

(g) Pressure discharge pipes, culverts connecting siphon well and desulfurization aeration basin

The cooling water of each unit is planned to be led out by 2×DN2600mm steel pipe in the turbine hall, and then merged into a single DN4100mm pipe outside A row columns and then connected to the siphon well.

It is planned to use B×H=4.1m×4.1m reinforced concrete box culvert to connect the siphon well to the desulfurization aeration basin, totally 2 box culverts are constructed. Length of a single box culvert is 290m, with covering earth depth of 3.0m. The water drainage box culvert adopts heavy excavation, cast-in-pace construction.

(h) Cooling water outfall

Cooling water is discharged to the sea area in the northwest of the plant after heat exchange. Such water is discharged via 2×4.6m×3.6m culverts with total length to be 3000m. The top of cooling water outfall shall be always underwater. The flow velocity of cooling water outfall is 1.26m/s. The schemes of the cooling water outfalls of the future 4×660MW units are similar with the scheme of the first 2×660MW units. The cooling water outfall schemes of all the planned 6×660MW units shall be validated together by the 3D modelling. This is to make sure that the cooling water outfall schemes of all the planned 6×660MW units can meet the

requirements of environmental protection and minimize the thermal recirculation.

(i) Anti-corrosion of cooling water system

As the operating medium of the system is seawater, effective anti-corrosion and anti-marine growth measures have to be taken for the facilities, equipment and welded steel piping. According to the experience of the coastal power plants, the facilities, equipment and welded steel piping of this project cooling water system plan to take the combined protection measures of sacrificial anode and coating or protect them with applied current method.

5.13.2 Fresh water supply system

1) Fresh water supply method

The fresh water in this phase of project is supplied by seawater desalination system.

2) Amount of fresh water consumption

Fresh water is mainly used as boiler makeup water treatment system, coal yard spray water, flushing water for coal handling system, ash removal water, air conditioner makeup water, fire water, potable water, and drinking water. The total amount of water consumption is shown in Table 5.13.2-1.

Table 5.13.2-1 Summary of total amount of fresh water consumption

Description / Plant capacity	2×660MW
Hourly consumption (m^3/h)	197.8
Consumption per GW ($m^3/s \cdot GW$)	0.042

3) Service and fire water basin, potable water tank, comprehensive pump house, and fire pump house.

In this phase of project, 2 service and fire water basins are deployed. The capacity of each basin is $3000m^3$. The capacity of service and fire water basins will be able to store water sufficient for one maximum water consumption (meeting NFPA standard) of fire-fighting or 60-hr water consumption for industrial purpose in plant. To make sure that such basins can always have necessary water for fire-fighting, the suctions of service water will be located higher that the suctions of fire water in those basins.

In this phase of project, 1 potable water tank is deployed, with the capacity of $300m^3$. The capacity of potable water tank will be able to store water sufficient for 24-hr potable water consumption in plant.

In this phase of project, 1 comprehensive pump house is deployed, which contains potable water-supply device, service water pumps, and other related accessories.

In this phase of project, 1 fire pump house is deployed, which contains fire pumps and other

related accessories.

5.13.3 Wastewater treatment system

The waste water in plant shall be collected and treated by waste water treatment system. The quality of treated water shall meet the requirement for reuse, and follow the principle of making full use of the "wastewater" in design.

The plant area drainage adopts complete separation system with clean and sewage separated. The waste sewage shall be collected according to the quality, treated centrally and controlled strictly is discharge. The treatment system includes the sanitary waste water treatment system, coal wastewater treatment system, oily wastewater treatment system, industrial wastewater treatment system (refer to 5.9.11).

1) Sanitary waste water treatment system

The sanitary waste water treatment system mainly treats the sanitary waste water from administration building, turbine house, and auxiliary/ancillary buildings. A sanitary waste water treatment facility with treatment capacity of $2\times10m^3/h$ will be constructed based on $2 \times 660MW$ units. The quality of treated water shall meet the requirement for reuse, can be used for plant area greening and road spraying.

The treatment process of sanitary waste water treatment system is shown as follow:

Sanitary waste water→ grating →pre-aeration in storage basin →preliminary sedimentation basin →pressurized biological aeration basin→ sand filter → backwash water basin→ disinfection basin →for plant area greening and road spraying.

2) Oily waste water treatment system

Oily waste water treatment system mainly treats the oily waste water from transformer area and turbine house. An oily waste water treatment facility with treatment capacity of $2\times5m^3/h$ will be constructed based on $2 \times 660MW$ units. The quality of treated water shall meet the requirement for reuse, can be used for plant area coal yard spraying.

3) Coal waste water treatment system

A coal waste water treatment system will be constructed based on $2 \times 660MW$ units of this project, mainly for treating coal waste water from coal yard area and the flushing water from each coal handling transfer tower. The capacity is considered according to the planned capacity of the power plant, with the capacity of $2\times20m^3/h$. The treated water shall meet requirement of the plant area coal yard spraying.

The treatment process of coal waste water treatment system is shown as follow:

Coal waste water pipe→ coal waste water storage basin→ coal waste water pump → coal waste water treatment plant→ treated water reuse basin→ treated water pump→ coal yard spraying.

5.14 Emergency ash yard

The ash yard of this project is a plain emergency ash yard; ash storage site is formed by way of building ash dam around. The floor space of the ash yard is about $30\times10^4m^2$. When the ash-stacking height of the ash yard is 16m (design maximum height), volume is about $408\times10^4m^3$, in this case, the ash yard can store about 5.9 years of ash for 2×660MW units (under design coal condition).

The structural type of the ash dam is of slope dike; the negatively-excavated sandy soil in the plant area is used to form bagged border dike and ash dam; the ash dam is about 4m high which uses armor stone to protect slope, and provide stability and can prevent flooding. The geologic condition of the plant area is good, and the foundation of the ash dam does not need subgrade treatment. Multi-layer composite anti-seepage geomembrane (soil-technical membrane) is provided in the ash yard so as to prevent ash water from seepage and leakage.

More details of emergency ash yard structure, please see "Emergency ash yard plan layout and section", 44-FC08931K-A02-S06.

The project is equipped with sprinkling truck, which will spray water to exposed ash surface and guarantee moisture content of ash surface to increase cohesion of ash particles, when the ash reaches design elevation, it will be covered with soil to prevent fly ash pollution to the surrounding environment of plant and ash yard. Catch drain will be provided surrounding the ash yard so as to prevent the rainwater surrounding the ash yard from being drained into the ash yard. In order to prevent ash water from polluting environment, it intends to build a temporary $500m^3$ash water sedimentation basin in the ash yard so that the polluted rainwater can be used as spray and flush water after being filtrated by the ash water sedimentation basin.

5.15 Fire protection system

5.15.1 Design principle

The fire protection system shall be able to, firstly, take precautions against fire hazards; and secondly extinguish the fire if it occurs. The design of the facilities in plant (e.g. in the aspect of equipment and material selection, and system arrangement) shall fully consider the requirements of fire precaution in order to optimize the use of fire protection system. In general fire fighting systems will meet the NFPA requirements. In case Chinese standards are used, it will be ensured that they also meet the NFPA requirement

Different fire protection systems (e.g. water fire-extinguishing system, gas fire-extinguishing system, movable fire extinguisher) shall be used for different plant facilities accordingly in order to meet their different fire protection requirements. The important buildings and equipment shall be equipped with automatic fire monitoring & alarm system.

5.15.2 Primary fire protection systems

The following fire protection systems will be considered for this project:

1) Water fire-extinguishing system

Independent pressurized firewater supply system will be the part of plant design and will contain, but not limited to:

(a) Hydrant fire-extinguishing system

Aboveground fire hydrants are deployed at the plant outdoor area Indoor fire hydrants are deployed in the plant indoor area.

(b) Automatic sprinkler system

Automatic sprinkler systems are deployed at coal-handling trestle, and administration building, etc..

(c) Water spray fire-extinguishing system

Water spray fire-extinguishing systems are deployed for the main transformers, auxiliary transformers, startup & standby transformer, lube oil tank of steam turbine, clean oil tank, dirty oil tank, electrohydraulic device, hydrogen sealing oil device, oil tube at the operating floor and intermediate floor of steam turbine, oil tank of feedwater pumps, burner area of boiler proper, lube oil tank of coal mill, diesel generator house, and diesel-engine-driven firewater pumps, etc..

(d) Water curtain fire isolation system

Water curtain fire isolation systems are deployed in coal-handling trestle, coal transfer terminal tower, coal-crushing facility, and the facilities connected to the turbine house.

2) Gas fire-extinguishing system

Gas fire-extinguishing systems are deployed in electronic device room, electric relay room, computer room, low-voltage power distribution room, etc.

3) Foam fire-fighting system

Foam fire-fighting system is used in oil tank are

4) Movable fire extinguisher

Dry powder, carbon dioxide or foam fire extinguishers are deployed in turbine house, central control room, and the auxiliary and accessory buildings of the power plant.

5) Fire alarm system

The fire detection, alarm and control system of this new project will be of intelligent analog system. This system adopts control center alarm system and is consisted of the following equipment: centralized fire alarm controller, fire-protection interlock controller, zone fire alarm controller, fire emergency broadcast equipment and fire-protection communication equipment, CRT display, detector, manual alarm pushbutton, audible and visual alarm, various types of module, etc.

The centralized fire alarm controller, fire-protection interlock control equipment, CRT display, fire emergency broadcast equipment and fire-protection communication equipment are

arranged in the control room of central control building; this control room is used as the fire-protection control center of this project. Zone fire alarm controllers and actuation devices will be provided respectively at the operating level of the main power house and the ash-handling control room of each Unit.

5.15.3 Deployment of fire brigade and fire engine

A firewater & foam engine and a dry powder & foam fire engine are deployed for 2×660MW units. A fire engine garage will be built in this project.

5.16 Operation regime and redundancy concept

The power plant is designed as per continuous operation of 24 hours and annual utilization hours are 7446h. Since Pakistan grid is not stable, grid instability and power loss, should be considered for main equipments type/parameters selection and equipment redundancy to guarantee safe and reliable operation over the life of power plant.

5.17 Conclusions

5.17.1 Main conclusions

1) In this project, 2×660MW supercritical units are built, and land for expansion of 4×660MW units is reserved. The BOP (balance of plant) shall be constructed according to 2×660MW units in principle. Only seawater intake channel is designed for 6 units to provide assistance in construction phase of future projects, however, all the other facilities are designed for 2 units;

2) After comparing the three plot plan scheme, the scheme I (44- FC08931K-A02-Z03) has lower relative investment, and also has the advantage of reasonable general layout, smooth process flow, smooth 500kV outgoing lines, less land occupation, good construction condition, no need for relocation of facilities of the old plant etc. Therefore, in this stage, scheme I will be used as the recommended scheme.

3) Main equipments:

Boiler: supercritical once-through pulverized coal boiler, corner tangential combustion, one reheat cycle, single furnace balanced draft, ∏ arrangement, dry bottom furnace, all steel frame suspension structure and tri-sector rotary air preheater. Positive pressure primary cold air direct blowing pulverization system.

Turbine: supercritical, one reheat cycle, tandem compound, three-casing-four-flow, condensing turbine. Three HP heater stages, four LP heater stage, and one deaeration stage.

Generator: under rated power factor and rated hydrogen pressure condition, rated power of generator matches output under rated condition of turbine. Maximum continuous output power of generator matches with maximum continuous output of turbine.

4) Main steam adopts unitized system. Main steam pipes adopt 2-1-2 arrangement.

5) Bypass capacity is temporarily 40% of boiler maximum continuous rating (BMCR) to meet quick start requirement of the units. Considering the impact of unit trip due to grid instability, it's necessary to make closely coordination with the manufacturer to finally determine bypass capacity.

6) Feedwater system is provided with 2×50%B-MCR turbine-driven speed-regulating feedwater pump. Every unit is provided with 1×50% startup and standby motor-driven feedwater pump.

7) 1×35t/h oil startup boiler is considered to supply steam to auxiliary steam system. Final capacity of startup boiler will be determined in basic design phase, based on the amount of steam and startup time required for startup.

8) Every boiler is provided with six (preliminary) medium speed coal mills. Under both design and check coal conditions at BMCR, 5 mills will be in operations while 1 remains standby.

9) Two boilers share one 210.0m high sleeved double-cylinder stack with outlet diameter of 2×Φ6.4m (preliminary).

10) Fly ash handling system adopts positive pressure pneumatic conveying system to transport the fly ash discharged from ESP and economizer ash hopper to the ash silo.

11) Two fly ash silos shall be provided and another fly ash silo place shall be reserved. 24h storage capacity shall be provided for the storage of fly ash and bottom ash.

12) Trucks shall be used to transport the ash to ash yard.

13) Fresh water for operation of the power plant takes from seawater desalination system.

14) The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project, with Arabian Sea as the source of cooling water. Each unit equips with 3 cooling pumps (3×33.33%). The total capacity of the 3 cooling water pumps shall be able to provide the maximum design volume of cooling water for one unit.

15) Layout of the main plant building: Adopt a four-row layout pattern of turbine hall, deaerator bay, coal bunker bay and boiler house.

16) Arrangement of boiler rear area: make in-line arrangement of FD fan room—ESP —ID fan room—chimney—desulfurization island.

17) A external ash yard is being investigated to cater for 30 years operation ash of the plant. The ash yard in plant of this project is a plain emergency ash yard; ash storage site is formed by way of building ash dam around.

18) The power plant is designed as per continuous operation of 24 hours and annual utilization hours are 7446h. Since Pakistan grid is not stable, grid instability and power loss, should be considered for main equipments type/parameters selection and equipment

redundancy to guarantee safe and reliable operation over the life of power plant.

5.17.2 Suggestions

1) Three samples of the seawater quality reports are not sufficient for design of sea water desalination system, more seawater analysis need to be carried out.

2) The further modelling shall be 3D, which includes computer and physical modelling, taking into account thermal discharge, sediment, and wave effects. The modelling will cover thermal recirculation and will take into account the impact of the existing Hubco plant and also the future expansion of the site for 6x660MW units.

6. Flue gas desulfurization and denitration

6.1 Flue gas desulfurization

6.1.1 Selection of flue gas desulfurization process

On the base of the application of desulfurization process, it intends to tentatively consider the comparison between the seawater desulfurization process and limestone – gypsum wet desulfurization process in this project.

1) Seawater desulfurization

Seawater desulfurization is accomplished by way of directly using the seawater of recirculating water system for flue gas desulfurization, and no chemical is added during desulfurization. The basic principle of desulfurization can be expressed in the following equations (1) and (2). The sulfur dioxide in flue gas is absorbed with seawater, and subsequently converted into sulfuric acid after oxidation and aeration.

$$SO_2+H_2O+\frac{1}{2}O_2=SO_4^{2-}+2H^+ \qquad (1)$$

The hydrogen radical generated in equation (2) is neutralized with bicarbonate radical.

$$HCO_3^-+H^+=CO_2\,(\text{gas and liquid})+H_2O \qquad (2)$$

The recirculating water from the outlet of condenser is divided into two parts: absorber water and aeration water. Washing water flows to the water basin of seawater booster pumps by gravity from the back of the siphon well of the Unit via water diversion pipe; and then, the washing water is boosted to desulfurization absorber with the booster pumps, where the washing water comes in contact with flue gas and washes the flue gas and absorbs sulfur dioxide. After leaving the absorber, the absorbed seawater is drained into the aeration basin via pipeline. At this time, the seawater is mixed with another part of aeration water in the aeration basin. The pH of seawater is restored to above 6.5 after oxidation and aeration; and then, the seawater is drained into the sea via the discharge port of recirculating water.

The main equipment of seawater desulfurization process includes gas-gas heater, absorber, aeration basin, oxidation fan and seawater lifting pump, etc.

Advantages:

Seawater desulfurization process has great advantage for seaside power plants that are available with seawater intake and drain condition and that use seawater as the cooling water of power plants. The seawater desulfurization process is characterized by simple process, reliable system and convenient operation and maintenance. Since this process uses seawater to absorb SO_2, no other additive is required any more, and system maintenance workload is less.

The required desulfurization rate can be obtained and environmental protection requirement can be met under the condition that sulfur content of firing coal is low and seawater salinity is

appropriate.

No solid waste is produced, and there is no emission of secondary pollutant such as waste residue, land occupation of waste storage yard is saved, thus minimizing the additional impact of FGD unit on environment.

Disadvantages:

There are many factors affecting desulfurization efficiency, namely, sulfur content of coal as well as the seawater salinity, flow and temperature of recirculating water, etc. Seawater restoration system is provided in the seawater desulfurization process, and so it needs blast aeration, and the aeration basin needs great area.

2) Limestone –gypsum wet desulfurization

Limestone –gypsum wet desulfurization is a process that uses limestone slurry to wash and to remove sulfur dioxide from flue gas and to generate byproduct gypsum. The basic principle can be expressed in the following equations (1)~(3). The sulfur dioxide in flue gas is absorbed with limestone and gypsum is generated after oxidation and neutralization.

$$2SO_2+H_2O+CaCO_3=Ca^{2+}+2H^{+}+2SO_3^{2-}+CO_2 \quad (1)$$

$$SO_3^{2-}+\frac{1}{2}O_2=SO_4^{2-} \quad (2)$$

$$Ca^{2+}+SO_4^{2-}+2H_2O=CaSO_4\cdot(2H_2O) \quad (3)$$

The main process equipment of limestone–gypsum wet desulfurization includes gas – gas heater, absorber, slurry recirculation pumps, oxidation fan, etc. The process system is mainly consisted of absorbent preparation equipment & system, SO_2 absorption system, flue gas system, process water system, gypsum treatment system, compressed air system, wastewater treatment system, etc.

Advantages:

The application scope of this process is wide, this process is not restricted with the sulfur content and the capacity of Units; the factors that affect desulfurization effiiency are fewer, and market share is great.

Desulfurization rate is high and can be above 95%.

The technology of this process is sophisticated, application is wide and operation is reliable; this technology is the desulfurization technology whose application is the widest in the desulfurization process of the coal-fired power plant in the world at present.

Desulfurization absorbent is cheap limestone, and utilization factor is high, calcium to sulfur ratio can be less than 1.03.

Limestone –gypsum wet desulfurization technology has been greatly improved, and homemade extent is also being increased, and also, fabrication cost has been greatly

decreased.

Limestone –gypsum wet desulfurization is the desulfurization process that is technically the most sophisticated and widely used in the world at present, especially, in the USA, Germany and Japan; the capacity of the Units using this process accounts for about 90% of the total installed desulfurization capacity of power station.

Disadvantages:

Wet-type desulfurization system is complicated, and the workload of operation and maintenance is great; in addition to absorber proper and flue gas system, desulfurization process system includes various auxiliary systems such as limestone storage, slurry preparation, gypsum recovery, draining and wastewater treatment.

Wet-type desulfurization system will consume limestone and fresh water resources.

Currently, desulfurization byproduct has to be reused in actual operation; if the byproduct cannot be reused, the byproduct has to be stored or disposed on ash yard; as a result, land will be occupied and secondary pollution such as dust emission may be produced.

3) Comparison conclusions

Technically speaking, the above-mentioned two proposals are feasible. Since this project is located at seaside and the existing seawater parameter analysis indicates that seawater can be used for desulfurization. For this reason, it is recommended to use seawater for desulfurization, considering economical efficiency and maintainability. The final desulfurization type is to be determined as per the government comments of environmental impact assessment report. For detail comparison that considering economical efficiency and maintainability, please see document NO.44-FC08931K-A03-T02.

6.1.2 Source and consumption of desulfurization absorbent

The power plant water takes from sea water. Desulfurization absorbent will be of the CCW seawater effluent from condenser. As for the main water quality conditions of plant inlet seawater, please see Annexure 8 and 8a, Sea water quality analysis report. At present stage, this analysis report is used as the design inputs for SWFGD.

Table 6.1-1 Seawater quality design basis

No.	Item	Unit	Value	Remark
1	pH value		8.02	Water temperature 25°C
2	Alkalinity (Carbonate) alkalinity (carbonic acid radical)	mg/L	<5.0	
3	Alkalinity (Bicarbonate) alkalinity (Bicarbonate radical)	mg/L	127.50	
4	Alkalinity (Total as $CaCO_3$)	mg/L	127.50	

In the basic design phase the performance evaluation of SWFGD will consider the variation in sea water parameters like pH, alkalinity etc after additional sea water sampling for 6 months to 1 year and the design of FGD system will be ensured to meet the SO_2 limit in stack i.e. 220 mg/Nm^3.

Based on the final design of FGD system including sea water flow to FGD, absorber sizing etc, the check limits for pH, Alkalinity etc will be provided keeping in view the requirement of less than 220 mg/Nm^3 SO_2 in stack.

Seawater consumption is preliminarily estimated as follows base on seawater quality shown above:

Table 6.1-2 Seawater consumption of desulfurization system of a single Unit

Seawater consumption	Seawater absorption system	Seawater restoration system
Hourly consumption (m^3/h)	38100	77100

Note: Desulfurization efficiency is designed as 91%.

6.1.3 Quality of seawater effluent

The temperature-rise of circulating cooling water caused by seawater desulfurization does not exceed 1.5℃ base on seawater quality shown above; circulating cooling water effluent is considered as per the following seawater quality NEQS standard shown in Chapter 7.1.1 quoted from ESIA:

6.1.4 Assumption of flue gas desulfurization engineering

1) Design basis parameters

Table 6.1-3 Coal consumption (a single furnace, BMCR condition)

Item	Unit	Design coal
Sulfur content of as-received basis (Sar)	%	1.035
Coal consumption	t/h	252.22
Annual coal consumption （7446 hours）	$\times 10^4$ t/a	187.81

Table 6.1-4 Flue gas parameters (a single furnace, BMCR condition)

Item	Unit	Design coal

Flue gas temperature at the discharge of induced draft fan	℃	112.1
Volume of wet flue gas at the discharge of induced draft fan（actual state）	m^3/h	3100637
Volume of the dry flue gas at the discharge of induced draft fan（standard state, dry basis, actual oxygen content）	Nm^3/h	2011395
Coefficient of excessive air at the discharge of induced draft fan	—	1.401
Volume of wet flue gas at FGD outlet (actual state) with GGH	m^3/h	2844518
Flue gas temperature at FGD outlet with GGH	℃	70
Stack Diameter with GGH	m	6.4
Volume of wet flue gas at FGD outlet (actual state) without GGH	m^3/h	2595727
Flue gas temperature at FGD outlet without GGH	℃	40
Stack Diameter without GGH	m	6.9

Note: the NO_x content after the boiler economizer is lower than 350mg/Nm^3（standard state, dry basis, oxygen content 6%）.

2) System and equipment of desulfurization process

Full flue gas desulfurization will be performed in this project; desulfurization system will be of seawater desulfurization process; overall desulfurization system efficiency shall not be lower than 91% (with or without GGH); a boiler will be equipped with an absorber; the FGD system will be designed based on the flue gas flow from boiler under BMCR conditions.

(a) Flue gas system

Having been dedusted in ESP, flue gas is led out via the flue gas duct between the discharge of the induced draft fan of boiler and stack, and is sent into seawater desulfurization system. Having flowing through damper and GGH (if any), flue gas flows through the absorber upward from the bottom of the absorber, where SO_2 is removed from flue gas. The clean flue gas is heated to certain temperature in GGH once treated in the absorber; and then, the clean flue gas is discharged into atmosphere from stack via damper. GGH design leakage is about 1%.

To ensure the safe and stable operation of the main flue gas system, emergency bypass flue gas duct with flue gas capacity of 100% is provided between the suction and discharge dampers of the seawater desulfurization system. The damper on the bypass flue gas duct will

be closed and the inlet & outlet dampers of desulfurization system will be opened during normal operation. Flue gas will be vented after being sent into the flue gas desulfurization (FGD) system for desulfurization treatment. When the desulfurization system stops operating, the damper on bypass flue gas duct will be opened, and the inlet & outlet dampers of the desulfurization system will be closed, in this way, flue gas directly enters the stack for venting so as to ensure that the operation of the main Unit will not be affected when the desulfurization system is shut down for maintenance. Sealing air fan system will be set to prevent the leakage from through the bypass duct damper.

Many of the desulfurization units in Asia adopt gas-gas heater (simplified as GGH), e.g., China (including Taiwan), Korea, etc. Most of the coastal power plants under construction in Viet Nam adopt seawater desulfurization, and these power plants are basically equipped with GGH. The emission laws in some countries (such as Japan and Germany) require the flue gas temperature at stack outlet not to be lower than 72℃ and 92℃; therefore, desulfurization system must be provided with GGH.

In China, Many plants adopt GHH in the early 2000 year. But currently, most desulfurization units of the power plants in China adopt GGH-free proposal because the system is complicated and more expensive; however, this proposal shall not be implemented until environmental impact assessment is performed and approval from relevant environmental protection authorities is obtained. Among the seawater desulfurization units in China, Houshi Power Plant in Zhangzhou does not adopt GGH, while Qinhuangdao Power Plant, Huangdao Power Plant, Haimen Power Plant and Western Power Plant adopt GGH.

Advantages and disadvantages for setting up GGH:

Advantages: mitigate corrosion to stack; lift the raise height of flue gas so as to decrease the ground concentration of pollutant; avoid stack from venting "white smoke"; avoid the production of flue gas condensate.

Disadvantages: resistance of FGD system is increased; fabrication cost and operation cost are high; corrosion-related issues may occur because of the long-term operation of GGH; the system is complicated; GGH leakage rate may affect desulfurization efficiency; land occupation is great. In China, GGH design leakage rate will be about 1% normally. Sealing blade in the GGH and low leakage fan system will be adopted to minimize leakage rate.

Whether to set up GGH has little impact on FGD process flow. If GGH is not set up, the initial investment of power plant can be saved and the operation & maintenance cost can be saved after FGD island is put into operation, thus saving energy source; however, considering environmental protection, although setting up GGH cannot change the emission amount of pollutant of power plant after desulfurization, flue gas can be heated up to increase the raise height of flue gas and to decrease the pollutant concentration surrounding power plant, which reduces the corrosion to downstream equipment to some degrees, and "white smoke" phenomena can be partially eliminated, thus improving the vision appearance of power plant in the eyes of the public.

The desulfurization system is tentatively considered to be provided with GGH at this stage after comprehensive consideration, and FGD without GGH is also feasible from technology and meet environment requirement from ESIA. Detail comparison of FGD system with GGH and without GGH will be conducted in the basic design phase.

(b) Absorption system

Each Unit will be equipped with a set of SO_2 absorption system, namely, one boiler one absorber allocation mode will be adopted.

SO_2 absorption system is the core system of desulfurization unit; The Unit will be separately provided with a set of absorption system. The flue gas to be treated enters absorber and comes in contact with spraying seawater in a countercurrent manner so as to remove SO_2 from flue gas. The entire absorption process is completed in the absorber. The absorber is the main structure of this system.

Absorber can be of sprinkler-type empty tower or packed tower. Seawater absorbs the $SO_2$from flue gas by way of once-through. Fresh seawater enters the spray layer at the top of absorber, and is injected into the absorber via the sprinkling bank. Flue gas flows upward through the rinkling bank from bottom and fully comes in contact with seawater; In this way, the SO_2 in flue gas is promptly absorbed with seawater. The flue gas flows through the mist eliminator above the sprinkling bank on the top of the absorber so as to remove the water drop from the washed flue gas. The project is tentatively designed as per sprinkling tower system at this stage.

The absorber is in reinforced concrete or steel structure lined with glass flake; the gas-liquid contact areas inside the tower are sprinkling bank, mist eliminator and mist eliminator flushing water system bank. Seawater tank is provided at the bottom of the absorber; mist eliminator and seawater sprinkling system are provided on the top inside the absorber. The flushing water system of mist eliminator is provided. The possibility of mist eliminator clogging in the absorber is low during seawater desulfurization. To minimize the energy consumption of process water pump, operation personnel need to turn on/off the process water pumps for flushing the mist eliminator according to the differential pressure of the mist eliminator; each flushing cycle of the mist eliminator is accomplished automatically.

(c) Seawater supply system

The seawater of the water supply system of desulfurization absorber comes from the recirculating water effluent of the Units; after the recirculating water effluent flows through siphon well, part of the effluent is pumped to the absorber with seawater booster pumps so as to remove the SO_2 from flue gas. The acid effluent, of which flue gas has been washed off, flows to the seawater treatment plants (aeration basin) of various Units by gravity from the bottom of the absorber; the remaining seawater directly enters the aeration basin by gravity. Having absorbed the SO_2 from flue gas, seawater flows to the aeration basin by gravity from the bottom of the absorber; a great amount of the remaining seawater (the warm effluent of recirculating water system) that has not participated in the desulfurization directly flows to the

aeration basin so as to further mix with the acidic seawater of desulfurization absorber and to aerate, thus attaining the purpose of restoring seawater quality.

Seawater pump station adopts indoor arrangement, and is arranged beside the absorber. The seawater supply system for the desulfurization of each Unit is divided into the water supply system of desulfurization absorber and the water supply system of seawater treatment (aeration basin). Preliminary estimation reveals that, the total seawater capacity of a single Unit is about 115200m^3/h, of which the seawater capacity required by the absorber is 38100m^3/h, and the seawater capacity required by the aeration basin is 77100m^3/h.

(d) Seawater restoration system

Untized seawater quality restoration system is adopted in this project.

The seawater quality restoration system includes influent channel, water distribution tank, aeration basin, effluent channel and blast aeration system; the front four parts adopt combined reinforced concrete structure. The aeration basin is also divided into front mixing area and rear aeration area. A part of the a great amount of alkaline coming from the siphon well of the recirculating water system of the Units enters the front mixing area of the aeration basin via the influent channel and water distribution tank, and accomplishes full mixture and neutralization reaction in this area with the acidic return water coming from desulfurization absorber with pH being about 3; and then, the mixed seawater enters the rear aeration area of the aeration basin. There are multiple rows of porous aeration tube at the bottom of the aeration area. A great amount of air is blown into the aeration basin with several aeration fans so as to produce a great amount of little bubble for the purpose of making the dissolved oxygen of the seawater in the aeration basin be saturated, and making the decomposable sulfite oxidize into steady sulfate. The aeration can also make the carbonic acid radical CO_3^{2-} and bicarbonate radical HCO_3^- rapidly conduct neutralization reaction with the H^+ released from the absorber, thus releasing CO_2; in this way, the pH in seawater can be restored and can be improved to above 6.5, thus meeting the requirement of release standard. Overflow weir is also provided at the effluent side of the aeration basin so that acceptable seawater can overflow to the effluent channel. The restored seawater returns to the open effluent channel of the recirculating water system of the Units and will be finally drained into the sea.

Aeration air duct is provided at the bottom of the channel of the aeration basin; the air duct is of FRP pipe.

Deep layer aeration is adopted in the aeration basin, which reduces the floor space of the aeration basin. Enclosed mixing tank is eliminated; instead, streams are directly mixed at the end head of the aeration basin. The bottom elevation of the aeration basin has been increased, and civil work amount has been reduced.

Two aeration basins are provided in this project, one for each Unit. Aeration and neutralization are accomplished with the aeration basins; the desulfurization seawater, of which water quality has been restored, is drained into recirculating water effluent pipeline.

Overflow weir is provided at the outlet of aeration basin, and measures for preventing seawater corrosion are provided for the inner wall of the overflow weir; meanwhile, applicable water quality monitoring instrument is provided at the outlet of the aeration basin; pH, DO and effluent temperature shall be on-line monitored; COD and BOD analysis instrument shall be provided.

(e) Process water system

The process water supply of seawater desulfurization unit comes from the process water of the power plant, and is used for low-pressure flush and pipeline flush of GGH. A process water tank is provided in the desulfurization island and is equipped with process water pumps.

(f) Compressed air

The compressed air supply of the instrument air system comes from the main part of the project; the instrument air coming from the main part of the project provides the compressed air for the purge of the CEMS of the FGD plant after passing through pressure-stabilizing air storage tank.

3) Arrangement of desulfurization system

The desulfurization island is to be arranged behind the induced draft fan and stack of boiler; this island includes various equipment and buildings & structures such as desulfurization flue gas duct, GGH, desulfurization absorber and the like. Each Unit is provided with a desulfurization island; the desulfurization islands of 1# Unit and 2# Unit are symmetrically arranged along the centerline of stacks.

The seawater booster pump house of 1# Unit is arranged to the west of No. 1 absorber; the seawater booster pump house of 2# Unit is arranged to the east of No. 2 absorber; the seawater booster pump houses of 1# and 2# Units are symmetrically arranged along the centerline of stacks.

Aeration basins are separately planned and are arranged to the west of the main power house; there are totally 2 aeration basins. The aeration fan houses of the two Units are merged and are located to the north of the aeration basins.

6.2 Flue gas denitration

Low-nitrogen combustion technology is adopted for the boilers of this project, which can control the NO_X emission concentration at the outlet of boilers to be less than 400mg/Nm^3 and can meet the local emission requirement of Pakistan. Therefore, it is not to set up flue gas denitration unit in this project; however, considering the improvement of the installation requirement of denitration unit in future, the installation positions of SCR unit and ammonia area are reserved.

Boiler burner zone heat release rate is the key factor that affects the NOx emission level. In this project, burner input is low, which can help reduce the thermal loading to the combustion zone, also the big burners vertical and horizontal space is used to increase the burner zone

area, in order to decrease the burner zone heat release. Thermal NOx is decreased by reducing the temperature in furnace.

The Low NOx Burner is designed to efficiently burn pulverized coal in a manner that greatly reduces emissions of nitric oxides, it makes use of air staging and fuel staging technology by virtue of its design.

6.3 Conclusions

6.3.1 Main conclusions

1) Seawater FGD technology is suitable for this project, and SO_2 emission will meet NEQS requirement base on design and check condition, include coal sulphur and seawater quality etc.

2) Low-nitrogen combustion technology is adopted for the boilers of this project, which can control the NOx emission meet NEQS requirement.

6.3.2 Suggestions

The seawater sampling data is not enough，a at least one year long sampling should be taken to measure the FGD input data.

7. Environmental & ecological protection

7.1 Applicable environmental protection design standards and design basis

The following environmental standards are at least to be met for the project and are part of ESIA report.

National Environmental Quality Standards of Pakistan (NEQS)

Ambient Air Quality Standards of Pakistan

In order to meet the Ambient air quality standards and to keep margin for future expansions, the following stack limits are suggested to be met as part of the OWNER's requirement Please refer to Table 7.1.1. The same is the basis for ESIA study **Table 7.1-1 Emission requirements at Stack**

Item	Stack limits
SO_2	< 220 mg/Nm^3
NOx	< 400 mg/Nm^3
PM10	50 mg/Nm^3

7.2 Pollution prevention measures

7.2.1 Prevention measures for atmospheric pollution

The atmospheric pollutants produced in coal-fired power plant are mainly SO_2,NO_X and dust. As for dust, the dilution, diffusion and purification of atmosphere shall be utilized as practical as possible and proper prevention measures shall be taken so as to minimize pollution impact. It intends to take the following measures in the aspect of the prevention of flue gas and dust emission:

1) Prevention measures for dust

(a) Comparison of ESP and Fabric Filter

ESP have several advantages over fabric filter, including lower draft loss and lower maintenance cost, and they are not easily damaged by high temperature. The lower draft loss reduces the induced draft fan size and fan power consumption compared to fabric filter.

Major maintenance is not typically required as prior to ten years of service, and rebuilds are not required as prior to 20 to 30 year of service if routine maintenance is completed and proper unit operating conditions are maintained. While continuous maintenance and high operating cost in terms of power consumption is required in Fabric Filter.

(b) Technology Description:

CHINA POWER HUB GENERATION COMPANY

Prospectus

1. General

China Power HUBCO 2×660MW coal-fired power plant project is invested jointly by China Power International Limited and The Hub Power Company Limited with equity investment of 51% and 49% respectively. The design capacity is 1320 MW gross, with imported coal as the fuel. Coal jetty will be built for this project.

2. Environmental Control

The Project will incorporate state of the art, proven technological interventions including low NOx Burners, Sea Water Flue Gas Desulfurizer (FGD), Electrostatic Precipitators (ESP) and waste water treatment units to minimize and treat gaseous emissions and liquid effluents generated from plant processes to ensure compliance with NEQS.

2.1 Environmental Control Technologies

Treatment of Particulate Matter using Electrostatic Precipitator (ESP)

Emissions from proposed plant are 45.8 (mg/Nm^3) . The limit determined for the project is 50 (mg/Nm^3).

Description	Control Efficiency	Advantages
ESP is applicable to a variety of coal combustion sources and the negatively charged dry precipitator is most commonly used. The high-voltage fields apply large electrical charges to particles moving through the field. The charged particles move toward an oppositely charged collection surface, where they accumulate. The accumulated particles are than removed by scrapper and collected at ESP hopper.	>99 %	High collection efficiency of 99% or greater at relatively low energy consumption. Low pressure drop. Continuous operation with minimum maintenance. Relatively low operational costs. Operation capability at high temperature (up to 700 °C) and high pressure (up to 10 atm) Capability to handle relatively large gas flow rates. (up to 50,000 m^3/min)

Treatment of SO_2 using Wet Scrubber Technology of Sea Water Flue Gas Desulfurizers

Emissions from proposed plant are 208.93 (mg/Nm^3) . The limit determined for the project is 220 (mg/Nm^3).

Description	Control Efficiency	Advantages
Sea water Flue Gas Desulfurizer (FGD)	≥98%	Has the largest fuel flexibility, including all types of heavy fuel oils with up to 4.5% sulphur content.

Reduction in NOx levels using Low NOx burners

Emissions from the proposed plant are less than 400 (mg/Nm^3). The limit determined for this project is 400 (mg/Nm^3). Studies have shown that Tangential Low NOx Burners will meet the NOx emissions limit. Provision has been given in the flue gas duct for installation of Selective Catalytic Reduction (SCR) Unit in the future if required.

Control Technology	Description
Low NOx burners are designed to control fuel and air mixing at each burner in order to create larger and more branched flames. Peak flame temperature is thereby reduced, and results in less NOx formation The standard practice of modern Pulverized fuel boilers is to have both Low NO_x burners with Overfire air ports. This is by far the easiest solution, which also has one of the highest NO_x reduction rates. The proposed Project will also be using this arrangement to lower NO_x emissions to ensure compliance with NEQS Ambient Air Quality Requirements.	Low NOx burners

3. Power Plant

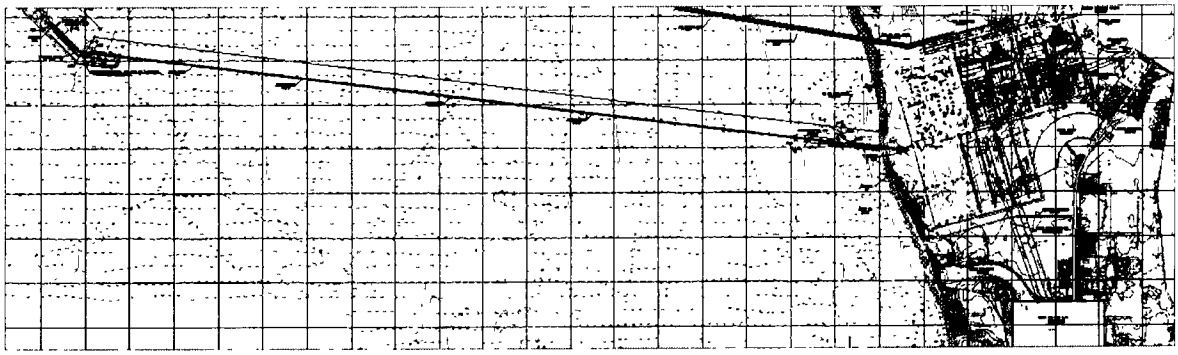
3.1 Overview

China Power Hubco 2×660MW coal-fired power plant project constructs 2×660MW supercritical pulverized coal-fired units and reserves extension conditions for 4×660MW units. power plant project is located southwest of Baluchistan Province, N 24º54' 9'' and E 66º41' 31''. It is

about 20km from the downtown area of Hub and is within Hubco's 1500-acre (600hm^2) power generation unit site and close to HUBCO Power Plant (Oil-fired units). This project adopts the site at northwest of HUBCO Power Plant, north of its intake open channel and west of 500kV outgoing line corridor. Land area within the plant enclosing wall is about 43.4hm^2. Only seawater intake channel is designed for 6 units to provide assistance in construction phase of future projects, however, all the other facilities are designed for 2 units.

3.2 **Plant Layout**

The main plant layout scheme shown below offers less land occupation, lower investment, smooth technical process flow and outgoing lines, short coal trestle, good construction conditions and almost no impact on existing oil fired units.



3.3 **Main Technical Indexes**

Annual power supply capacity	9052.2GW.h
Annual utilization hours:	7446h
Plant land occupation	43.3 hectare (not counting ash yard area)
Plant net efficiency (LHV)	>39%
Rate of auxiliary power	7.9%
Standard coal consumption of power generation	285.17g/kWh
Standard coal consumption of power supply	309.63g/kWh
Water consumption per GW	0.042m^3/s
Emission concentration	SO_2<220mg/Nm^3, NOx <350mg/Nm^3, and dust≤50mg/Nm^3

3.4 **Main Equipment**

Main equipment includes 2x660MW once-through supercritical, Pulverized Coal boilers with one reheat, supercritical parameter condensing turbines and three-phase AC generators, capable of

generating approximately 2x607 MW Net power output with the auxiliary load of 7.93% and efficiency of greater than 39% as per the requirement of Up-front Tariff. Project equipment and technology is being designed to meet the 85% availability requirement of PPA (Power Purchase Agreement).

3.5 **Fuel Specification**

Design coal for this project is South African RB-3 (5,500 kcal/kg NAR) and check coal is blend of 50% Indonesian NAR4700 and 50% South African RB-3.

The transportation of South African coal and Indonesian coal are both by sea to the power plant.

Light diesel oil is used for ignition and combustion of the boiler, and temporary fuel is transported by truck to the power plant. Coal specs are given in the table below

Country of origin		**South Africa**	**Indonesia**	**Indonesia + South Africa**
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Technical analysis	%			
Total moisture	ar	9.27	25.3	17.29
Internal moisture	ad	4.44	15.64	9.84
Ash content	ad	18.5	5.57	12.26
Ash content	ar	17.56	4.93	11.25
Volatile matter	ad	24.98	40.07	32.2
Sulfur	ad	1.09	0.82	0.96
Sulfur	ar	1.035	0.73	0.88
Fixed carbon	ad	52.08		

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Net calorific value	ar, kcal	5371	4712	4991
Gross calorific value	ar, kcal	5591	4918	5254
Gross calorific value	ad, kcal	5889	5554	5721
Grindability index		53	43	48
Element analysis	%			
Carbon	d	65.25	69.58	67.21
Hydrogen	d	3.81	5.17	4.42
Nitrogen	d	1.64	1.33	1.50
Sulfur	d	1.14	0.98	1.06
Oxygen	d	8.8	16.22	12.15
Ash analysis	%			
Silicon dioxide	db	53.39	41.65	50.82
Aluminum oxide	db	22.65	21.48	22.39
Iron oxide	db	6.56	13.96	8.18
Calcium oxide	db	6.92	6.93	6.92
Magnesium oxide	db	2.23	2.49	2.29

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Sodium oxide	db	0.19	0.68	0.30
Potassium oxide	db	0.66	1.38	0.82
Titanium oxide	db	1.06	0.98	1.04
Manganese oxide	db	0.50	0.09	0.41
Sulfur oxide	db	5.22	9.27	6.11
Phosphorous oxide	db	0.62	0.23	0.53
Ash fusion temperature	°C			
Deformation temperature	degc	1240	1110	1175
Softening temperature	degc	1270		
Hemispherical temperature	degc	1290		
Flow temperature	degc	1310		
Grain size	%			
<50		99.2	92.54	95.87

Coal Consumption

Item \ Unit capacity	Value	1×660MW		2×660MW	
		Design coal	Check coal	Design coal	Check coal
Hourly coal consumption	t/h	252.22	270.79	504.44	541.58
Daily coal consumption	t/d	6053.28	6498.99	12106.56	12997.98
Annual coal consumption	10^4t/a	187.80	201.63	375.61	403.26

3.6 Main Systems at the Plant

3.6.1 Coal Handling System

Coal Unloading

With consideration of the site coast natural conditions and impact of the 4 months monsoon period, the wharf part is considered based on 2 schemes.

Scheme I:

One 100,000DWT bulk carrier offshore coal jetty is planned to be constructed at the place about 5.4km away from the plant area coastline. The comprehensive downtime of jetty is 65d, and the continuous downtime is about 25d after protected by the breakwater. The jetty is provided with 2 ship unloaders of 1500t/h. The jetty is installed with one-way belt conveyer tentatively, with the belt width of 1800mm, rated output of 3600t/h, which supply coal for the power plant of 2×660MW units.

Scheme II:

One 10,000t barge offshore coal jetty is planned to be constructed. During the non-monsoon period,

the coal is transferred to barges at the open sea by an offshore lighterage station, and then transferred to the barge jetty for unloading. The comprehensive downtime of jetty is 85d, and the continuous downtime is about 45d after protected by the breakwater. The jetty is provided with 2 ship unloaders with output of 1250t/h. The jetty is installed with one-way belt conveyer, with the belt width of 1800mm, rated output of 3000t/h, which supply coal for the power plant 2×660MW units.

Coal Handling

Upfront Tariff's Philosophy of "coal on ground" is adopted to define the battery limits of plant and jetty. Stacker is considered as part of the jetty, whereas Re-claimer is under plant's scope.

For matching with the 2 jetty schemes, 2 schemes are also considered for the coal yard capacity, namely, the 60-day coal yard scheme (corresponding to the jetty scheme I Mother vessel jetty) and the 90-day coal yard scheme (corresponding to the jetty scheme II Barging jetty).

Scheme 1

One strip-shaped open air coal yard with bucket wheel machine will be provided in the power plant. The yard has total 3 coal stockpiles A, B, and C. Width of coal stockpiles A and C is 50m, width of coal stockpile B is 90m, the coal stockpile length is 455m, the coal stockpile height is 15m. The total coal storage capacity of the 3 coal stockpiles is 72.6×10^4t, meeting the coal demands of 60d of the power plant of 2 units (design coal). The coal yard is installed with 2 reentrant type cantilever bucket wheel stackers/reclaimers, with the cantilever length of 50m, the stacking output of 3600t/h, reclaiming output of 1000/h. The coal stacking capacity matches with the coal unloading system conveying capacity, and the coal reclaiming capacity matches with the coal handling system output. One belt conveyer with belt width of 1800mm, output of 3600t/h is arranged respectively at bottom of the bucket wheel machine.

Scheme II:

One strip-shaped open air coal yard with bucket wheel machine will be provided in the power plant. The coal yard has total 3 coal stockpiles A, B, and C. Width of coal stockpiles A and C is 50m, width of coal stockpile B is 90m, the coal stockpile length is 660m and the coal stockpile height is 15m. The total coal storage capacity of the 3 coal stockpiles is 109×10^4t, meeting the coal demands of 90d of the power plant of 2 units (design coal). The coal yard is installed with 2 reentrant type cantilever bucket wheel stackers/reclaimers, with the cantilever length of 50m, stacking output of 3000t/h, reclaiming output of 1000t/h, the coal stacking capacity matches with the conveying capacity of the coal unloading system, the coal reclaiming capacity matches with the output of the coal handing system. 1 belt conveyer with belt width of 1800mm and output of 3000t/h is provided respectively at bottom of the bucket wheel machine.

The coal yard of the two schemes is provided with 2 coal bulldozers, 2 loading machines, and 1 excavator for supporting operation. With consideration of environmental protection requirement

and the local windy environment, the coal yard is provided with wind dust network. Coal yard spray facilities are also provided. Drainage trenches shall be provided around the coal pile for water run-off.

The check coal is blended coal by two coals. As a result of high volatile matter and high moisture, it will cause large fire risk and coal block problem if the Indonesian NAR4700 is stored in silos. So the coal silos are not fit to be the coal blending facilities in this project. According to the characteristics and coal yard type of the power plant, it is fit to adopt the method of blending coal in the coal yard by stacker-reclaimers. Besides, because only the check coal shall be blend and it won't frequently happen, there is no need to install additional reclaimer in the coal yard. The two stacker-reclaimers shall be used to blend the coal. When the power plant needs to burn the check coal, the two coals shall be stored separate coal piles along the longitude direction of the coal yard. Both the two stacker-reclaimers will be used to blend the coal, one reclaiming coal from RB-3 at 50% capacity and another reclaiming coal from NAR4700 at 50% capacity. When the coal arrives coal bunkers, it has already been blended.

3.6.2 Ash Handling System

Fly Ash Handling System

Economizer and ESP ash hoppers adopt dry ash dense phase pneumatic conveying system to convey the fly ash to 2 ash silos.

The boilers in this project share 2 ash silos and 1 aeration fan room, another fly ash silo placed in reserve for future utilization. Ash silos will be capable of storing the volume of ash produced in 24h.

Two options for unloading and transporting the ash are available: Dry ash unloading (to sell the ash) and Wet ash transport to ash yard via trucks.

Bottom Ash Handling System

Dry Air-cooled mechanical slag removal equipment is adopted for bottom ash handling instead of wet slurry or Sub-merged Scrapper Conveyor system as it enables a higher efficiency of the boiler, is a less complex system and allows ease of maintenance.

High temperature slag is conveyed out by slag conveyer steel belt. Design output of the steel belt slag conveyer is not lower than 250% of the slag discharge capacity at B-MCR of design coal.

The air cooled Slag is discharged into the slag silo after being crushed. The effective volume of slag silo is 150m^3 with a storage capacity of 24h.

Slag inside the slag silo is loaded onto the truck through unloading device and transported outside for comprehensive utilization or transported to the ash yard after humidification.

3.6.3 Coal Pulverization and Combustion System

Coal Pulverization

Each boiler is provided with six medium speed coal mills. For both design and check coal at BMCR conditions, 1 mill will be on standby. Output of coal mill shall be considered based on 115% fuel coal consumption under BMCR.

Coal pulverization system of every boiler is provided with 2×100% centrifugal booster sealing air fans, 1 operating and 1 on standby.

Each Boiler is provided with 2×50% adjustable moving vane axial primary cooling fans.

Coal Combustion System

The Low NOx Burner is designed to efficiently burn pulverized coal that reduces emissions of nitric oxides. It makes use of air staging and fuel staging technology by virtue of its design.

Light diesel oil is used for ignition and combustion of the boiler, and will be transported by trucks to the power plant.

2×50% adjustable moving vane axial forced draft fans will be provided (Secondary air fans).

3.6.4 Thermal System

Boiler

Once through supercritical pulverized coal boiler, one reheat cycle, single furnace balanced draft, "П" type arrangement and all steel frame suspension structure are the salient features of the boilers in the project. Main technical parameters (BMCR Condition) are as follows:

Main Steam Temp/Pressure/Flow	571 °C / 25.4MPa / 2078t/h
Re-heater steam outlet temperature	568°C
Economizer FW inlet temperature	296.1°C

Exhaust flue gas temperature	110.7℃
Boiler fuel efficiency (ASME, PTC4, LHV)	93.3%
Boiler outlet NOx concentration	＜350mg/Nm³

Turbine

Supercritical, one reheat cycle, tandem compound, three-casing-four-flow, condensing turbine. The turbine has Three HP heater stages, four LP heater stage, and one deaeration stage. Main Technical Parameters as BMCR condition are as follows:

Generation power	689.3 MW
Main Steam pressure before MSV	24.2 MPa(a)
Main Steam temperature before MSV	566 ℃
HP cylinder exhaust pressure (CRH)	5.754 MPa(a)
HP cylinder exhaust temperature	348.2℃
Cooling water temperature	27.9 ℃
Exhaust backpressure	6.4 KPa(a)

3.6.5 Electrical System

The power plant will be connected into the power grid with 500kV voltage class. Each generator of this project is connected to the 500kV switchyard through a Generator Step-up Transformer (GST) as a generator-transformer unit. Two transmission lines, approx.220km long, connected to Matiari Switching/Convertor Station, will be considered. The specific connection mode will be finally determined by National Transmission and Despatch Co. Ltd. (NTDC).

Generator: under rated power factor and rated hydrogen pressure condition, rated power of generator matches output under rated condition of turbine. Maximum continuous output power of generator matches with maximum continuous output of turbine. Main technical parameters of the Generator are as follows:

Rated Capacity	776.47 MVA
Rated Power	660 MW
Rated Voltage	20~26 kV
Rated Power Factor	0.85 (lag)
Rated Speed	3000 r/min
Rated Frequency	50 Hz
Cooling Type	Water-Hydrogen-Hydrogen

Generator Circuit Breaker is not considered for the time being. 500 kV switchgear is based on 3/2 connection.

The two levels of auxiliary voltage are 10 kV and 400 V.

3.6.6 Instrumentation and Control System

Each unit is provided with a set of DCS system. DCS controls the following systems

- Boiler proper and auxiliary systems
- Boiler proper and auxiliary systems
- Turbine proper and auxiliary systems
- Generator proper and auxiliary system
- Chemical sampling
- Condensate polishing etc

Each unit is monitored by 1 on-duty operator through operator station, with 1~2 assistants to complete the startup and shutdown operation, monitoring of normal operation and emergency handling of the unit.

3.6.7 Cooling Water System

The process of cooling water system is described as:

Cooling water intake from Sea cooling water intake open channel → land cooling water intake open channel → cooling water pump house forebay → cooling water pump house → condenser→siphon well → desulfurization aeration basin → discharge culvert

Cooling water is taken from Arabian Sea by an intake open channel designed for 6x660 MW units. Each unit will have 3x33.33% cooling water pumps to meet the requirements of BMCR condition and heated cooling water will be discharged into the sea by two box culverts northwest of the plant site.

3.6.8 Sea Water Desalination and Condensate Polishing Systems

Sea Water Desalination system

The main process flow of sea water desalination system is as follows:

Seawater feedwater pump →reaction and sedimentation tank →clear seawater tank →seawater UF feedwater pump →seawater UF cartridge filter →seawater UF equipment →seawater UF water

tank→ SWRO feedwater pump → SWRO cartridge filter→ SWRO high pressure pump → SWRO equipment (with energy recovery device) →SWRO water tank →BWRO feedwater pump →BWRO cartridge filter →BWRO high pressure pump →SWRO equipment →pre-demineralized water tank →each consumer

Condensate Polishing System

Full flow medium pressure condensate polishing system shall be provided for this project, adopting "prefilter + mixed bed" process scheme and external regeneration mixed bed mode. Condensate polishing system is mainly configured with the following equipment:

2×50% prefilter for each unit, without standby; 3×50% high speed mixed bed for each unit, 2 on operation, and 1 on standby.

Two units share one set mixed bed external regeneration equipment and one set prefilter backwash equipment.

3.6.9 Flue Gas System

Duct work for SCR provision, Air pre-heaters, ESPs, ID fans, FGD and Chimney (Stack) are considered under Flue Gas System

SCR is used to reduce NOx limits by a catalytic reaction. If the NOx limits change to more stringent values than 400 mg/Nm^3, duct work along with physical space will be reserved to cater for the future possibility of installing the SCR.

Common and widely used technology of tri-sector rotary regenerative air pre-heaters will be used in the system.

Two pass and five field ESPs with the efficiencies of 99.775% will meet the limits of 50 mg/Nm^3 in Stack.

Each boiler will be equipped with 2×50% adjustable movable vane axial induced draft fans.

After evaluation in the FSR, seawater FGD technology comes out to be the suitable option for this project. SO_2 emission will meet NEQS requirement based on both design and check coal conditions at a range of sulphur and seawater quality etc.

Two boilers share one 210.0m high sleeved double-cylinder stack with outlet diameter of 2×Φ6.4m (preliminary).

4. JETTY

The coal used for HUB II 2×660MW coal fired power plant will be supplied from South Africa or Indonesia. The total coal requirement is 4.185 million tons per year. The company has decided to make a dedicated coal import jetty for this project.

As per the requirements of NEPRA in Upfront Tariff dated 26th June 2014, all possible options were examined to optimize coal import. Table given below summarizes the analysis:

No.	Coal unloading	Vessel	Transportation mode	Advantage	Disadvantage	Feasibility analysis
1	Existing port-KPT	55,000 DWT	Truck	1) The KPT is an existing port can supply for this project immediately 2) The prime investment is lower 3) The coal can be supplied in all seasons	1) From KPT to coal yard if use 50t truck for the transporting there will be about 220 trucks every day This will serious influence to KPT further more the coal transport road is nearly 55km and about 10km is in the city the traffic jam is very normal in the city so the truck argument will be very difficult 2) As too far transport line the cost and supply risk will high either 3) The unloading fee at KPT is higher 4) The coal supply will be restricted by KPT 5) The freight of vessel is higher	Unfeasibility
2	Existing port-KPT	55,000 DWT	Train	1) The railway is special for the power plant the influence to local traffic is low 2) the transport fee from KPT to HUB is lower than using truck 3) The coal can be supplied in all seasons	1) There is no existing railway to link the KPT and HUB 2) Build a railway to link the KPT and HUB the project cost is high 3) this need a long construct period 4) all the land for the railway need to buy from other company or citizen this will be very difficult 5) the unloading fee at KPT is higher 6) The coal supply will be restricted by KPT 7) The freight of vessel is higher	Unfeasibility
3	Existing port-KPT	55,000 DWT	Barge	1) The KPT is an existing port can supply for this project immediately 2) The prime	1) A barge jetty shall be build at HUB 2) The risk of barge transport from KPT to HUB in	Unfeasibility

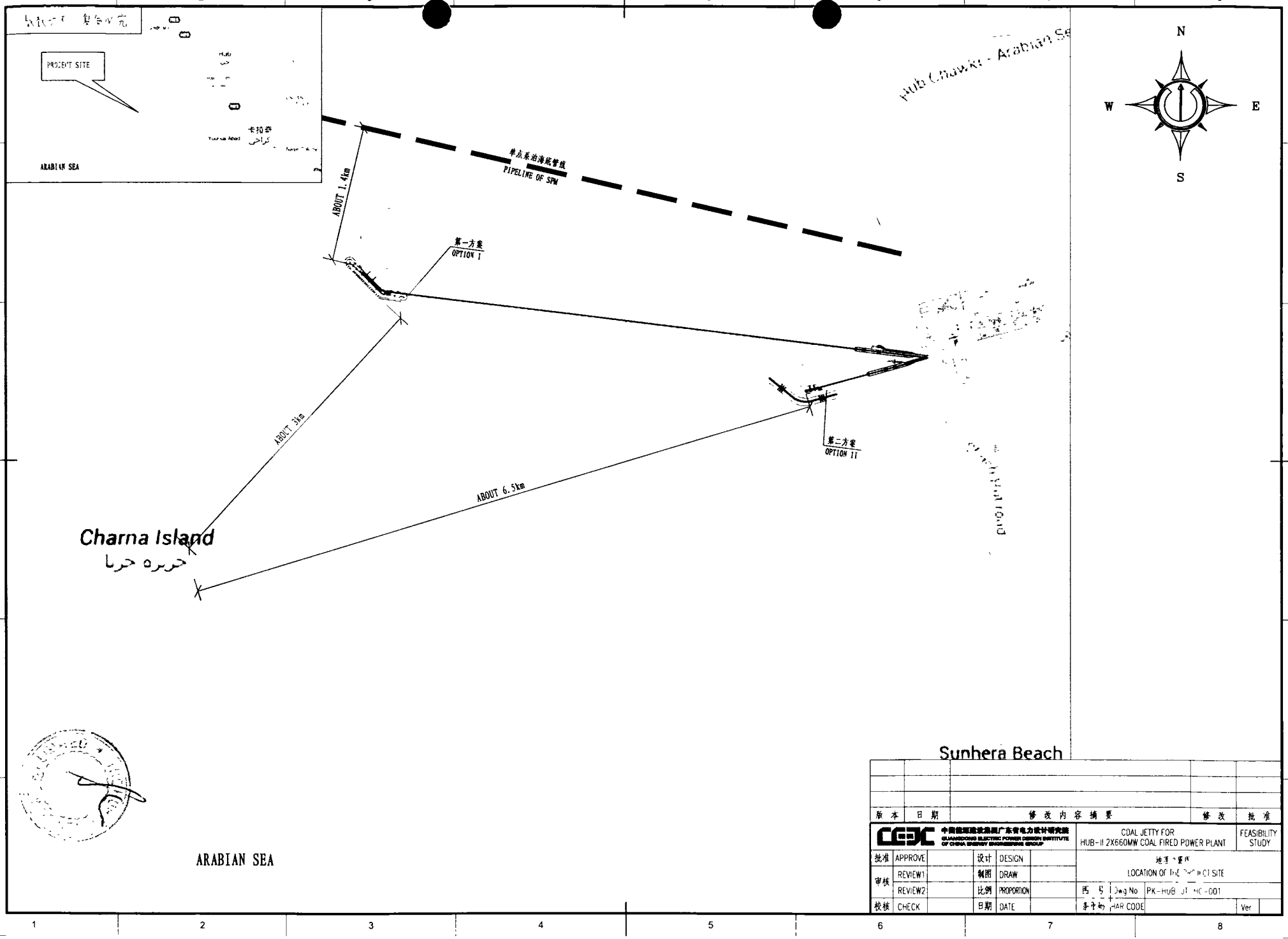
No.	Coal unloading	Vessel	Transportation mode	Advantage	Disadvantage	Feasibility analysis
				investment is lower 3) the coal transport from KPT to HUB by barge no influence to coal traffic	monsoon season is higher 3) The unloading and loading fee at KPT is higher 4) The coal supply will be restricted by KPT 5) The freight of vessel is higher	
4	Existing port-PQA	55,000 DWT	Truck	1) The PQA is an existing port can supply for this project immediately 2) The prime investment is lower 3) The coal can be supplied in all seasons	1) From PQA to coal yard if use 50t truck for the transporting there will be about 220 trucks every day This will serious influence to PQA further more the coal transport road is nearly 115km the truck argument will be very difficult 2) As too far transport line, the cost and supply risk will high either 3) The unloading fee at PQA is higher 4) The coal supply will be restricted by PQA 5) The freight of vessel is higher	Unfeasibility
5	Existing port-PQA	55,000 DWT	Train	1) The railway is special for the power plant the influence to local traffic is low 2) the transport fee is lower than transport by using truck 3) The coal can be supplied in all seasons	1) There is no existing railway to link the PQA and HUB 2) Build a railway to link the PQA and HUB the project cost is high 3) this need a long construct period 4) all the land for the railway need to buy from other company or citizen this will be very difficult 5) the unloading fee at PQA is higher 6) The coal supply will be restricted by PQA	Unfeasibility
6	Existing	55,000	Barge	1) The KPT is an existing port, can supply for	1) A barge jetty shall be build at HUB 2) The	Unfeasibility

No.	Coal unloading	Vessel	Transportation mode	Advantage	Disadvantage	Feasibility analysis
	port-PQA	DWT		this project immediately 2) The prime investment is lower 3) the coal transport from PQA to HUB by barge no influence to local traffic	risk of barge transport coal from PQA to HUB in monsoon season is higher, 3) The unloading and loading fee at PQA is higher, 4) The coal supply will be restricted by PQA, 5) The freight of vessel is higher.	
7	Existing port-PIBT	55,000 DWT	Truck, train or barge	Same as use PQA	1) Same as use PQA 2) PIBT is not operation until now and the company operation data for PIBT is not explicit.	Unfeasibility
8	New built mother ship unloading jetty	100,000 DWT	Belt conveyor	1) the coal will be unload by mother ship unloading jetty than transport to coal yard by belt conveyor the coal unloading system is simple 2) the operation cost is low in operation period, 3) all the coal supply section will be control by the power plant 4) in the further when another two units power plant is be constructed the mother ship unloading jetty only need to remake the equipment, than it will meet the requirement of the new power plant 5) the coal supply risk is low	1) The initial investment is high, 2) the construct period is long and construct technical is complex, 3) in monsoon season the coal supply by jetty will be shut down a few time	Feasibility
9	New built Offshore ligterage	100,000 DWT	10,000t barge and belt conveyor	1) The initial investment is lower than built the a mother ship unloading jetty 2) the construct period is short and construct technical is sample 3)	1) the 100,000DWT bulk carrier will berth directly at the newly-built OLS through which the coal is transported to 10,000t barge, than	Feasibility

No.	Coal unloading	Vessel	Transportation mode	Advantage	Disadvantage	Feasibility analysis
	station and barge unloading jetty				if unloaded at barge jetty the coal unloading system is complex 2) too many coal transport steeps means too many operation risk and operation cost 3) in monsoon season the coal supply by jetty will be shut down a long time 4) in monsoon season the OLS shall be shut down and then the coal transport vessel shall be replaced by 50,000DWT bulk carrier and used KPT for lighterage, 5) the coal supply risk is high especially in monsoon season	

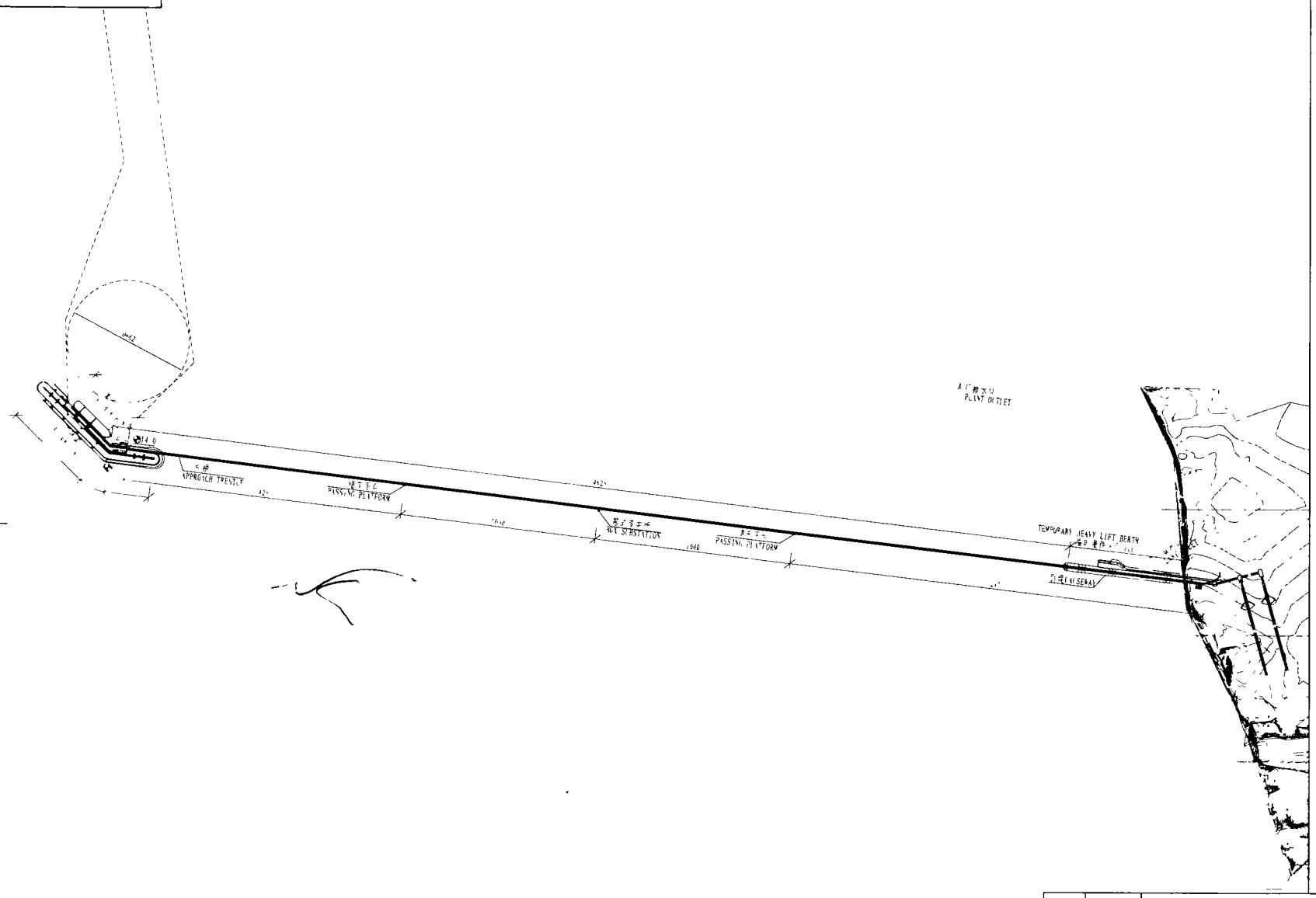
The two options found technically feasible were examined in detail, and it was found that Barge Jetty option (Option II) though technically feasible is not bankable because of outage time besides higher probabilities of accidents during monsoon operations. Therefore, Mother Vessel Jetty protected with a breakwater has been finalized as the most optimized solution. Layout of the jetty is also attached herewith.

The layout and length of trestle (versus length of dredging) is subject to finalization after completion of navigation study. The tariff of jetty shall be sought from NEPRA on cost plus principle as allowed under Upfront Tariff dated 26th June 2014.



版本	日期	修改内容摘要	修改	批准

CEDI 中国能源建设集团广东省电力设计研究院 GUANGDONG ELECTRIC POWER DESIGN INSTITUTE OF CHINA ENERGY ENGINEERING GROUP					CDAL JETTY FOR HUB-II 2X660MW COAL FIRED POWER PLANT		FEASIBILITY STUDY
批准	APPROVE		设计	DESIGN			
审核	REVIEW1		制图	DRAW	LOCATION OF THE PROJECT SITE		
	REVIEW2		比例	PROPORTION	图号	Dwg No	PK-HUB JT-HC-001
校核	CHECK		日期	DATE	条形码	BAR CODE	Ver



NOTES
1 ALL DIMENS ONS ARE IN METERS
2 ALL ELEVAT ONS ARE Mas-T ON C)

版本	日期	修改内容摘要	修改	批准

CEDC 中国能源建设集团广东省电力设计研究院 GUANGDONG ELECTRIC POWER DESIGN INSTITUTE OF CHINA ENERGY ENGINEERING GROUP						COAL JETTY FOR HUB-II 2X660MW COAL FIRED POWER PLANT		FEASIBILITY STUDY
批准	APPROVE		设计	DESIGN		OVERALL LAYOUT OF THE JETTY (OPTION I)		
审核	REVIEW1		制图	DRAW				
	REVIEW2		比例	PROPORTION	AS SHOWN	图号	Dwg.No	PK-HUB-JT-GL-001
校核	CHECK		日	DATE	2015.07	条形码	BAR CODE	Ver

SCHEDULE III

Annexure 'P'

Project Details for 2x660

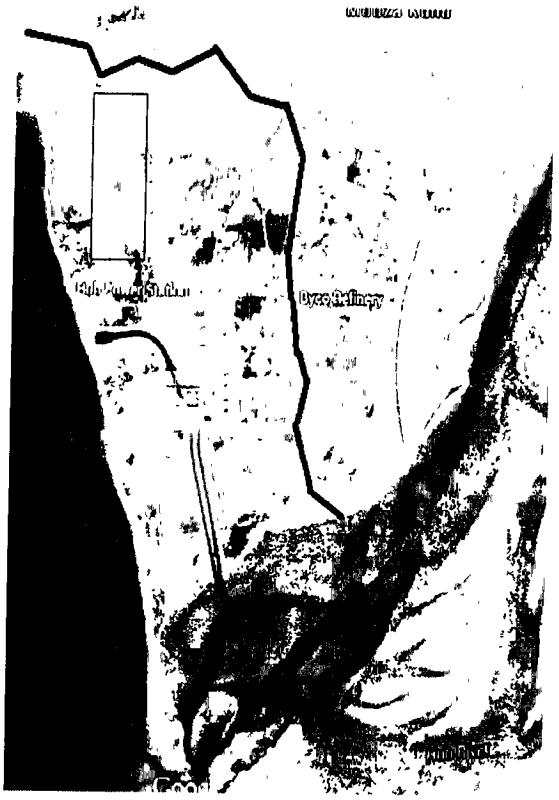
CHINA POWER HUB GENERATION COMPANY

Table of Contents

1 Location

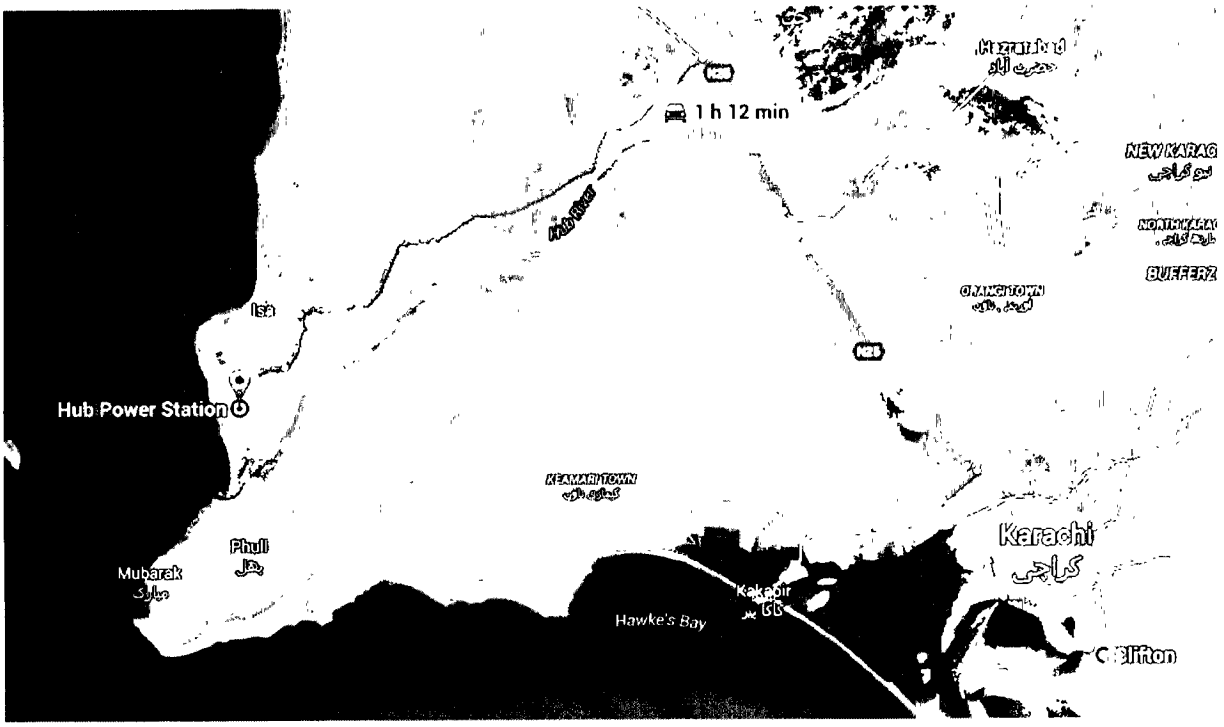
1.1 2x660 MW plant of China Power Hub Generation company will be located southwest of Baluchistan Province, N 24º54'9'' and E 66º41'31''. It is about 20km from the downtown area of Hub and is within Hubco's 1500-acre (600hm^2) power generation unit site and close to HUBCO Power Plant (Oil-fired units)

1.2 The site map with the boundary highlighted is given below:



The area bounded by the rectangle is the proposed site for the 2x660 plant.

1.3 The distance from Karachi can be seen in the following map:



2 Technology

2.1 CPHGC will install two units of six hundred and sixty megawatts each. The Plant will be of super critical technology and will use pulverized coal as fuel.

3 Fuel

3.1 Design coal for this project will be South African RB-3 and check coal will be blend of 50% Indonesian NAR4700 and 50% South African RB-3. Trafigura will be the coal supplier. The coal will be transported through Marine Shipment.

3.2 Coal quality data:

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Technical analysis	%			
Total moisture	ar	9.27	25.3	17.29
Internal moisture	ad	4.44	15.64	9.84
Ash content	ad	18.5	5.57	12.26
Ash content	ar	17.56	4.93	11.25
Volatile matter	ad	24.98	40.07	32.2
Sulfur	ad	1.09	0.82	0.96
Sulfur	ar	1.035	0.73	0.88
Fixed carbon	ad	52.08		
Net calorific value	ar, kcal	5371	4712	4991
Gross calorific value	ar, kcal	5591	4918	5254
Gross calorific value	ad, kcal	5889	5554	5721
Grindability index		53	43	48
Element analysis	%			
Carbon	d	65.25	69.58	67.21
Hydrogen	d	3.81	5.17	4.42

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Nitrogen	d	1.64	1.33	1.50
Sulfur	d	1.14	0.98	1.06
Oxygen	d	8.8	16.22	12.15
Ash analysis	%			
Silicon dioxide	db	53.39	41.65	50.82
Aluminum oxide	db	22.65	21.48	22.39
Iron oxide	db	6.56	13.96	8.18
Calcium oxide	db	6.92	6.93	6.92
Magnesium oxide	db	2.23	2.49	2.29
Sodium oxide	db	0.19	0.68	0.30
Potassium oxide	db	0.66	1.38	0.82
Titanium oxide	db	1.06	0.98	1.04
Manganese oxide	db	0.50	0.09	0.41
Sulfur oxide	db	5.22	9.27	6.11
Phosphorous oxide	db	0.62	0.23	0.53
Ash fusion temperature	°C			

Country of origin		South Africa	Indonesia	Indonesia + South Africa
Index	Unit	Design coal (RB3)	NAR4700	Check coal (50% NAR4700 + 50% RB3)
Deformation temperature	degc	1240	1110	1175
Softening temperature	degc	1270		
Hemispherical temperature	degc	1290		
Flow temperature	degc	1310		
Grain size	%			
<50		99.2	92.54	95.87

4 Emission Values

4.1 Liquid Effluent Standards-NEQS:

The units are in **mg/L** or otherwise mentioned.

Parameter	Limits for Discharge to Sea
Temperature Increase	=< 3°C
pH value	6-9
Biochemical Oxygen Demand (BOD) 5 at 20°C (1)	80**
Chemical Oxygen Demand (COD)(')	400
Total suspended solids (TSS)	200
Total dissolved solids (TDS)	3500

Grease and oil	10
Phenolic compounds (as phenol)	0.3
Chloride(as Cl-)	SC***
Fluoride (as F-)	10
Cyanide (as CN') total	1.0
An-ionic detergents (as MBAS) . (2)	20
Sulphate (SO4 -2)	SC***
Sulphide (S -2)	1.0
Ammonia (NH3)	40
Pesticides(□)	0.15
Cadmium(4)	0.1
Chromium (trivalent and hexavalent) (4)	1.0
Copper (4)	1.0
Lead (4)	0.5
Mercury(4)	0.01
Selenium(4)	0.5
Nickel(4)	1.0
Silver(4)	1.0
Total Toxic metals	2.0
Zinc	5.0
Arsenic(4)	1.0
Barium(4)	1.5
Iron	8.0
Manganese	1.5
Boron(4)	6.0
Chlorine	1.0

4.2 Gaseous Emissions Standards:

Parameter	Limit for Stack Emissions-IFC	Requirement for Ambient Air Quality-NEQS
SOx	< 220 mg/Nm3	80 ug/m3 (Annual) as SO2 120 ug/m3 (24 hrs) as SO2
NOx	< 400 mg/Nm3	40 ug/m3 (Annual) as NO or NO2 40 ug/m3 (24 hrs) as NO and 80 ug/m3 (24 hrs) as NO2
SPM		360ug/m3(Annual Average*) 500ug/m3(24 hours**)
PM10	50 mg/Nm3	120ug/m3(Annual Average*) 150ug/m3(24 hours**)
PM2.5		15ug/m3(Annual Average*) 35ug/m3(24 hours**) 15ug/m3(1 hour)
Hydrogen Chloride	400 mg/Nm3	
Chlorine	150 mg/Nm3	
Hydrogen Flouride	150 mg/Nm3	
Hydrogen sulphide	10 mg/Nm3	
Carbon Monoxide	800 mg/Nm3	5 mg/m3(8 hours**) 10 mg/m3(1 hour)
Lead	50 mg/Nm3	
Mercury	10 mg/Nm3	
Cadmium	20 mg/Nm3	
Arsenic	20 mg/Nm3	
Copper	50 mg/Nm3	
Antimony	20 mg/Nm3	

Zinc	200 mg/Nm3	
O_3		130 ug/m3(1 hour)
Lead Pb		1 ug/m3(Annual Average*) 1.5 ug/m3 (24 hours**)
Smoke	< 40 % or < 2 Ringlemann or equivalent smoke number	

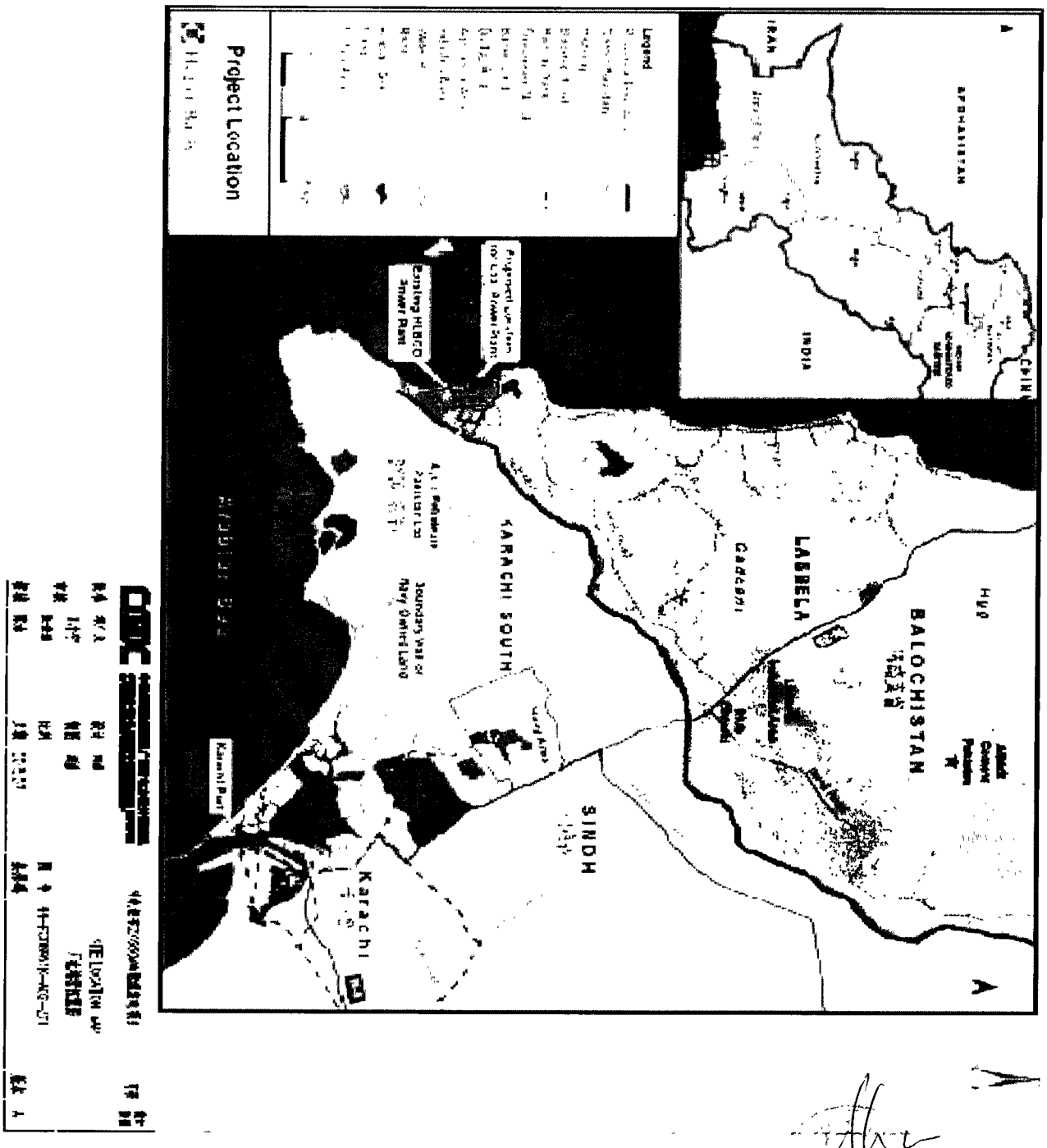
5 Cooling Water Source

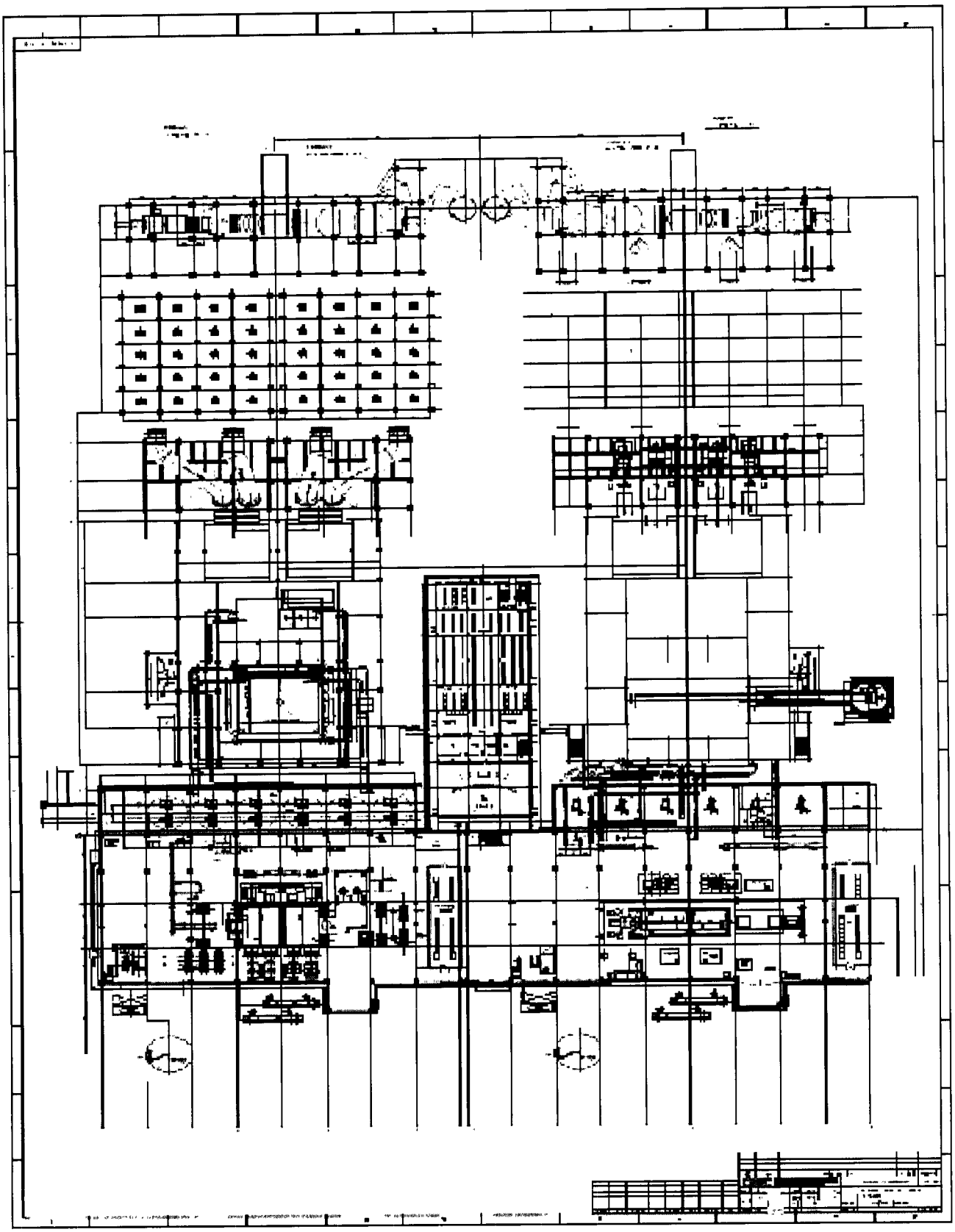
5.1 The plant is in the southwest of Hub City in Baluchistan Province, with the Arabian sea at its west. The expended unit once through cooling water system is used for the 2×660MW units in this phase of the project. The cooling water is taken from Arabian Sea by a sea cooling water intake open channel, which is located next to the heavy cargo berth, around 500m to the west of the plant site.

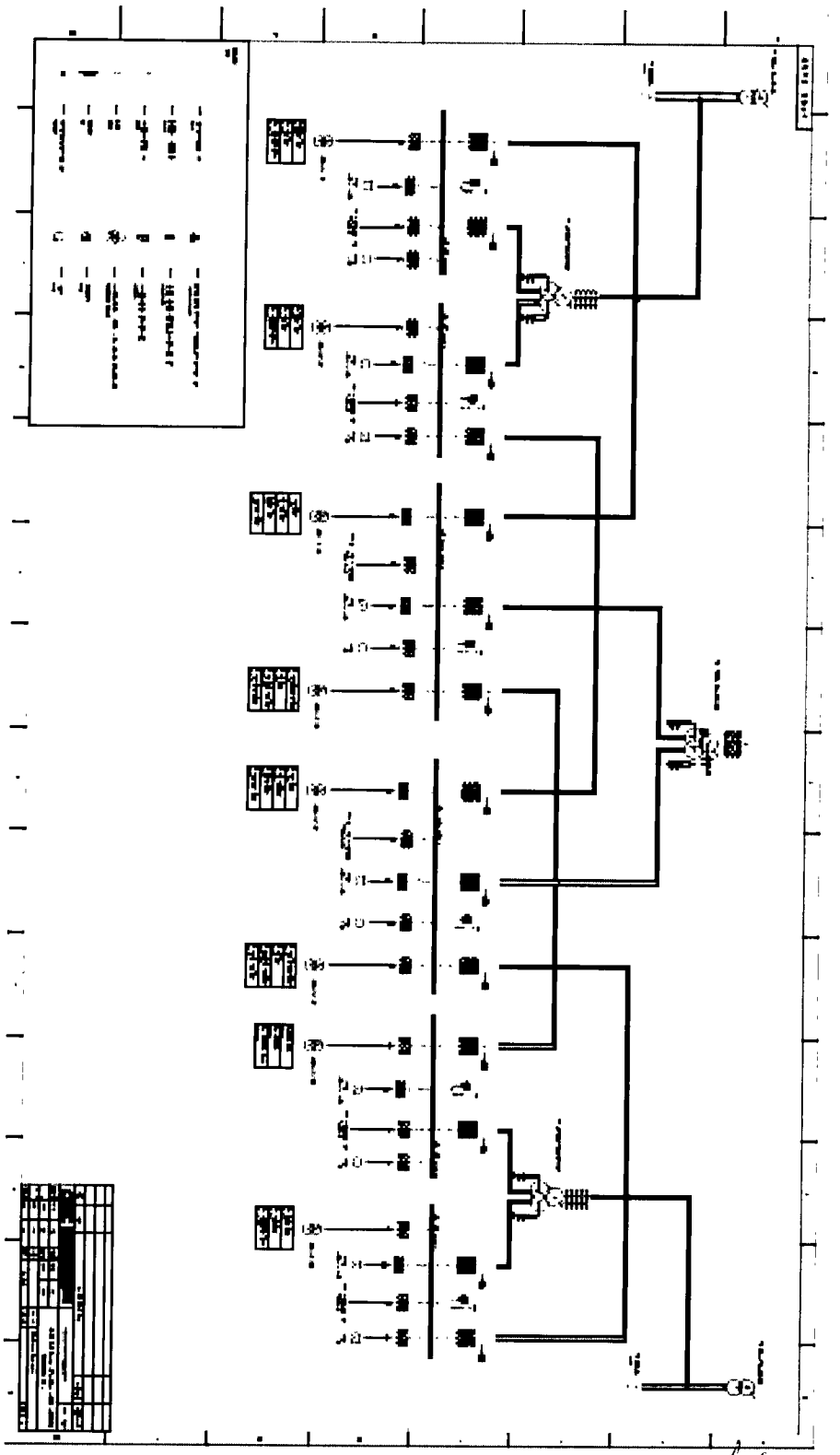
5.2 The cooling water process can be summarized as follows:

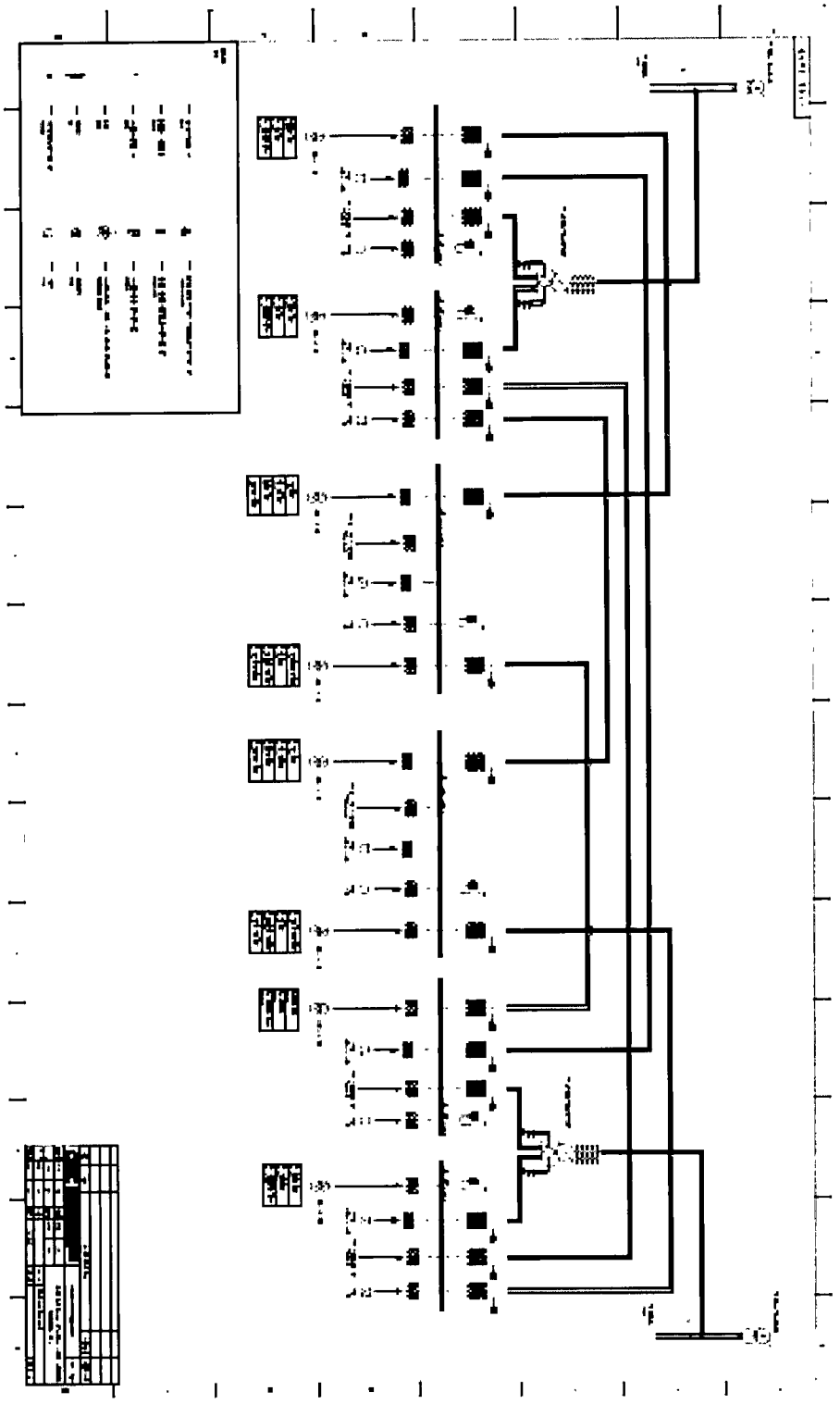
Cooling water intake from Sea cooling water intake open channel → land cooling water intake open channel → cooling water pump house forebay → cooling water pump house → condenser→siphon well → desulfurization aeration basin → discharge culvert

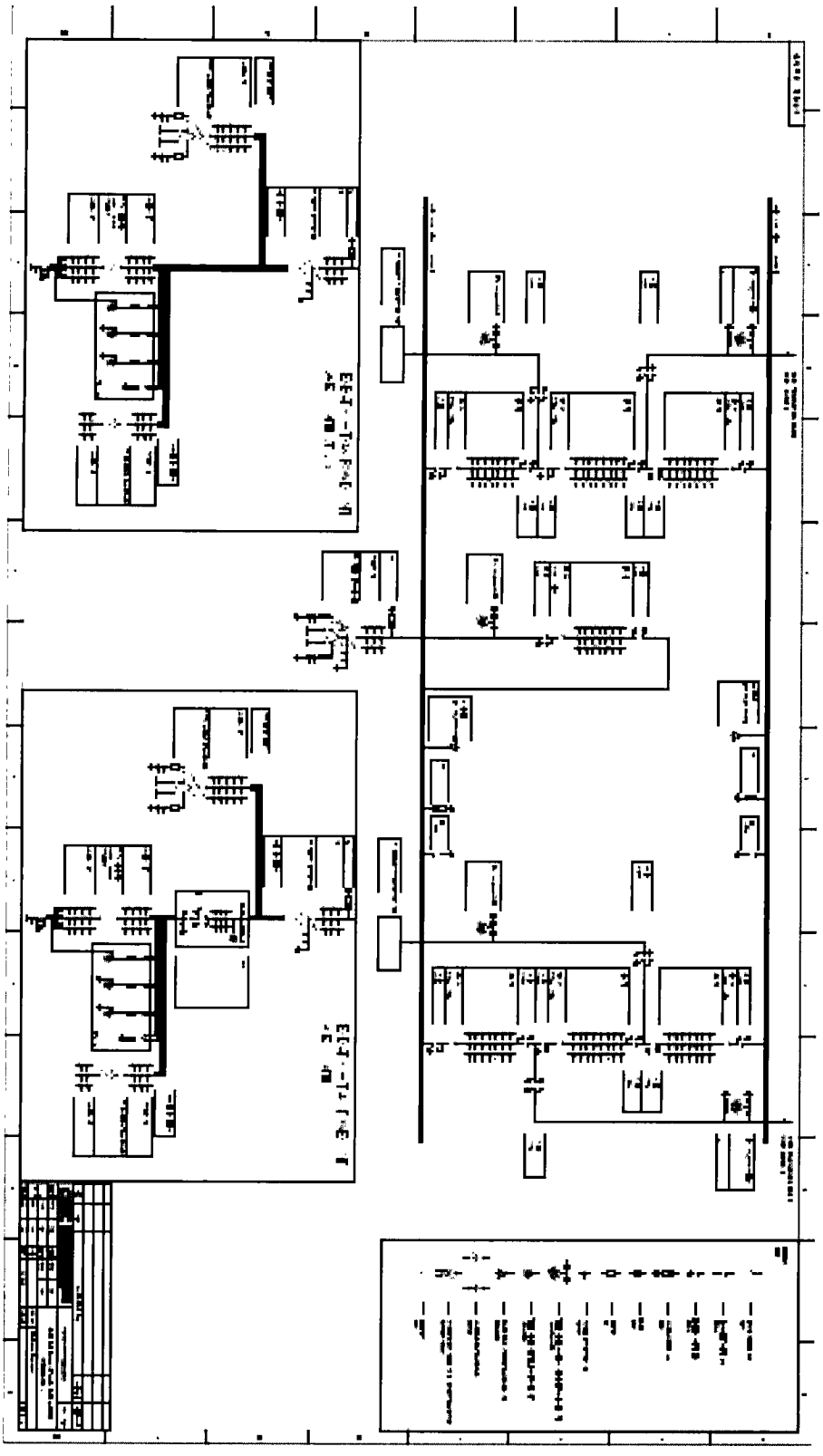
6 Interconnection with National Grid Company

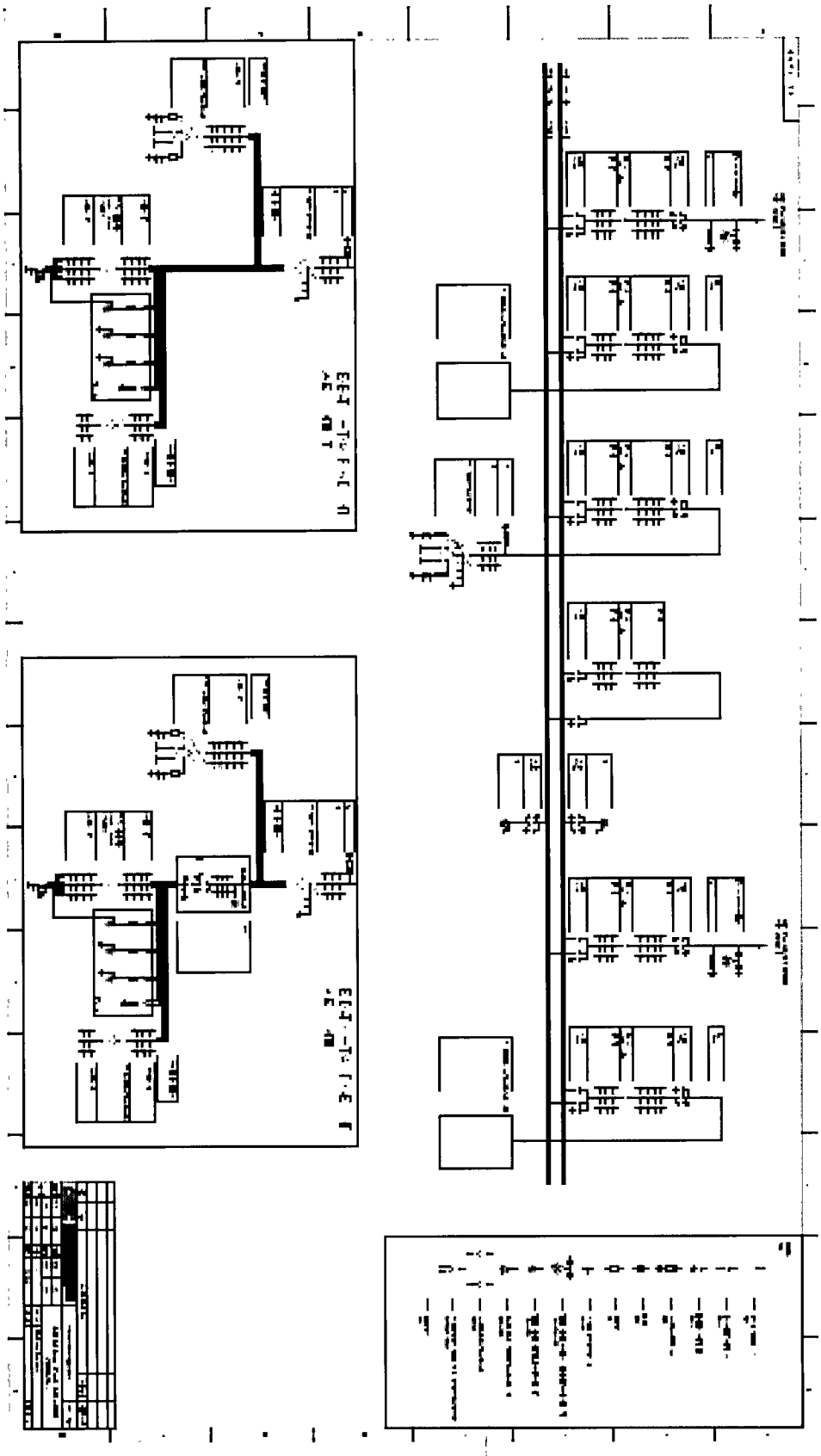












6.1 Proposed scheme for year 2017-2018

6.1.1 A 500 kV Double Circuit (D/C) transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO Coal Fired Power Plant to the already planned Matiari Switching/Convertor Station

6.1.2 A ±600kV HVDC Bipole of 910 km from Matiari Switching/Convertor station to Lahore HVDC switching convertor station

6.2 Proposed scheme for year 2021-2022

6.2.1 A 500kV Transmission line from K-2/K-3 2x1100 MW power projects to HUBCO Coal Fired Power Plant via in-out configuration to Port Qasim Convertor station

6.2.2 A ±600kV HVDC Bipole of 1100 km from Port Qasim convertor station to Faislabad West Convertor Station.

Figure # 1: **NTDC Network Diagram with Proposed Interconnection Scheme for 2x660 MW HUBCO CFPP**

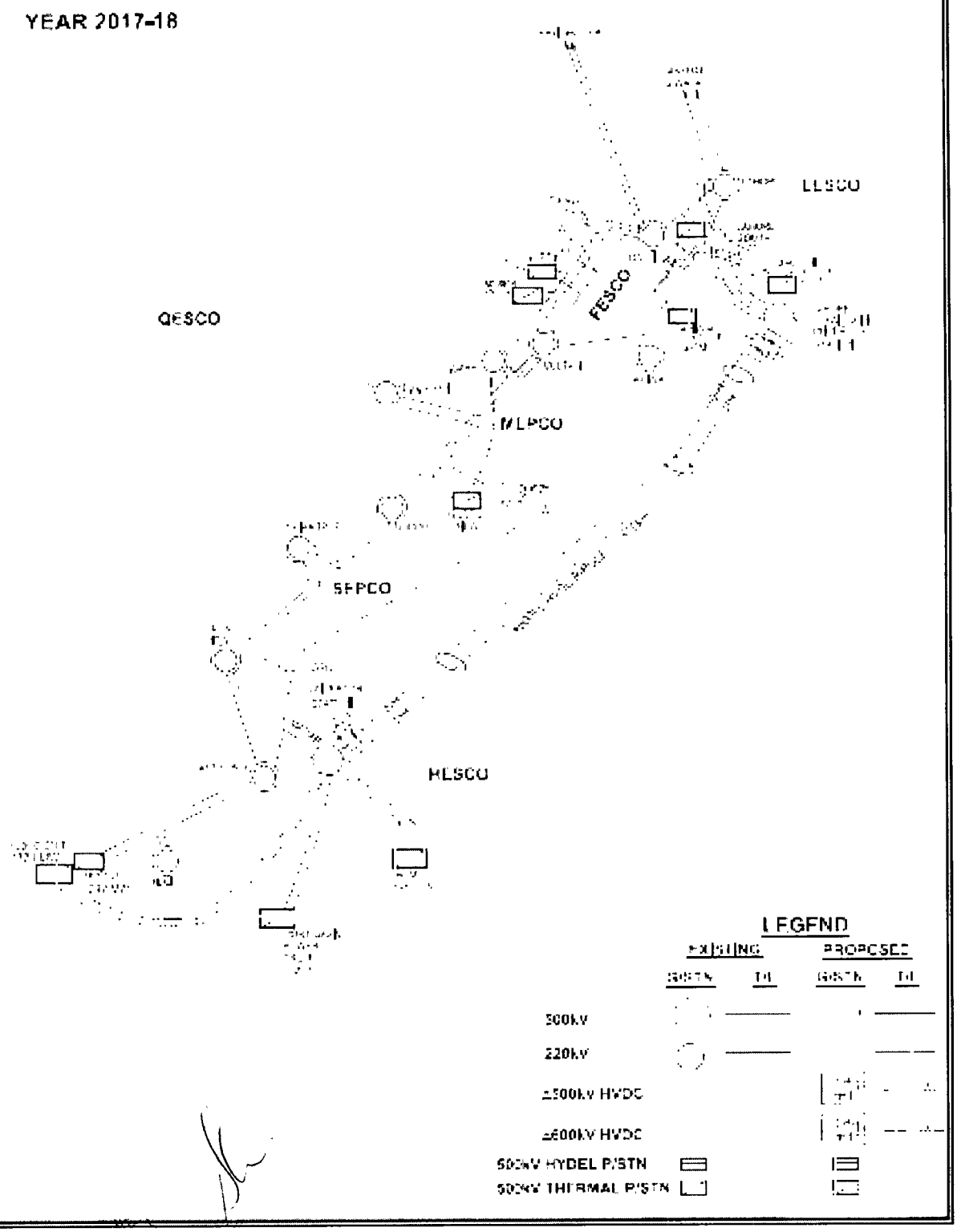
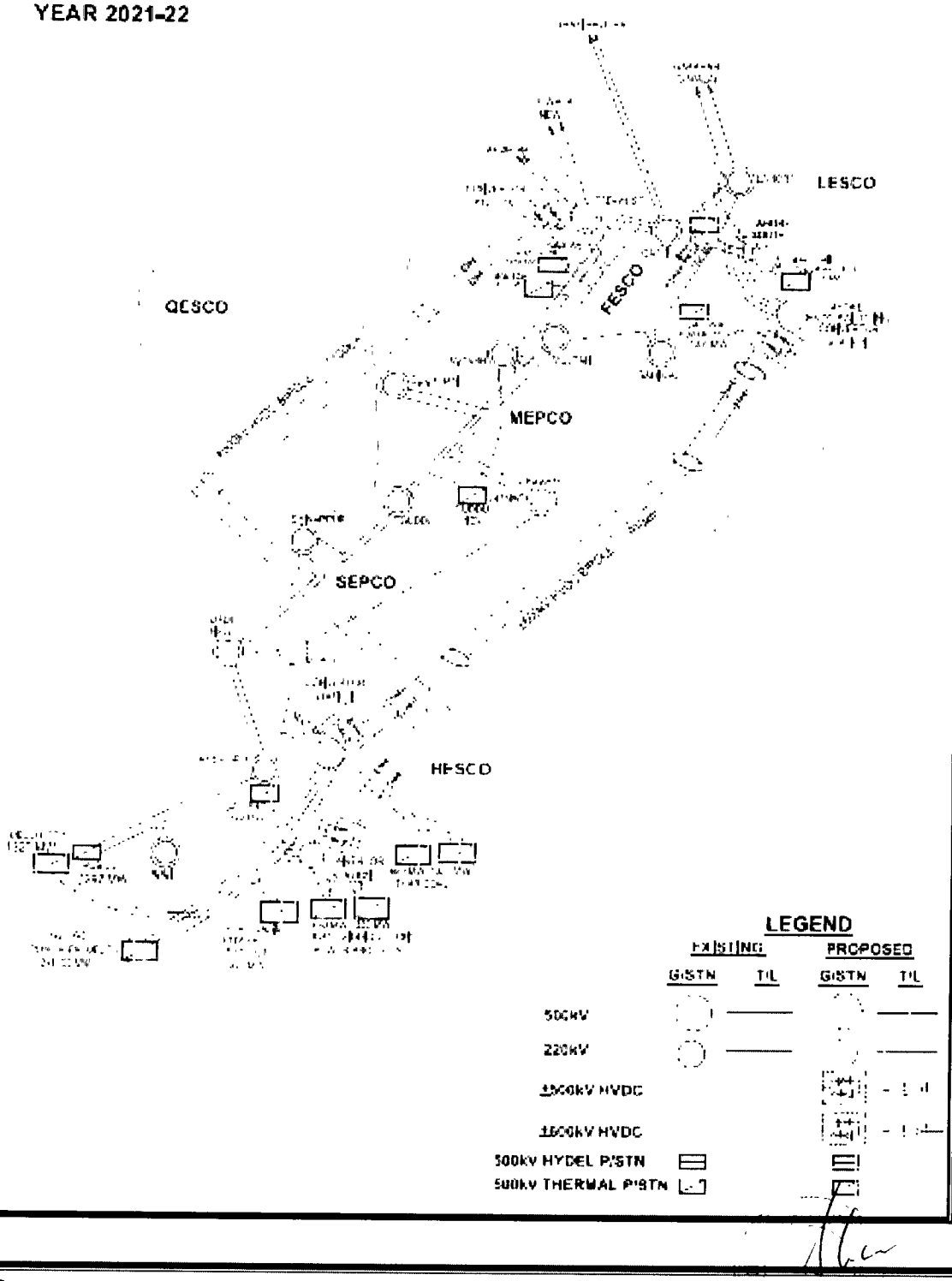


Figure # 2: **NTDC Network Diagram with Proposed Interconnection Scheme for 2x660 MW HUBCO CFPP**

YEAR 2021-22



7 Infrastructure

7.1 The plant site is adjacent to Karachi, a city with a well-developed network of roads. Karachi airport is located 45 km from plant site, and Karachi port is 30 km away. The plant can be accessed from Karachi by taking the No. 25 national highway shifting to HUB chawki-Arabian sea Rd in HUB Town and then the access road of the plant. A south-north road has been built on the plant site to allow for access to HUBCO Power Plant. Roads in the HUB plant site area are under quite good conditions, and they are two-lane city roads with asphalt pavement. Access road for the 2×660MW units in this phase can be connected to the access road of the existing HUBCO Power Plant.

7.2 Lodging facilities for the staff that will be mobilized will be built so as to accommodate the employees during construction phase. Food and other necessary amenities will be catered for.

8 Project Cost

8.1 The Total Project Cost is USD 1,800 Million.

8.2 The Total Equity is USD 450 Million. CPIH's share is USD 230 Million and HUBCO's share is USD 220 Million.

8.3 The Total Debt is USD 1,350 Million which will be raised through Chinese Lending Consortium.

9 Project Commencement and completion schedule with milestones

9.1 Refer to Annexure S

10 ESSA

10.1 Refer to Annexure T

11 Safety Plans, Emergency Plans

11.1 JV Company Safety Plan

11.1.1 Health and Safety Standards and Related Requirements

Contractor must ensure that Health and Safety requirements are met during all phases of the project and is to be considered as of critical importance. For this the contractor has to meet all the OSHA standard requirements mentioned in 29 CFR

1910. The following two sets of standards are of primary importance, but not limited to, and are to be met with special commitment and focus

1) 1910.119 Process Safety Management of Highly Hazardous Chemicals.
2) 1910.269 Electric Power Generation, Transmission, and Distribution.

Other OSHA standards listed in 29 CFR 1910 are to be met where applicable. The following table summarizes the various safety elements which OWNER consider to be fulfilled and managed during various phases of the project.

Element	**Phase Of Implementation**
Process Safety Information	Engineering, Procurement, Construction and Commissioning
Process Hazard Analysis	Conceptual Stage, On completion of basic engineering, On completion of design engineering followed by post Construction
Operating Procedures and Practices	Engineering, Construction and Pre-Commissioning
Employee Training	Construction and Pre-Commissioning
Contractors Safety	Construction
Pre-Startup Safety Review	Pre-Commissioning
Mechanical Integrity	Procurement, Construction, Pre-commissioning
Quality Assurance	Engineering, Procurement and Construction
Hot Work Permit, Confined space etc	Construction
Management of Change	Engineering and Construction
Incident Investigation	Construction
Emergency Planning and Response	Construction
Compliance Audits	Construction
Safety Personnel	Construction
Effective Communication	Construction

In addition a comprehensive Safety Integrity Level (SIL) analysis shall be carried out by the contractor and all recommendations shall be incorporated in the design.

Hazard area classification shall also be done and all relevant design shall conform this classification.

In addition a Safety Critical Top Level Document will be developed to identify Safety Critical equipment at site in order to meet requirements of Quality assurance and Mechanical Integrity elements during procurement, construction and future maintenance and installations and to define defeat protocol of such equipment during normal plant operation.

An equipment will be classified as Safety Critical if any one of the following eight criteria is met

A: Equipment Containing Hazardous Substances: The equipment which are part of the process circuit (enclosed by NODES that can be remotely and readily isolated) containing hazardous substances in threshold amounts (as determined in OSHA list of regulated chemicals) are included in the list of Safety Critical Equipment. It includes all "wetted" parts e.g. Vessels, Heat Exchangers, Piping Systems, Control valves, Pumps, etc.

B. Containment Controls Equipment ensuring containment control will be placed under the Safety Critical Equipment List for each corresponding Unit. This include for example i) Relief devices such as PSV's, PSD's etc.(Note that all relief valves and rupture disks are treated as Safety Critical, regardless of the substance handled, because of the concern for equipment failure/rupture hazards) ii) Conservation vents, emergency vents, overflow pots and their vent systems, if wetted by hazardous substances. iii) Check valves and excess flow valves. iv) Cathodic Protection for the underground lines.

C. Shutdown Controls Equipment and systems ensuring shutdown controls at the Unit will be considered Safety Critical. This include for example i) Sensors, final control elements and their associated interconnecting hardware that make up interlock loops that mitigate hazardous events. ii) Manual emergency shutdown systems in hazardous substance services. iii) Process safety alarms and associated controls that involve operator action to prevent a process safety incident.

D. Controlled Release Equipment/Systems: Operating equipment or systems associated with the controlled release of hazardous substances are Safety Critical. This include for example i) Liquid separators from relief devices ii) Flare and flare header systems iii) Scrubbing systems for hazardous substance release control iv) Overflow tanks for hazardous substances etc

E. Safety Monitoring and Emergency Communication Systems: Unit will consider systems associated with the detection of or people's response to release of hazardous substances as Safety Critical. This include for example i) Detection systems provided for early detection of releases of hazardous substances. ii) Pipe leak detection system associated with hazardous substances service. iii) Emergency alarm systems and emergency radio and telephones. iv) Low O2 detectors for personnel protection in control rooms, etc.

F. Active Mitigation Systems that need activation to reduce the potential of or minimize hazardous releases and process-related fires and explosions are Safety Critical. This include for example i) Fire protection systems directly associated with Safety Critical Process areas, including sprinklers, deluge systems, fire water supply, storage and piping distribution systems. ii) Explosion suppression systems and fire doors. iii) Area ventilation systems to dilute hazardous substances, to provide

positive pressure to exclude hazardous substances from an area or for electrical classification purpose.

G. Passive Prevention and Mitigation Systems that do not need activation but can reduce the potential of or minimize hazardous releases and process-related fires and explosions are Safety Critical. This include for example i) Secondary Containment Systems e.g., Dykes and Drainage Systems ii) Fire walls iii) Static protection used to prevent possible ignition sources.

H. Service and Utility Systems designed to ensure reliable operation of a Critical circuit or equipment: Service and utility systems that help maintain safe operation or process shutdown are Safety Critical. This include for example i) Backup power supply systems providing emergency electrical power to another Safety Critical Equipment. ii) UPS for powered Safety Critical Controls. iii) Diesel generators for Safety Critical Equipment such as fire pumps, communication and control equipment with battery backup when batteries run down. iv) Batteries for normal communication systems that are needed during emergencies. v) Tracing system for containment control related devices etc

11.1.2 Fire Detection & Fighting Systems

In a coal power plant, the biggest process safety hazard is of fire and coal dust explosion. Due to this reason the fire detection and mitigation systems design and functioning is of critical importance. All firefighting equipment shall comply with relevant NFPA standard. The fire detection and mitigation systems shall include, but not limited to, the following

1) A fire and gas safety philosophy shall be formulated and shared with the owner.
2) All coal conveyors shall have fire/smoke detection systems for early detection.
3) Coal storage area to be provided with fire / smoldering detection and mitigation systems.
4) Area in the vicinity of coal pulverizes and their downstream hoppers and feeders need to be provided with dust detection systems to avoid explosive mixture formation.
5) Hydrogen generation unit room and its related supply unit (transformer) need to be provided with gas leakage detection system
6) All switchgear rooms, generator rooms, transformers, cable trenches, cable rooms and tariff metering rooms shall be equipped with adequate fire detection and suppression systems according to the standards
7) All the above detection systems need to be the part of a centralized monitoring system similar to Fire and Gas (F&G) detection system, in addition to local alarms and mitigation actions.

8) Boiler burner area shall have smoke/optical beam detectors
9) All liquid fuel and lubricating oil tanks shall have adequate fire detection and suppression system
10) A compressive water based firefighting system shall be designed comprising of, but not limited to, fire water tanks, pumps, fire water network and hydrants.
11) Adequate portable fire extinguishers shall be provided based on fire risk assessment

11.2 JV Company Emergency Response Plan

11.2.1 Objective:

The Company's foremost objective is to ensure that all activities at the site are carried out in a manner that its employees, neighboring community, plant equipment and the environment are not endangered. However, this is not enough; if in spite of maintaining high safety standards an emergency occurs, the Company fully expects its employees to respond skillfully in an organized and timely fashion to contain / minimize the consequences of such an event.

This plan is intended as an action guide and reference document to respond to serious emergencies at the site. The objectives of this plan are:

a) Define lines of communication both internal and external to the project organization.

b) Assign responsibilities of personnel who are in positions of leadership and / or are required to take specific actions.

c) Make all persons knowledgeable of the actions they must take in event of an emergency.

d) Provide essential information on the hazards, emergency handling equipment etc.

Through training and regular practice under simulated conditions, it is expected that this plan will enable the organization to respond effectively to emergencies.

11.2.2 Emergencies:

There are several types of emergencies that can occur at the site. Most emergencies can be handled by quick localized action of the operating staff. However, in other instances, the emergency may be beyond the handling capability of the immediate staff and / or could endanger human life, project equipment or the environment unless additional support is provided and proper precautionary steps are taken on time. This plan addresses such emergencies.

Such emergencies can occur as a result of fire / explosion at the site.

Fire (in some cases explosion) can occur due to ignition of combustible materials such as natural gas, oil spills etc. Other calamities such as floods, earthquakes, sabotage etc. could also cause conditions which result in fire / explosion.

11.2.3 Detection and Declaration of Emergency:

11.2.3.1 Detection:

Any employee (JV company or contractor) within the site on hearing an explosion or seeing a fire combustible gas release must take the following actions immediately:

1. Report to the JV Company Contact Person through phone, pager, walkie talkie or by rushing himself and provide the following information;
   - His name
   - Location and extent of unsafe condition.
   - Wind direction

11.2.3.2 Declaration:

On getting information about the unsafe conditions, the JV Company Contact Person will take the following actions to verify the seriousness of the reported incident.

1. He will immediately verify the wind direction.
2. He will then sound alarm to inform everybody about the unsafe condition.
3. He will get as close to the incident location as is safe, to verify the unsafe condition and to assess the magnitude or severity of the incident.
4. He must then decide
   - Can the emergency be contained by quick localized action without endangering employees, equipment or the environment?

11.2.4 End of Emergency:

After the emergency has been fully controlled, the Contact Person will obtain permission from the Emergency Control Center Leader to authorize sounding of all clear siren.

The alarm will be sounded again to declare end of the emergency.

11.2.5 Emergency Control Centre and Members:

On declaration of an emergency, emergency control center will be developed with following role statements.

11.2.5.1 Role Statement of Personnel Working at Site

On hearing the emergency alarm all employees (either JV Company or contract) or visitors should take the following actions:

- Stop their assigned jobs in a safe manner.
- Vacate working area and assemble at a specific location.
- Stop all electrical Machines
- Stop use of telephone unless there is a serious emergency.

11.2.5.2 Role Statement of Contact Person

On getting information about the emergency, the contact person will take following actions.

- Inform all Emergency Control Members about the emergency.
- Verify wind direction.
- Approach emergency site taking safe route.
- Try to extinguish fire using portable fire extinguisher or water hose.
- Once the emergency has been handled, he will call any of the Emergency Control Members to get his permission to call the emergency over.

11.2.5.3 Role Statement of Emergency Control Members

On getting information about the emergency, each of the emergency control members will take following actions.

- Gather at a specified location.
- Keep in contact with the JV Company Contact Person.
- Guide the Contact Person on emergency handling.
- Decide to call the emergency over.

11.2.6 Emergency Control Equipment

The following will be considered as emergency control equipment.

11.2.6.1 Fire Extinguishers

Fire extinguishers will be placed at all strategic locations of the site. All types of fire extinguishers will be present on site i.e. CO2, Dry Powder etc. to handle various types of fire. Fire extinguisher trolleys will also be available at site.

11.2.6.2 Fire Water

Raw water which will be supplied for use at site will also be used as fire water. Some of the connections will be dedicated as fire point.

11.2.6.3 Fire Hose

Steel reinforced rubber hoses will be connected to the fire point. These hoses will be of 50 ft length. Spare hoses will also be available on site for extension of existing hoses.

11.2.7 Head Counting Procedure

To facilitate head count and closer monitoring, assembly locations will be made. Every employee (JV Company or contractor) will gather at the assembly location on hearing the emergency alarm. Contractor Supervisor will be responsible to do the head count.

11.3 Medical Emergency Plan

11.3.1 Objective:

Providing safe and healthy working environment to its employees is one of the top priorities of the company. For this purpose personal protective equipment and training is given to all employees. However this is not enough, in spite of all these efforts an accident can happen which may lead to serious injury to an employee. In addition to this an employee may suffer from an attack of angina, asthmas, high blood pressure stroke etc.

To deal with such type of emergencies the company will obtain an ambulance which will remain at the site all the time.

The main objective of this plan is to set up a line of actions against all type of emergencies in a manner that injured person / patient gets proper medical treatment well in time.

11.3.2 Type of Medical Emergencies

There are several types of medical emergencies than can happen at the site, these can be broadly categorized in two classes.

- Life Threatening Medical Cases
- Routine Medical Cases / Injuries

11.3.2.1 Life Threatening Medical Cases

These cases include heat attack, severe bleeding from an injury, third degree burns (covering more than 30% of body), stroke etc. Time is the most critical factor in such cases and it should be ensured that the patient is immediately shifted to the hospital.

11.3.2.2 Routine Medical Cases / Injuries

This includes all cases other than life threatening one i.e. cut, fracture, first-degree burns, chemical inhalation etc.

11.3.3 Medical Emergency Handling Facility

Till the site boundary wall and temporary offices, the following will be the arrangement to handle medical emergency.

- Ambulance will be available at site.
- Contact with nearby hospital/clinic.

Once the site boundary wall has been constructed, the contractor will arrange a place for clinic; arrange a doctor and some paramedic's staff for handling medical emergencies.

11.3.4 Line of Action

Following should be the line of action in case of a Medical Emergency.

- Properly trained First Aider will provide First Aid to the patient/injured till the arrival of medical help.
- The patient/injured will be shifted to the nearby hospital/clinic on ambulance.
- An attendant will always accompany the patient/injured to the hospital.
- Security/Services Officer will be informed immediately who will contact the hospital for proper handling of the patient.
- Security/Services Officer will ensure availability of some alternate arrangement in the absence of ambulance.
- Security/Services Officer to inform the patients family and make arrangements to bring them to the hospital if required.

12 System Studies

12.1 Refer to Annexure U

13 Plant Characteristics

13.1 The following table illustrates the plant configuration

1.	Plant size installed capacity (Gross ISO)	1320 MW
1.	Type of Technology	3 phase AC Synchronous machines
2.	Number of Units/Size	2x660 MW
3.	Unit make and model	-
4.	De-rated capacity at mean site conditions	-
5.	Auxiliary consumption	7.93% (104.763 MW for 2 units)
6.	Commissioning and commercial operation date	-
7.	Expected life of the facility from COD	30 years

13.2 The following table illustrates the plant characteristics

1	Generation Voltage	20~26 KV
2	Frequency	50 Hz
3	Power Factor	0.85(Lag)
4	Automatic Generation Control	To be provided later
5	Ramping Rate	To be provided later
6	Alternative Fuel	To be provided later
7	Auxiliary Consumption	7.9%
8	Time Required to Synchronize to Grid	To be provided later

13.3 Net capacity of the licensee's generation facilities

1.	Installed Capacity Gross ISO	1320 MW
2.	De-rated Capacity at Mean Site Conditions	-
3.	Auxiliary Consumption	7.93% (104.763 MW for 2 units)
4.	Net Capacity of the Plant at Mean Site Conditions	1214 MW

14 Control, Metering, Instrumentation and Protection

14.1 The I&C system is designed to ensure safe, reliable, available economic and simple operation and easy coordination to different operation requirements.

14.2 This project plans to adopt turbine, boiler, generator and auxiliary workshops central control mode. The two units share one central control room, with an area of about 150m2, the central control room is planned to be arranged between the two boilers or at the fixed end of the main plant building. The unit control room is arranged the unit monitoring console, network control console, auxiliary production system monitoring console, shift supervisor console, fire alarm panel, etc.

Each unit is provided with a set of DCS system. DCS control following systems: boiler proper and auxiliary systems, turbine proper and auxiliary systems, generator proper and auxiliary system, chemical sampling, and condensate polishing, etc. Each unit is monitored by on-duty operator through operator station, with assistants to complete the startup and shutdown operation, monitoring of normal operation and emergency handling of the unit. The backup control panel only retains a small number of necessary backup conventional instruments and operating equipment. Each unit is planned to be equipped with several operator stations and LCD display (arranged on the backup panel).

The backup control panel, which separated form DCS, is configured to ensure operators safety shutdown unit when DCS fail. The backup control panel include following: Main Fuel Trip (MFT), Turbine Emergency Trip, Generator Trip, PCV, DC lube oil pump and so on. Those output signal of the backup control panel will be sent to equipment directly by using hardwire connections.

14.3 For more detail, please review Paragraph 5.10 of Feasibility Study Report.

15 Training and Development

15.1 Training Plan

The Hub Power Company (Hubco), in association with the China Power International (CPI) holding Company, envisage on setting up two Coal Fired Power Plants at Hub, Baluchistan. Each of the two units will have an installed capacity of 660MW, with a total installed capacity of 1320MW for the complex.

The 2x660MW, Super-critical, Pulverized Coal Fired Power Plant will be a pioneering project in Pakistan from both Technology and type of fuel perspectives. In view of the dearth of Operation and Maintenance (O&M) of Power Plants, Hubco intends to address these challenges through rigorous training of its O&M staff, to bring the competency of its staff to prevailing global practices in Power Plants worldwide.

The training of the O&M staff will be diverse, focusing on theoretical knowledge, specialized skill knowledge, practical, through simulators and hands-on experience.

15.2 Locations

Training will be carried out at the following locations:

- China at Training Institutes (Classroom)
- Original Equipment Manufacturers (OEM) Factories in China
- Middle Eastern/European Training Institutes (Classroom)
- Pakistan (Classroom and On-site)
- Visits to Power Plants in China and Pakistan

15.3 Schedules

The training process will start 1 year before the Commercial Operations Date (COD). During this period, industry experienced O & M staff consisting of Operators and Maintenance personnel shall be hired. After being trained both as Trainers and normal O& M Staff they shall:

- Monitor and supervise the construction and erection of the Power Plant.
- Get trained by Vendor Representatives during erection and commissioning.
- Trained Trainers shall educate their Juniors.

15.4 Training Methodology

15.4.1 Train the Trainer Concept

Following the train the trainer concept, the trainers will be given intensive training following teaching methods, the technology itself and the O&M procedures of the power plant. The training materials will include OEM Manuals and technical presentations by experienced engineers. A select group of around 70-80 trainees will be sent to China for acquired specialized knowledge, visit to the OEM factories followed by interaction with the Operation and Maintenance Departments of the Power Plant running on similar technology.

15.4.2 Training Materials

Extensive Training materials and equipment shall be used for training.

- Simulators.
- Specially prepared training courses.
- On Job Training.
- Vendor O&M manuals.
- Engineering Standards
- Presentations and Videos
- Workshop Demonstrations

15.4.3 Training in Pakistan

Training in Pakistan will comprise of class-room training, on-site training, simulator training and on-the-job training. The training will be carried out by specialized engineers and trainers from China, other O&M personnel who acquired training from China.

15.4.4 Post COD In-Plant Training

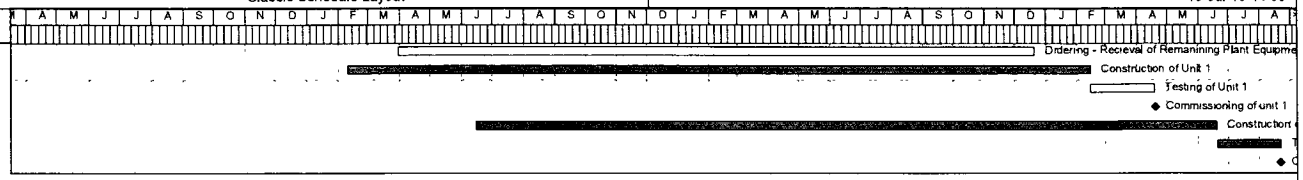
Post COD, a full fledged Training Department will be set up that would

- Constantly update the O&M personnel with the latest knowledge on Hub II Systems
- Persistently keep them abreact of the latest O& M requirements.
- Train newly hired staff.
- Refresh staff knowledge and competency to assume new roles.
- Train Management Trainees

16 Feasibility Report

16.1 Refer to Annexure P

Activity ID	Activity Name	Original Duration	Start	Finish
A5510	Ordering - Recieval of Remanining Plant Equipment	450	31-Mar-16	20-Dec-17
A5200	Construction of Unit 1	525	10-Feb-16	13-Feb-18
A5530	Testing of Unit 1	46	14-Feb-18	18-Apr-18
A5220	Commissioning of unit 1	0		19-Apr-18
A5540	Construction of Unit 2	525	15-Jun-16	19-Jun-18
A5550	Testing of Unit 2	46	20-Jun-18	22-Aug-18
A5560	Commissioning of unit 2	0		22-Aug-18



◆ Milestone ▬ Actual Work ▼ Summary
▭ Remaining Work ▬ Critical Remaining Work

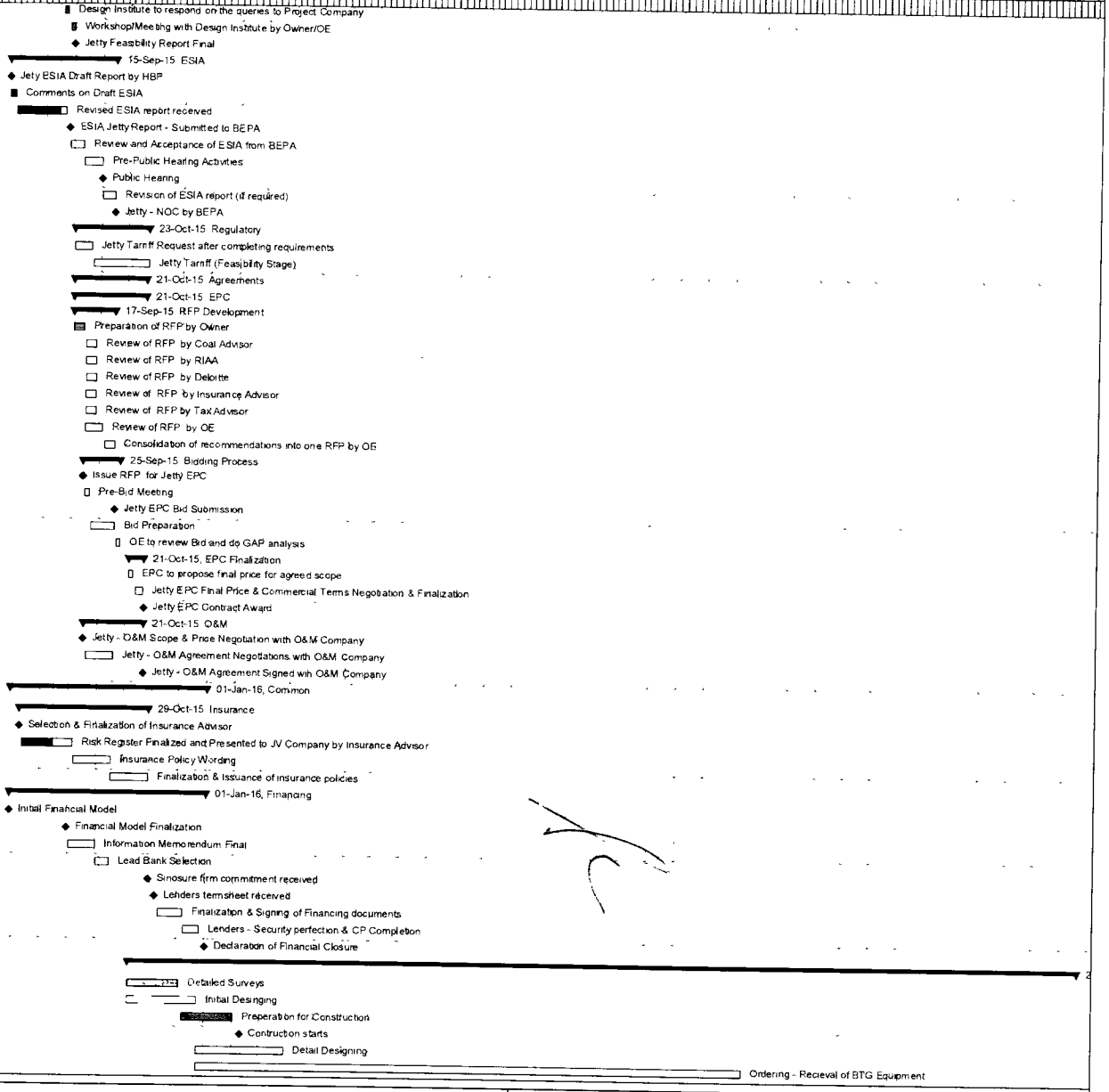
TASK filter: All Activities

Coal Power Project Timeline-Actual (G)-7/7/15

Classic Schedule Layout

15-Jul-15 14:55

Activity ID	Activity Name	Original Duration	Start	Finish
A4720	Design Institute to respond on the queries to Project Company	5	20-Jul-15	24-Jul-15
A4730	Workshop/Meeting with Design Institute by Owner/OE	5	27-Jul-15	31-Jul-15
A4160	Jetty Feasibility Report Final	0		31-Jul-15
ESIA				
A4750	Jety ESIA Draft Report by HBP	0		21-May-15 A
A4760	Comments on Draft ESIA	5	22-May-15	28-May-15 A
A4770	Revised ESIA report received	5	29-May-15	22-Jul-15
A4780	ESIA Jetty Report - Submitted to BEPA	0		27-Jul-15
A4790	Review and Acceptance of ESIA from BEPA	11	28-Jul-15	11-Aug-15
A4800	Pre-Public Hearing Activities	15	12-Aug-15	01-Sep-15
A4810	Public Hearing	0		01-Sep-15
A4820	Revision of ESIA report (if required)	10	02-Sep-15	15-Sep-15
A4830	Jetty - NOC by BEPA	0		15-Sep-15
Regulatory				
A4090	Jetty Tarriff Request after completing requirements	15	03-Aug-15	21-Aug-15
A3160	Jetty Tarriff (Feasibility Stage)	45	24-Aug-15	23-Oct-15
Agreements				
EPC		**58**	**03-Aug-15**	**21-Oct-15**
A4	Preparation of RFP by Owner	10	03-Aug-15	14 Aug 15
A48	Review of RFP by Coal Advisor	10	17-Aug-15	28-Aug-15
A48	Review of RFP by RIAA	10	17-Aug-15	28-Aug-15
A48	Review of RFP by Deloitte	10	17-Aug-15	28-Aug-15
A48	Review of RFP by Insurance Advisor	10	17-Aug-15	28-Aug-15
A48	Review of RFP by Tax Advisor	10	17-Aug-15	28-Aug-15
A49	Review of RFP by OE	15	17-Aug-15	04-Sep-15
A49	Consolidation of recommendations into one RFP by OE	3	07-Sep-15	7 Sep 15
A49	Issue RFP for Jetty EPC	0		4 Aug 15
A49	Pre-Bid Meeting	5	17-Aug-15	21-Aug-15
A49	Jetty EPC Bid Submission	0		18-Sep-15
A49	Bid Preparation	20	24-Aug-15	18-Sep-15
A49	OE to review Bid and do GAP analys	5	21-Sep-15	25-Sep-15
A49	EPC to propose final price for agreed scope	5	05-Oct-15	09-Oct-15
A50	Jetty EPC Final Price & Commercial Terms Negotiation & Fin	7	12-Oct-15	20-Oct-15
A41	Jetty EPC Contract Award	0		21-Oct-15
O&M		**48**	**17-Aug-15**	**21-Oct-15**
A4240	Jetty - O&M Scope & Price Negotiation with O&M Company	0		17-Aug-15*
A4320	Jetty - O&M Agreement Negotiations with O&M Company	22	20-Aug-15	18-Sep-15
A4250	Jetty - O&M Agreement Signed wih O&M Company	0		21-Oct-15
Common		**155**	**29-May-15**	**01-Jan-16**
Insurance		99	09-Jun-15	29-Oct-15
A2480	Selection & Finalization of Insurance Advisor	0		09-Jun-15 A
A1990	Risk Register Finalized and Presented to JV Company by Ins	30	12-Jun-15	06-Aug-15
A4150	Insurance Policy Wording	30	07-Aug-15	17-Sep-15
A2150	Finalization & Issuance of insurance policies	30	18-Sep-15	29-Oct-15
Financing		155	29-May-15	01-Jan-16
A5460	Initial Financial Model	0		29-May-15 A
A4170	Financial Model Finalization	0		31-Jul-15
A5480	Information Memorendum Final	22	03-Aug-15	01-Sep-15
A5490	Lead Bank Selection	11	02-Sep-15	16-Sep-15
A3540	Sinosure firm commitment received	0		30-Oct-15
A5470	Lenders termsheet received	0		06-Nov-15
A3700	Finalization & Signing of Financing documents	20	10-Nov-15	07-Dec-15
A3710	Lenders - Security perfection & CP Completion	14	08-Dec-15	25-Dec-15
A3910	Declaration of Financial Closure	0		01-Jan-16
Engineering to COD		**750**	**08-Oct-15**	**22-Aug-18**
A5520	Detailed Surveys	42	08-Oct-15	04-Dec-15
A5170	Initial Designing	55	08-Oct-15	23-Dec-15
A5210	Preperation for Construction	42	07-Dec-15	02-Feb-16
A5190	Contruction starts	0		09-Feb-16
A5180	Detail Designing	70	24-Dec-15	30-Mar-16
A5230	Ordering - Recieval of BTG Equipment	430	24-Dec-15	16-Aug-17



◆ Milestone Actual Work Summary

Remaining Work Critical Remaining Work

TASK filter: All Activities

Coal Power Project Timeline-Actual (G)-7/7/15

Classic Schedule Layout

15-Jul-15 14:55

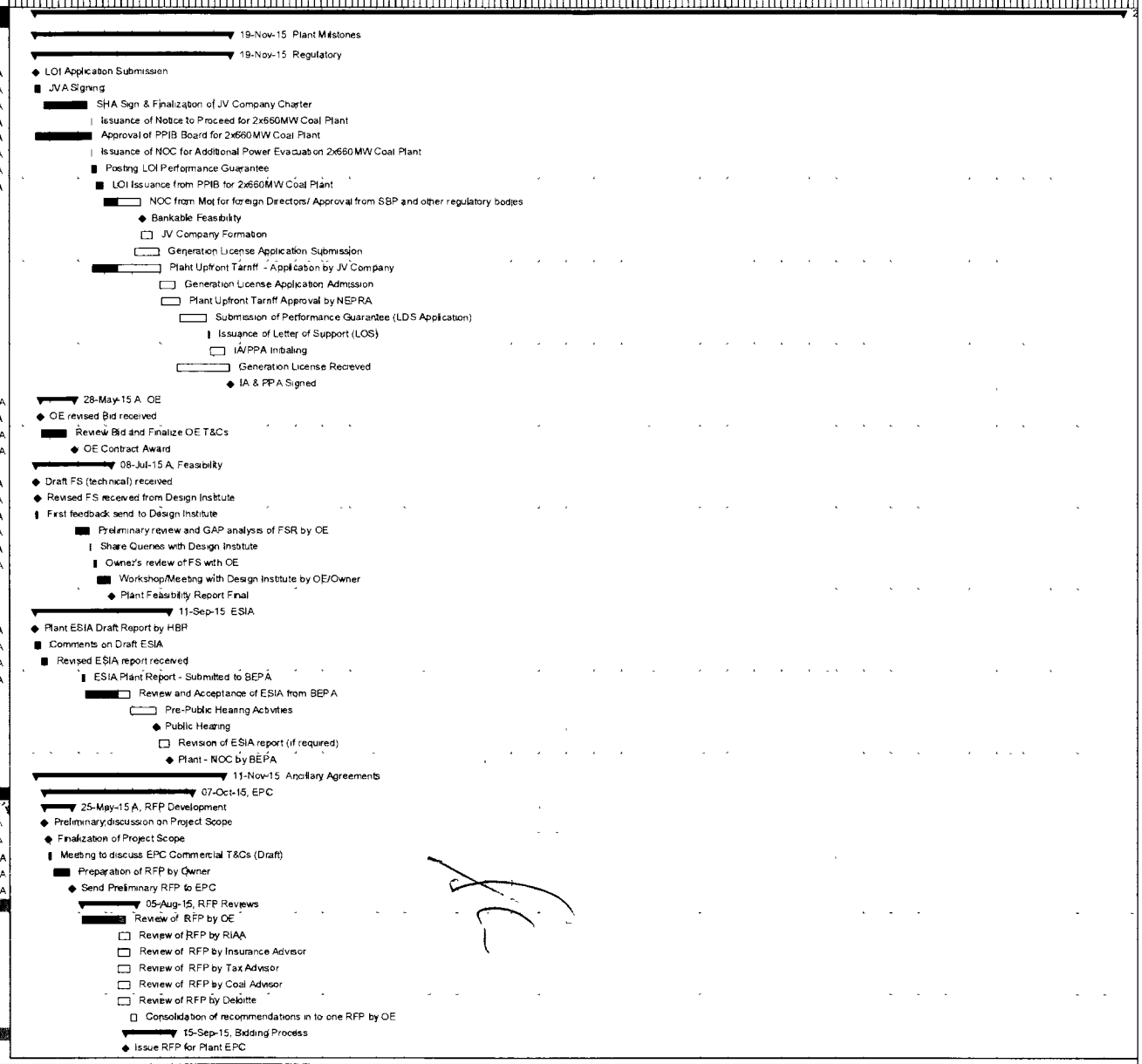
Activity ID	Activity Name	Original Duration	Start	Finish
A46	Bid Preparation	15	27-Jul-15	14-Aug-15
A46	Pre-Bid Meeting	5	17-Aug-15	21-Aug-15
A46	Bid finalization by EPC	4	24-Aug-15	27-Aug-15
A40	Plant EPC Bid Submission	0		28-Aug-15*
A46	OE to review Bid and do GAP analysis	6	31-Aug-15	07-Sep-15
A41	Post Bid Clarification Meeting (tech)	6	08-Sep-15	15-Sep-15
EPC Finalization		16	16-Sep-15	07-Oct-15
A46	EPC to propose final price for agreed scope	5	16-Sep-15	22-Sep-15
A40	Plant EPC Final Price & Commercial Terms Negotiation & Fi	8	23-Sep-15	02-Oct-15
A25	Plant EPC Agreements Signed	0		07-Oct-15
O&M		106	01-Jun-15	26-Oct-15
A5420	O&M Framework review	15	01-Jun-15	08-Jul-15 A
A5430	Prepare O&M Scope	10	09-Jul-15 A	29-Jul-15
A5250	Develop Manpower Requirements	10	30-Jul-15	12-Aug-15
A5260	Develop Budget	10	13-Aug-15	26-Aug-15
A5440	Develop Maintenance Regime	22	30-Jul-15	28-Aug-15
A5270	Sensitize Budget based on design	25	13-Aug-15	16-Sep-15
A5280	Prepare OMA	12	17-Sep-15	02-Oct-15
A5300	Submit OMA	1	05-Oct-15	05-Oct-15
A2790	O&M Agreement Signed	0		26-Oct-15
A5240	Negotiate OMA	15	06-Oct-15	26-Oct-15
TSA		81	06-Jul-15 A	26-Oct-15
A2770	Development scope for technical services for TSA	0		06-Jul-15 A
A4300	TSA contract negotiation	35	20-Jul-15	04-Sep-15
A2800	TSA contract signed	0		26-Oct-15
CSA		151	15-Apr-15 A	11-Nov-15
RFP for Coal Supplier		70	22-May-15 A	21-Sep-15
A50	JV Company Commercial Terms Discussion	5	06-Jul-15 A	10-Jul-15 A
A50	Development of Coal Supplier RFP	8	16-Jul-15	27-Jul-15
A50	Financial Advisor Recommendations on RFP	5	28-Jul-15	03-Aug-15
A50	Float RFP	0		03-Aug-15
A51	Recieval of Bids from Coal Suppliers	20	04-Aug-15	31-Aug-15
A51	Review of Bids by Owner & Consultant	15	01-Sep-15	21-Sep-15
A5	Shortlist Coal Supplier(s)	0		2-Sep-15
[illegible]		[illegible]	[illegible]	[illegible]
A5	Termsheet Evaluation from Suppliers	5	22-Sep-15	1-Oct-15
A40	CSA Signed	0		11-Nov-15
A51	Termsheet Negotiation with Suppliers	22	1-Oct-15	1-Nov-15
[illegible]		[illegible]	[illegible]	[illegible]
A50	Development of RFP for Coal Consultant	12	16-Apr-15 A	30-Apr-15 A
A50	Relase RFP	0		30-Apr-15 A
A50	Recieve Coal consultant Bids	15	01-May-15	21-May-15 A
A50	Bids Evaluation	15	22-May-15	24-Jun-15 A
A50	Award Contract to Coal Consultant	0		16-Jul-15
LSA		85	16-Jul-15	11-Nov-15
A1690	GOB Approval for Land Carve out	0		16-Jul-15*
A1700	Approval from Lenders & PPIB for Land Carve out	15	16-Jul-15	05-Aug-15
A1710	Security composite agreement among HBL,NBP,Hubco LDT	17	06-Aug-15	28-Aug-15
A4310	Land Sale/Lease Agreement - Price Negotiated & Signed	33	31-Aug-15	14-Oct-15
A4020	Land Sale/Agreement - Negotiation	0		11-Nov-15
Jetty Milestones		133	22-Apr-15 A	23-Oct-15
OE		61	22-Apr-15 A	16-Jul-15
A3090	Jetty OE 1 Bid Received	0		22-Apr-15 A
A3080	Meeting with Jetty OE 2	3	22-Apr-15 A	24-Apr-15 A
A3100	Revised bid from Jetty OE 2	4	27-Apr-15 A	30-Apr-15 A
A3110	Revised Bid of Jetty OE 1 based on scope as agreed with Jet	4	27-Apr-15 A	30-Apr-15 A
A3120	Review Bid and Finalize OE T&Cs	25	01-May-15	02-Jul-15 A
A3070	Jetty - OE Contract Award	0		16-Jul-15
Feasibility		54	04-May-15	31-Jul-15
A4230	1st Draft FSR from Design Institute	0		04-May-15 A
A4680	First feedback sent to Design Institute	5	05-May-15	11-May-15 A
A4690	Revised FS received from Design Institute	5	12-May-15	18-May-15 A
A4200	Preliminary review and GAP analysis of FSR by OE	5	06-Jul-15 A	10-Jul-15 A
A4710	Send Queries to Design Institute	2	16-Jul-15	17-Jul-15
A4700	Owner's review of FS with OE	5	10-Jul-15 A	20-Jul-15

◆ Milestone Actual Work Summary

Remaining Work Critical Remaining Work

TASK filter: All Activities

Activity ID	Activity Name	Original Duration	Start	Finish
Coal Power Project Timeline-Actual (G)-7/7/15		877	13-Apr-15 A	22-Aug-18
Plant Milstones		158	13-Apr-15 A	19-Nov-15
Regulatory		57	-Apr-15 A	9-Nov-15
A1250	LOI Application Submission	0		14-Apr-15 A
A1610	JVA Signing	4	14-Apr-15 A	20-Apr-15 A
A5600	SHA Sign & Finalization of JV Company Charter	36	24-Apr-15 A	12-Jun-15 A
A1600	Issuance of Notice to Proceed for 2x660MW Coal Plant	1	17-Jun-15	17-Jun-15 A
A5590	Approval of PPIB Board for 2x660 MW Coal Plant	34	15-Apr-15 A	17-Jun-15 A
A5630	Issuance of NOC for Additional Power Evacuation 2x660 MW	1	17-Jun-15	17-Jun-15 A
A4130	Posting LOI Performance Guarantee	15	17-Jun-15	22-Jun-15 A
A1260	LOI Issuance from PPIB for 2x660MW Coal Plant	6	22-Jun-15	29-Jun-15 A
A5610	NOC from MoI for foreign Directors/ Approval from SBP and	30	30-Jun-15	10-Aug-15
A4260	Bankable Feasibility	0		12-Aug-15
A5620	JV Company Formation	10	11-Aug-15	24-Aug-15
A5450	Generation License Application Submission	20	04-Aug-15	31-Aug-15
A1310	Plant Upfront Tariff - Application by JV Company	55	18-Jun-15	02-Sep-15
A1300	Generation License Application Admission	14	01-Sep-15	18-Sep-15
A2470	Plant Upfront Tariff Approval by NEPRA	15	03-Sep-15	23-Sep-15
A1320	Submission of Performance Guarantee (LOS Application)	22	24-Sep-15	23-Oct-15
A1330	Issuance of Letter of Support (LOS)	2	26-Oct-15	27-Oct-15
A5500	IA/PPA Initialing	13	28-Oct-15	13-Nov-15
A2460	Generation License Recieved	43	21-Sep-15	18-Nov-15
A1340	IA & PPA Signed	0		19-Nov-15
OE		32	20-Apr-15 A	28-May-15 A
A4340	OE revised Bid received	0		20-Apr-15 A
A4350	Review Bid and Finalize OE T&Cs	20	21-Apr-15 A	18-May-15 A
A4360	OE Contract Award	0		28-May-15 A
Feasibility		81	14-Apr-15 A	08-Jul-15 A
A4370	Draft FS (technical) received	0		14-Apr-15 A
A4440	Revised FS received from Design Institute	0		16-Apr-15 A
A4380	First feedback send to Design Institute	2	15 Apr 15 A	16-Apr-15 A
A4180	Preliminary review and GAP analysis of FSR by OE	4	29 May-15	14-Jun-15 A
A4400	Share Queries with Design Institute	1	15 Jun 15	15-Jun-15 A
A4390	Owner's review of FS with OE	2	19 Jun-15	22 Jun-15 A
A4420	Workshop/Meeting with Design Institute by OE/Owner	10	23-Jun-15	07-Jul-15 A
A4140	Plant Feasibility Report Final	0		08-Jul-15 A
ESIA		109	-Apr-15 A	11-Sep-15
A2530	Plant ESIA Draft Report by HBP	0		13-Apr-15 A
A4450	Comments on Draft ESIA	5	14-Apr-15 A	20-Apr-15 A
A4270	Revised ESIA report received	5	21-Apr-15 A	27-Apr-15 A
A2510	ESIA Plant Report - Submitted to BEPA	1	05-Jun-15	08-Jun-15 A
A2540	Review and Acceptance of ESIA from BEPA	11	10-Jun-15	29-Jul-15
A4470	Pre-Public Hearing Activities	22	30-Jul-15	28-Aug-15
A4480	Public Hearing	0		28-Aug-15
A4490	Revision of ESIA report (if required)	10	31-Aug-15	11-Sep-15
A4500	Plant - NOC by BEPA	0		11-Sep-15
Ancillary Agreements		1	Apr-1	
EPC		118	24-Apr-15 A	07-Oct-15
RFP Development		21	24-Apr-15 A	25-May-15 A
A45	Preliminary discussion on Project Scope	0		24 Apr 15 A
A45	Finalization of Project Scope	0		28-Apr 15 A
A45	Meeting to discuss EPC Commercial T&Cs (Draft)	3	29-Apr-15 A	01-May-15 A
A45	Preparation of RFP by Owner	14	04 May-15	21 May-15 A
A51	Send Preliminary RFP to EPC	0		25 May-15 A
RFP Reviews		21	05-Jun-15	05-Aug-15
A45	Review of RFP by OE	15	05-Jun-15	24-Jul-15
A45	Review of RFP by RIAA	10	16-Jul-15	29-Jul-15
A45	Review of RFP by Insurance Advisor	10	16-Jul-15	29-Jul-15
A45	Review of RFP by Tax Advisor	10	16-Jul-15	29-Jul-15
A46	Review of RFP by Coal Advisor	10	16-Jul-15	29-Jul-15
A45	Review of RFP by Deloitte	10	16-Jul-15	29-Jul-15
A46	Consolidation of recommendations in to one RFP by OE	5	30-Jul-15	05-Aug-15
Bidding Process		21	06-Aug-15	15-Sep-15
A15	Issue RFP for Plant EPC	0		24-Jul-15



◆ Milestone | Actual Work | Summary | Remaining Work | Critical Remaining Work

TASK filter: All Activities

National Transmission and Despatch Company Limited (NTDCL)

Grid Interconnection Study for Evacuation of Power from 2x660 MW HUBCO Coal Fired Power Plant to the National Grid

(Report-1)

Planning (Power) Department
4th Floor, PIA Tower, Egerton Road, Lahore.

June 2015

Table of Contents

Executive Summary

1. M/s Hub Power Company Limited is planning to set up a Coal Fired Power Plant (CFPP) comprising of two steam units, each of 660 MW capacity, in the vicinity of the existing HUBCO power plant. This power plant is also included in the list of China Pakistan Economic Corridor (CPEC) Energy Projects. The target CODs of the first and second units, as indicated by M/s Hub Power Company Limited, are December 2017 and June 2018 respectively subject to issuance of LOI, LOS and signing of IA/PPA without delay on part of Government agencies.

2. M/s Hub Power Company Limited has approached Planning Power department of National Transmission and Despatch Company Limited (NTDCL) to carry out interconnection studies of the said power plant. This is Grid Interconnection Study Report-1 in which the results of load flow studies have been presented for the integration of 2x660 MW HUBCO CFPP with the National Grid. The interconnection studies have been carried out to evaluate the adequacy of the proposed interconnection scheme for evacuation of power from 1320MW HUBCO CFPP to the National Grid in the light of National Electric Power Regulatory Authority (NEPRA) Grid Code.

3 Considering the capacity, indicated timeline & location of 2x660 MW HUBCO CFPP and the existing/planned system network in the vicinity, the following interconnection scheme has been proposed for its power evacuation to the National Grid:

> *"A 500 kV Double Circuit (D/C) transmission line, approx 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station"*

It is important to highlight that the above proposed interconnection arrangement for HUBCO CFPP would be modified later with the addition of other planned coastal power plants in future.

4. Detailed load flow studies have been carried out for various operating scenarios of summer and winter with the above proposed interconnection scheme. It has been found on the basis of the study results that the power from 2x660 MW HUBCO CFPP can be dispersed to the National Grid in a reliable manner during normal and N-1 contingency conditions without any transmission constraints.

5. M/s Hub Power Company Limited has provided detailed design data/parameters of HUBCO CFPP to NTDCL for the interconnection study. It is important to intimate that the generator power factor limits for HUBCO CFPP are 0.85 lagging/0.95 leading as opposed to 0.8 lagging/0.9 leading as mentioned in the NEPRA Grid Code. The load flow studies for this report have been carried out with the given generator power factor

limits to assess their adequacy as per system requirements. However, this matter would be finalized after transient stability analysis which will be carried out in the Grid Interconnection Report-2.

6. Some plant parameters required to carry out short circuit and transient stability studies were missing. NTDCL Planning Power is in continuous contact with M/s Hub Power Company Limited which is arranging the desired plant parameters from their plant designer. After received of the remaining plant parameters, short circuit and transient stability studies will be carried out and their results will be presented in the Grid Interconnection Report-2.

7. The comments of M/s Hub Power Company Limited and their plant designers on this report are welcome and would be incorporated in the Grid Interconnection Report-2 where found necessary.

1. Introduction

This is Grid Interconnection Study Report-1 in which the results of load flow studies have been presented for evacuation of power from the proposed 2x660 MW HUBCO Coal Fired Power Plant (CFPP), to the National Grid. The interconnection studies have been carried out to evaluate the adequacy of the proposed interconnection scheme for evacuation of power from 2x660 MW HUBCO CFPP to the National Grid in the light of National Electric Power Regulatory Authority (NEPRA) Grid Code.

The site of the proposed power project is adjacent to the existing 1292 MW HUBCO power plant. The configuration of the proposed plant comprises of two steam turbines units having capacity of 660 MW each. The subject power plant is also included in China Pakistan Economic Corridor (CPEC) Energy Projects. As per information provided by M/s Hub Power Company Limited, subject to issuance of LOI, LOS and signing of IA/PPA without delay on part of Government agencies, it will try first unit synchronization by December 2017 and second unit synchronization within six months after the first unit.

It is important to highlight that the power factor limits for a generator at the rated output(MW) are 0.8 lagging and 0.9 leading, at generator terminals as per NEPRA Grid Code. M/s Hub Power Company Limited have provided generator data for the 2x660 MW with the power factor limits of "0.85 lagging/0.95 leading", at the rated output. NEPRA has already issued instruction on the above mention matter given at para-3 of the letter No: NEPRA/DG(Std)/NTDC/2014-453 dated 14-10-2014 regarding the Minutes of 14th Meeting of the Grid Code Review Panel (GCRP), which is reproduced as under:

> *"It is therefore suggested that instead of making overall amendment in the code, the issue of power factor be decided on case to case basis, based on the system studies as mentioned in connection code page # 136 of Grid Code."*

In pursuance to above, load flow studies of various operating scenarios have been carried out for this report with the given generator power factor limits to assess their adequacy at the proposed site as per system requirements as well. However, this matter would be finalized after transient stability analysis which will be carried out in the Grid Interconnection Report-2.

2. Interconnection Scheme for 2x660 MW HUBCO CFPP

The objective of this interconnection study is to propose a transmission scheme for reliable dispersal of power from 2x660 MW HUBCO CFPP power project to the National Grid under normal and single line contingency (N-1) conditions. The following interconnection scheme has been proposed for 2x660 MW HUBCO CFPP keeping in view its generation capacity, location, indicated timeline and the existing/planned system network in the vicinity.

> *"A 500 kV D/C transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station"*

The geographical diagram showing above interconnection scheme for power dispersal of HUBCO CFPP is attached as Figure #1.

It is important to highlight that the above proposed interconnection arrangement for HUBCO CFPP would be modified later with the addition of other planned coastal power plants in future. The geographical diagram showing the modified interconnection scheme for HUBCO CFPP as well as other coastal power plants is attached as Figure #2.

3. Study Assumptions and Criterion

3.1 Study Assumptions

The load flow studies are based on the following assumptions:

- Latest load forecast.
- Latest generation expansion plan.
- Latest transmission expansion plans of NTDC and DISCOs.
- In the studies, interconnection transmission system has been assumed.
- The significant quantum of the planned coal power projects in the southern part of the network have been assumed in the studies as per their expected commissioning schedules. The gross and net capacities of these projects are given as under:
  - Engro Thar Coal Power Project (Gross Capacity: 2x330 MW & Net Capacity: 2x300 MW)
  - Port Qasim Imported Coal Power Project (Gross Capacity: 1320 MW & Net Capacity: 1200 MW)
  - SSRL Thar Coal Fired Power Project (Gross Capacity: 1320 MW & Net Capacity: 1200 MW)
  - Jamshoro Coal Fired Power Project (Gross Capacity: 1320 MW & Net Capacity: 1200 MW)
  - Siddique Sons Imported Coal Fired Power Project (Gross Capacity: 350 MW & Net Capacity 320 MW)
  - Lucky Imported Coal Fired Power Project (Gross Capacity: 660 MW & Net Capacity: 600 MW)
- Maximum generation of the existing thermal power plants at Hubco, Jamshoro, Kotri, Uch-1, Uch-2 and Guddu power plant in south.
- The existing/planned wind power projects with total gross capacity of 1756 MW in the southern part of the system. The wind power has been planned to be evacuated to the 132 kV and 220 kV network underneath Jamshoro. The seasonal variation in wind power output has been assumed in the studies, i.e., high in summer and low in winter.

- Two nuclear power projects (K-2/K-3) at Karachi (Gross Capacity: 1100 MW & Net Capacity: 1017.5 MW) for each have been assumed in the studies as per their commissioning schedule.
- ±600 kV HVDC bipole from Matiari switching/convertor station to Lahore South convertor station and ±600 kV HVDC bipole from Port Qasim convertor station to Faisalabad West have been assumed in the studies.
- The total net output capacity for the HUBCO CFPP has been assumed as 1214.4 MW (607.2 MW per unit) after deducting 8% auxiliary consumption from gross capacity as per information provided by M/s Hub Power Company Limited.

3.2 System Study Criterion

The load flow studies have been carried out keeping in view of the following system operating criteria/limits in accordance with NEPRA Grid Code:

Voltage Limits:	±5% under normal and ±10% under contingency conditions. However, voltages at generation buses and substations may be kept upto +8% under normal operating conditions as per network configuration and/or system requirements.
Transmission Line/Transformer Loading Limits:	100% under normal and N-1 contingency conditions.

4. Load Flow Studies

The necessary load flow analysis has been carried out with the proposed interconnection scheme of various operating scenarios for the months of Aug/Sep and January corresponding to the typical summer and winter seasons respectively. In this regard, the system scenarios of peak load conditions of Aug/Sep. 2018, January 2019, Aug/Sep. 2021 and January 2022 have been simulated to evaluate the adequacy of the proposed interconnection scheme and performance of 2x660 MW HUBCO CFPP under normal and single line (N-1) contingency conditions.

The results of the load flow studies for dispersal of power from 2x660 MW HUBCO CFPP to the National Grid with the proposed Interconnection scheme are described as under:

4.1 Peak Load Aug/Sep 2018 (Summer Scenario)

Load flow study for the peak load condition of Aug/Sep 2018 under normal system condition has been carried out with the induction of 2x660 MW HUBCO CFPP and is attached as Exhibit #1. As per load flow study, the power flows on the circuits emanating from HUBCO CFPP and in their vicinity are as under:

Transmission Line	Power Flow
Hubco CFPP – Matiari Converter Station (CS) D/C	2x607.2 MW
Port Qasim CFPP – Matiari CS D/C	2x600 MW
Matiari CS – Lahore South CS ±600kV HVDC bipole	2x1400 MW
Jamshoro – Matiari CS S/C	348 MW
Matiari CS – Moro S/C	602 MW
Engro Thar – Matiari CS D/C	2x300 MW
Moro – R.Yar Khan S/C	581 MW
Jamshoro – Dadu (circuit #1)	691 MW
Jamshoro – Dadu (circuit #2)	767 MW
Dadu – Shikarpur (circuit #1)	480 MW
Dadu – Shikarpur (circuit #2)	532 MW

Exhibit #	Contingency Conditions	Remarks
13	Port Qsim CFPP – Matiari CS 500 kV S/C out	-do-
14	Matiari CS – Lahore South CS ±600kV HVDC mono pole out	-do-
15	Matiari CS – Jamshoro 500 kV S/C out	-do-
16	Matiari CS – Moro 500 kV S/C out	-do-
17	Jamshoro – Dadu 500 kV S/C out	-do-
18	Engro Thar – Matiari CS 500 kV S/C out	-do-
19	Moro – R.Yar Khan 500 kV S/C out	-do-
20	Lahore South CS – Lahore South 500 kV S/C out	-do-

b. Comments on Normal and N-1 Contingency Analysis

As per load flow study results of system scenario in peak load January 2019, the power flows on transmission lines and transformers in the vicinity of proposed HUBCO CFPP are well within their capacities. In general, the study depicts that the voltage profile of the system is within limits and there would be no transmission system constraints in the flow of power from the proposed HUBCO CFPP to the system under normal and N-1 contingency conditions.

4.3 Peak Load Aug/Sep 2021 (Summer Scenario)

Load flow study for the peak load of Aug/Sep 2021 under normal system condition has been carried out with the induction of 2x660 MW HUBCO CFPP and is attached as Exhibit #21. In this scenario and onwards, the interconnection arrangement of HUBCO CFPP has been modified in view of interconnection of K-2/K-3 power plants and ±600kV HVDC convertor station at Port Qasim. As per load flow study, the power flows on the circuits emanating from HUBCO CFPP plant and in their vicinity are as under:

Transmission Line	Power Flow
HUBCO CFPP – K-2/K-3 S/C	146 MW
HUBCO CFPP – Port Qasim CS S/C	1360 MW
K-2/K-3 - Port Qasim CFPP S/C	511 MW
Port Qasim CFPP – Port Qasim CS S/C	1711 MW
K-2/K-3 – Matiari CS (circuit #1&2)	2x688 MW
Matiari CS – Lahore South -CS ±600kV HVDC bipole	2x1950 MW
Port Qasim CS – Faisalabad West ±600kV HVDC bipole	2x1950 MW
Matiari CS – Jamshoro S/C	1041 MW
Matiari CS – Moro S/C	336 MW
Engro Thar – Matiari CS S/C	870 MW
SSRL – Matiari CS S/C	930 MW
Moro – R.Yar Khan S/C	422 MW
Jamshoro – Dadu (circuit #1)	738 MW
Jamshoro – Dadu (circuit #2)	824 MW
Dadu – Shikarpur (circuit #1)	391 MW
Dadu – Shikarpur (circuit #2)	433 MW

a. N-1 Contingency Analysis

The load flow studies have also been carried out for single line contingency (N-1) analysis in the vicinity of proposed HUBCO CFPP and are attached as Exhibit # 22-36. The results of contingency studies have been summarized as under:

Exhibit #	Contingency Conditions	Remarks
22	HUBCO CFPP – K-2/K-3 500 kV S/C out	Power flows on the other transmission lines and transformers as well as the voltage profile of the system remain within limits.
23	HUBCO CFPP – Port Qasim CS 500 kV S/C out	-do-
24	Port Qasim CFPP – Port Qasim CS 500 kV S/C out	-do-
25	Port Qasim CFPP – K-2/K-3 500 kV S/C out	-do-
26	Matiari CS – Jamshoro 500 kV S/C out	-do-
27	Matiari CS – Moro 500 kV S/C out	-do-
28	Jamshoro – Dadu 500 kV S/C out	-do-
29	Engro Thar – Matiari CS 500 kV S/C out	-do-
30	SSRL – Matiari CS 500 kV S/C out	-do-
31	Matiari CS – Lahore South CS ±600kV HVDC mono pole out	-do-
32	Port Qasim CS – Faisalabad West ±600kV HVDC mono pole out	-do-
33	Moro – R.Yar Khan 500 kV S/C out	-do-
34	Lahore South CS – Lahore South 500 kV S/C out	-do-
35	Lahore South CS – Lahore North 500kV S/C out	-do-

Exhibit #	Contingency Conditions	Remarks
36	Faisalabad West – Ludewala 500 kV S/C out	-do-

b. Comments on Normal and N-1 Contingency Analysis

As per load flow study results of system scenario in peak load Aug/Sep 2021, the power flows on transmission lines and transformers in the vicinity of proposed HUBCO CFPP are well within their capacities. In general, the study depicts that the voltage profile of the system is within limits and there would be no transmission system constraints in the flow of power from the proposed HUBCO CFPP to the system under normal and N-1 contingency conditions.

4.4 Peak Load January 2022 (Winter Scenario)

Load flow study for the peak load condition of January 2022 under normal system condition has been carried out with the induction of 2x660 MW HUBCO CFPP and is attached as Exhibit #37. As per load flow study, the power flows on the circuits emanating from HUBCO CFPP plant and in their vicinity are as under:

Transmission Line	Power Flow
HUBCO CFPP –K-2/K-3 S/C	93 MW
HUBCO CFPP – Port Qasim CS S/C	1307 MW
K-2/K-3 - Port Qasim CFPP S/C	465 MW
Port Qsim CFPP – Port Qasim CS S/C	1665 MW
K-2/K-3 – Matiari CS (circuit #1&2)	738 MW
Matiari CS – Lahore-South CS ±600kV HVDC bipole	2x1800 MW
Port Qasim CS – Faisalabad West ±600kV HVDC bipole	2x1800 MW
Jamshoro - Matiari CS S/C	490 MW
Matiari CS – Moro S/C	383 MW
Engro Thar – Matiari CS S/C	870 MW

Transmission Line	Power Flow
SSRL – Matiari CS S/C	929 MW
Moro – R.Yar Khan S/C	527 MW
Jamshoro – Dadu (circuit #1)	705 MW
Jamshoro – Dadu (circuit #2)	787 MW
Dadu – Shikarpur (circuit #1)	416 MW
Dadu – Shikarpur (circuit #2)	461 MW

a. N-1 Contingency Analysis

The load flow studies have also been carried out for single line contingency (N-1) analysis in the vicinity of proposed HUBCO CFPP and are attached as Exhibit # 38-52. The results of contingency studies have been summarized as under:

Exhibit #	Contingency Conditions	Remarks
38	HUBCO CFPP – K-2/K-3 500 kV S/C out	Power flows on the other transmission lines and transformers as well as the voltage profile of the system remain within limits.
39	HUBCO CFPP – Port Qasim CS 500 kV S/C out	-do-
40	Port Qasim CFPP – Port Qasim CS 500 kV S/C out	-do-
41	Port Qasim CFPP – K-2/K-3 500 kV S/C out	-do-
42	Matiari CS – Jamshoro 500 kV S/C out	-do-
43	Matiari CS – Moro 500 kV S/C out	-do-
44	Jamshoro – Dadu 500 kV S/C out	-do-

Exhibit #	Contingency Conditions	Remarks
45	Engro Thar – Matiari CS 500 kV S/C out	-do-
46	SSRL – Matiari CS 500 kV S/C out	-do-
47	Matiari CS – Lahore South CS ±600kV HVDC mono pole out	-do-
48	Port Qasim CS – Faisalabad West ±600kV HVDC mono pole out	-do-
49	Moro – R.Yar Khan 500 kV S/C out	-do-
50	Lahore South CS – Lahore South 500 kV S/C out	-do-
51	Lahore South CS – Lahore North 500kV S/C out	-do-
52	Faisalabad West – Ludewala 500 kV S/C out	-do-

b. Comments on Normal and N-1 Contingency Analysis

As per load flow study results of system scenario in peak load January 2022, the power flows on transmission lines and transformers in the vicinity of proposed HUBCO CFPP are well within their capacities. In general, the study depicts that the voltage profile of the system is within limits and there would be no transmission system constraints in the flow of power from the proposed HUBCO CFPP to the system under normal and N-1 contingency conditions.

5. Conclusions

i) The following proposed interconnection scheme has been proposed for the reliable dispersal of power from 2x660 MW HUBCO CFPP to the National Grid in consideration of its capacity, indicated timeline & location and the existing/planned system network in the vicinity:

> *"A 500 kV D/C transmission line, approx. 220 km long, on Quad-bundled Greeley Conductor from HUBCO CFPP to the already planned Matiari Switching/Convertor Station"*

It is important to highlight that the above proposed interconnection arrangement for HUBCO CFPP would be modified later with the addition of other planned coastal power plants in future.

ii) Detailed load flow studies have been carried out for various operating scenarios of summer and winter with the above proposed interconnection scheme. It has been found on the basis of load flow study results that the power from 2x660 MW HUBCO CFPP can be dispersed to the National Grid in a reliable manner during normal and N-1 contingency conditions without any transmission constraints.

iii) M/s Hub Power Company Limited has provided detailed design data/parameters of HUBCO CFPP to NTDCL for the interconnection study. It is important to intimate that the generator power factor limits for HUBCO CFPP are 0.85 lagging/0.95 leading as opposed to 0.8 lagging/0.9 leading as mentioned in the NEPRA Grid Code. The load flow studies for this report have been carried out with the given generator power factor limits to assess their adequacy as per system requirements. However, this matter would be finalized after transient stability analysis which will be carried out in the Grid Interconnection Report-2.

iv) Some plant parameters required to carry out short circuit and transient stability studies were missing. NTDCL Planning Power is in continuous contact with M/s Hub Power Company Limited which is arranging the desired plant parameters from their plant designer. After receiptof the remaining plant parameters, short circuit and transient stability studies will be carried out and their results will be presented in the Grid Interconnection Report-2 (Final Report).

v) The comments of M/s Hub Power Company Limited and their plant designers on this report are welcome and would be incorporated in the Grid Interconnection Report-2 where found necessary.

Geographical Diagrams with Proposed Interconnection Scheme

Figure # 1: **NTDC Network Diagram with Proposed Interconnection Scheme for 2x660 MW HUBCO CFPP**

YEAR 2017-18

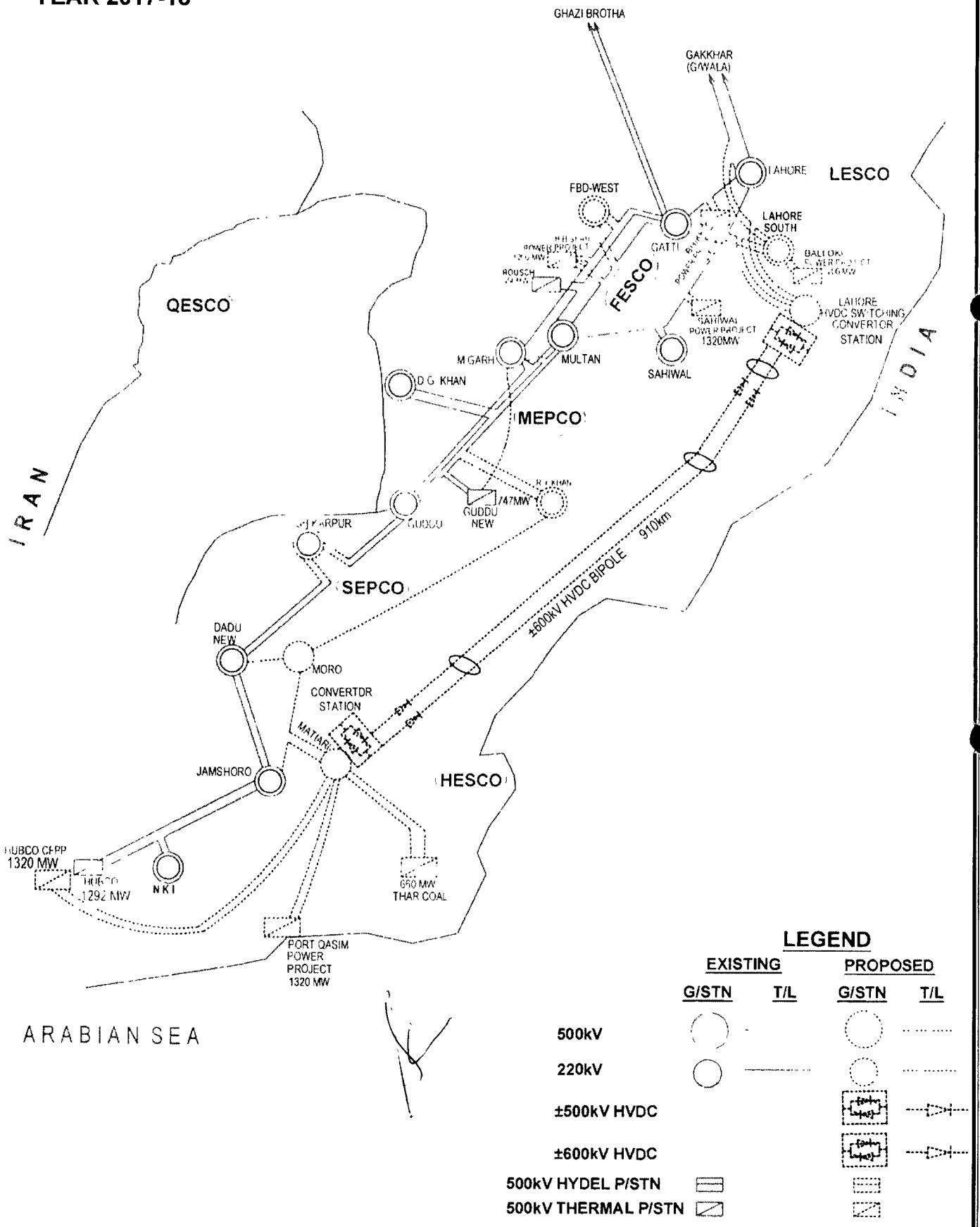


Figure # 2: **NTDC Network Diagram with Proposed Interconnection Scheme for 2x660 MW HUBCO CFPP**