MUGHAL ENERGY LIMITED

Ref: MEL/NEPRA/AGL-2019(1)

May 13, 2019

The Registrar
National Electric Power Regulatory Authority
NEPRA Tower, G-5/1
Islamabad.

Subject: - **APPLICATION OF MUGHAL ENERGY LIMITED FOR THE GRANT OF GENERATION LICENSE**

I, Mr. Khurram Javaid, Chief Executive Officer, being the duly authorized-representative of Mughal Energy Limited ("MEL") by virtue of BOARD RESOLUTION/POWER OF ATTORNEY DATED May 13, 2019 hereby apply to the National Electric Power Regulatory Authority for the grant of a GENERATION LICENSE to the MEL pursuant to Section 14-B of the regulations for Generation, Transmission and Distribution of Act 1997.

(2). I, certify that the documents in support attached with this application are prepared and submitted in conformity with provision of 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.

(3). A [Bank Draft/Pay Order in sum of Rupees 423560/- dated May 13, 2019 drawn on MCB Islamabad, 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.

Khurram Javaid
(Chief Executive Officer)
Mughal Energy Limited

Registered Office: 31-A, Shadman I,Lahore. Ph:# +92-42-35960841-3 Fax:+ 92-42-35960846
website:www.mughalsteel.com, Email:accounts@mughalsteel.com

MUGHAL ENERGY LIMITED

ABSTRACT OF RESOLUTION PASSED AT THE MEETING OF THE BOARD OF DIRECTORS OF MUGHAL ENERGY LIMITED HELD ON MAY 13, 2019 AT 31 A, SHADMAN 1 LAHORE

"Resolved that Mr. Khurram Javaid (Chief Executive Officer) and Mr. Shakeel Ahmad, (Chief Operating Officer) are hereby single authorized to produce affidavit on stamp paper to the National Electric Power Regulatory Authority on behalf of Mughal Energy Limited regarding all the filings of application for Generation License in respect of its 55.00 MW Coal Fired Power Project and in relation thereto enter into and execute all required documents, make all filings and pay all applicable fee and take all other steps in connection therewith, in each case, of any nature whatsoever."

I hereby confirm that the above resolution was duly passed by the Board of Directors of the Mughal Energy Limited in its meeting held on May 13, 2019 and the same has been entered in the minute book of the Company in accordance with the articles of the Company.

(Company Secretary)
Mughal Energy Limited

MUGHAL ENERGY LIMITED 31-Shadman-I, Lahore.

10

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE
LAHORE

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. 0080938

I hereby certify that MUGHAL STAR ENERGY 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 Lahore this Twenty Ninth day of August, Two Thousand and Twelve.

Fee Rs.7,000/-

(LIAQAT ALI DOLLA)
Joint Registrar Incharge

No.JRL/ Dated:

CERTIFIED TO BE TRUE COPY

17/12/13

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

THE COMPANIES ORDINANCE, 1984

(Company Limited by Shares)

MEMORANDUM OF ASSOCIATION

of

"MUGHAL ENERGY LIMITED"

I. The name of the Company is **"MUGHAL ENERGY LIMITED"**

II. The Registered Office of the Company will be situated in the Province of the Punjab.

III. The objects for which the Company is established are to carry out any or all of the following business:-

1. To carry on all or any of the businesses of generating, purchasing, importing, transforming, converting, distributing, supplying, exporting and dealing in electricity and all other forms of energy and products or services associated therewith and of promoting the conservation and efficient use of electricity and to perform all other acts which are necessary or incidental to the business of electricity generation, transmission, distribution and supply.

2. To make arrangement with power distribution companies for exchange of power supply and bridging of power supply arrangements.

3. To locate, establish, construct, equip, operate, use, manage and maintain power plants operated gas (Natural gas or coal gasification).

4. To locate, establish, construct, equip, operate, use, manage and maintain power plants grid station, transforming, switching, conversion, and transmission facilities, grid stations, cables, overhead lines, sub-stations, switching stations, tunnels, cable bridges,

link boxes, heat pumps, plant and equipment for combined heat and power schemes, offices, computer centres, shops, dispensing machines for pre-payment cards and other devices, showrooms, depots, factories, workshops, plants, printing facilities, warehouses and other storage facilities.

5. To carry on all or any of the businesses of wholesalers, retailers, traders, importers, exporters, suppliers, distributors, designers, developers, manufacturers, installer, filters, testers, repairers, maintainers, contractors, constructors, operators, users, reconditioners, improvers, alterers, removers, hirers, replacers of and dealers in, electrical appliances, systems, products and services used for energy conservation, equipments, machinery, materials and installations, including but not limited to cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity.

6. To ascertain the tariff for bulk supply that will secure recovery of operating costs, interest charges and depreciation of assets, redemption at due time of loans other than those covered by depreciation, expansion projects, payment of taxes, and reasonable return on investment, to quote the tariff to bulk purchasers of electrical power, and to prefer petition to the appropriate authority for approval of the schedule of tariff and of adjustments or increases in its bulk supply tariff, where desirable or necessary.

7. For the purposes of achieving the above objects, the company is authorized:-

(1) to purchase/import raw materials and allied items required in connection thereto in any manner the company may think fit;

(2) to do and perform all other acts and things as are incidental or conducive to the attainment of the objects of the company;

(3) to own, establish or have and maintain shops, branches and agencies all over Pakistan or elsewhere for sale and distribution of cables, wires, meters, pylons, tracks, rails, pipelines and any other plant, apparatus

equipment, systems and things incidental to the efficient generation, procurement, transformation, supply and distribution of electricity;

(4) to make known and give publicity to the business and products of the company by such means as the company may think fit;

(5) to purchase, acquire, protect, renew, improve, use and sell, whether in Pakistan or elsewhere any patent, right, invention, license, protection or concession which may appear advantageous or useful to the company for running the business;

(6) to pay all costs, charges and expenses, if any, incidental to the promotion, formation, registration and establishment of the company;

(7) to borrow and arrange the repayment of money from banks/financial institutions or any lawful sources whether in Pakistan or elsewhere and in such manner as the company may think fit, including the issue of debentures, preference shares, bonds, perpetual or otherwise charged upon the whole or any part of the company's property or assets, whether present or future, and to purchase, redeem or payoff such securities;

(8) to purchase, hold and get redeemed shares, debentures, bonds of any business, company, financial institution or any Government institutions;

(9) to guarantee the performance of contracts, agreements, obligations or discharge of any debt of the company or on behalf of any company or person in relation to the payment of any financial facility including but not limited to loans, advances, letters of credit or other obligations through creation of any or all types of mortgages, charges, pledges, hypothecations, on execution of the usual banking documents or instruments or otherwise encumbrance on any or all of the movable and immovable properties of the company, either present or future or both and issuance of any other securities or sureties by any other means in favour of banks, Non-Banking Finance Companies (NBFCs) or any financial

institutions and to borrow money for purpose of the company on such terms and conditions as may be considered proper.

8. It is, hereby, undertaken that the Company shall not engage in banking business or any business of investment company or non-banking finance company or insurance or leasing or business of managing agency or in any unlawful business and that nothing contained in the object clauses shall be so construed to entitle it to engage in such business directly or indirectly and the Company shall not launch multi-level marketing (MLM), *Pyramid* and *Ponzi* schemes.

9. Notwithstanding anything stated in any object clause, the Company shall obtain such other approval or license form competent authority, as may be required under law for the time being in force, to undertake a particular business.

LIABILITES OF MEMBERS

IV. The liability of the members is limited.

SHARE CAPITAL

V. The authorized capital of the company is Rs. 1,000,000/- (Rupees One Million only) divided into 10,000 ordinary shares of Rs. 100/- each with power to enhance, reduce or consolidate the share capital and to divide the shares of the company into different classes and kinds subject to the provisions of the Companies Ordinance, 1984.

We, the several persons, whose names and addresses are subscribed below are desirous of the being formed into a Company, under the Companies Ordinance, 1984 in pursuance of this Memorandum of Association, and we respectively agree to take the number of shares in the Capital of the Company given opposite our respective names:-

Name and surname (Present & Former) in Full (in Block Letter)	Father's/ Husband's Name in full	CNIC	National ity with any former National ity	Occupation	Residential address in full	Number of shares taken by each sub-scriber	Signature
Mirza Javaid Iqbal	Mirza Bashir Ahmed	35202-9761226-7	Pakistani	Business	House No. 31, Shadman Colony 1, Race Course Road Lahore.	1000	
Khurram Javaid	Mirza Javaid Iqbal	35202-9750871-7	Pakistani	Business	House No. 130-F, Phase - V DHA Lahore.	670	
Muhammad Mubeen Bin Tariq Mughal	Muhammad Tariq Iqbal Mughal	35201-0221455-5	Pakistani	Business	House No. 111-E, Phase-I, Defence Housing Authority Lahore.	1670	
Jamshed Iqbal	Bashir Ahmed	35201-2176101-7	Pakistani	Business	House No. 1, Phase-1, Defence Housing Authority Lahore.	1670	
	TOTAL SHARE					5010	

Dated the 19th day of **June 2012**

Witness to above signature

Full Name: National Institutional Facilitation Technologies (Pvt) Ltd.

Signature: _____

Occupation: Services (Public/Private) Ltd.

Full Address: 5th Floor, AWT Plaza

I.I. Chundrigar Road, Karachi, Pakistan

CERTIFIED TO BE TRUE COPY

28/5/14

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

THE COMPANIES ORDINANCE, 1984

(Company Limited by Shares)

ARTICLES OF ASSOCIATION

of

"MUGHAL ENERGY LIMITED"

1. The regulations in Table "A" in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except as reproduced herein:

2. In these Articles, unless the context or the subject matter otherwise reamers:

a) "Articles" means these Articles as originally framed or as from time to time altered in accordance with law.

b) "Board" means a meeting of the Directors duly called and constituted or as the case may be, the Directors assemble at a Board.

c) Company" means **"MUGHAL ENERGY LIMITED"**

d) "Directors" means the Directors for the time being of the Company or as the case may be, the Directors assembled at a Board.

e) "Month" means calendar month according to the English Calendar.

f) "Office" means the Registered Office for the time being of the Company.

g) "Ordinance" means the Companies Ordinance, 1984 or any modification or re-enactment thereof for the time being in force.

h) "Register" means, unless the context otherwise requires, the register of members to be kept pursuant to Section 147 of the Ordinance.

i) "Seal" means the common or official Seal of the Company.

j) "Section" means Section of the Ordinance.

k) "Special Resolution" means the special resolution of the Company as Defined in Section (2) (1) (36) of the Ordinance.

l) Words importing masculine gender include the feminine gender.

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

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

o) Words importing persons shall include bodies corporate.

p) The head notes are inserted for convenience and shall not affect the construction of these Articles.

q) Unless the context otherwise requires words or expressions contained in these Articles shall bear the same meaning as in the Ordinance.

PUBLIC COMPANY

3. The Company is a Public Company within the meanings of Section 2(1) (30) of the Companies Ordinance, 1984.

BUSINESS

4. The business of the Company shall include all or any of the objects enumerated in the Memorandum of Association.

5. The directors shall have regard to the restrictions on the commencement of the business imposed by section 146 of the Companies Ordinance, 1984, if and so far as those restrictions are binding upon the company.

CAPITAL

6. The authorized Capital of the Company is Rs.1,000,000/-, (Rupees One Million only) divided into 10,000/- ordinary shares of Rs. 100/- (Rupees One Hundred Only) each. The Company shall have the powers to increase, reduce or alter the capital in accordance with law.

7. The Directors shall, as regards any allotments of shares duly comply with such of the provisions of Section 68 to 73 as may be applicable to the Company.

8. The minimum subscription upon which the directors may proceeds to make first allotment has been fixed at Rs. 500,000/-

9. Every person whose name is entered as a member in the Register shall, without payment, be entitled to receive within ninety days after allotment or within forty-five days of the application for registration of transfer, a certificate under the Seal specifying the share or shares held by him and the amount paid up thereon. Provided that, in respect of a share or shares held jointly by several persons, the Company shall not be bound to issue more than one certificate, and delivery of a certificate for a share to one of several joint holders shall be sufficient delivery to all.

10. If a Share Certificate is defaced, lost or destroyed, it may be renewed on payment of such fee, if any, not exceeding one rupee, and on such terms, if any, as to evidence and indemnity any payment of expenses incurred by the Company in investigating title as the Directors think fit.

11. Except to the extent and in the manner allowed by Section 95, no part of the funds of the Company shall be employed in the purchase of, or in loans upon the security of, the Company's shares.

TRANSFER OF SHARES

12. The instrument of transfer of any share in the Company shall be executed both by the transferor and transferee and the transferor shall be deemed to remain holder of the share until the name of the transferee is entered in the Register in respect thereof.

13. Shares in the Company shall be transferred, without *fee,* in the following form, or in any usual or common form which the Directors shall approve;

I..... of.....in consideration of the sum of Rs .....Paid to me by..... .....of..... .....(hereinafter called the "Transferee" do hereby transfer to the Transferee .....the

share(s) ... ...\.. to :.....inclusive,' **"MUGHAL ENERGY LIMITED"** to hold into the transferee, his executors, Administrators and assigns, subject to the several conditions on which I held the same at the time of the Transferee, do hereby agree to take the said share (or shares) subject to the conditions aforesaid.

As witness our hands this..... day of..... 201

Transferor **Transferee**

_____ _____

Signature Signature

WITNESSES:

1._____

2_____.

(Signature) (Signature)
Full Address: Full Address
of

14. The Directors shall not refuse to transfer any fully paid shares unless the transfer deed is defective or invalid. The Directors may also suspend the registration of transfer prior to the determination of entitlement or rights of the shareholders by giving seven days previous notice in the manner provided in the Ordinance. The Directors may decline to recognize any instrument of transfer unless the duly stamped instrument of transfer is accompanied by the certificate of the shares to which it relates, and such other evidence as the Directors may reasonably require showing the right of the transferor to make the transfer.

15. If the Directors refuse to register a transfer of shares, they shall within thirty (30) days after the date on which the transfer deed was lodged with the Company send to the transferee and the transferor notice of the refusal indicating 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. The transferor or transferee or the person who gave intimation of the transmission by operation of law, as the case may be, may appeal to the

commission against any refusal of the Company to register the transfer or transmission or against any failure on its parts within period as specified in Section 78 for which Section 78/A will be applicable.

TRANSMISSION OF SHARES

16. The executors, administrators, heirs, or nominees as the case may be, of a deceased sole holder of a share shall be the only persons recognized by the Company as having any title to the shares. In the case of a share registered in the names of two or more holders, the survivor or survivors, or executors or administrators of the deceased survivor shall be the only persons recognized by the Company as having any title to the share.

17. Any person becoming entitled to a share in consequence of the death or insolvency of a member shall, upon such evidence being produced as may from time to time be required by the Directors, have the right, either to be registered as a member in respect of the share or, instead of being registered himself, to make such transfer of the share as the deceased or insolvent person could have made; but the Directors shall, in either case have the same right to decline or suspend registration as they would have had in the case of a transfer of the share by the deceased or insolvent person before the death or insolvency.

18. A person becoming entitled to a share by reason of the death or insolvency of the holder shall be entitled to the same dividends and other advantages to which he would be entitled if he were the registered holder of the share, except that he shall not, before being registered as a member in respect of the share be entitled in respect of it to exercise any right conferred by membership in relation to meetings by the Company.

ALTERATION OF CAPITAL

19. The Company may from time to time, by special resolution increase the share capital by such sum, to be divided into shares of such amount, as the resolution shall prescribe.

20. Subject to the Provisions of the Ordinance, all new shares shall, before issue be

offered to such persons as at the date of the offer are entitled to receive notices from the Company of General Meetings in proportion, as nearly as the circumstances admit, to the amount of the existing shares to which they are entitled. The offer shall be made by notice specifying the number of shares offered, and limiting a time within which the offer if not accepted, will be deemed to be declined and after the expiration of that time, or on the receipt of an intimation from the person to whom the offer is made that he declines to accept the shares offered, the Directors may 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 shares held by persons entitled to an offer of new shares) cannot, in the opinion of the Directors, be conveniently offered under this regulation.

21. Subject to the provisions of Section 87 of the Ordinance, the Company may issue ordinary shares or grant option to convert into ordinary shares the outstanding balance of any loans advances or credit or other non-interest bearing securities and obligations or having a term of not less than three years in the manner provided in any contract with any scheduled bank or financial institution to the extent of twenty per cent (20%) of such balance.

22. The new shares shall be subject to the same provisions with reference to transfer, transmission and otherwise as the shares in the original share capital.

23. The Company may, by ordinary resolution:

a) Consolidate and divide its share capital into shares of larger amount than its existing shares;

b) sub-divide its existing shares or any of them into shares of smaller amount than is fixed by the Company's Memorandum of Association, subject, nevertheless, to the provisions to clause (d) of sub-section (1) of Section (92).

c) Cancel any shares which at the date of passing of the resolution have not been taken or agreed to be taken by any person.

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

GENERAL MEETINGS

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

26. A General Meeting to be called Annual General Meeting, shall be held in accordance with provisions of Section 158, within eighteen months from the date of incorporation of the Company thereafter once at least in every calendar year within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding Annual General Meeting as may be determined by the Directors.

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

28. The Directors may whenever they think fit, call an Extraordinary General Meeting, and Extraordinary General Meetings shall also be called on such requisition, or in default, may be called by such requisition as is provided by Section 159. If at any time there are not within Pakistan sufficient Directors capable of acting to form a quorum, any Director of the Company may call an Extraordinary General Meeting in the same manner as nearly as possible as that in which Meetings may be called by the Directors.

NOTICE AND PROCEEDINGS OF GENERAL MEETINGS

29. Twenty one days notice at least (exclusive of the day on which the notice is served or deemed to be served, but inclusive of the day for which notice is given) specifying the place, the day and the hour of Meeting and, in case of special business, the general nature of that business, shall be given in the manner provided by the Ordinance for the General Meeting, to such persons as are, under the Ordinance or the regulations of the Company, entitled to receive such notices from the Company; but the accidental omission to give

notice to, or the non-receipt of notice by, any member shall not invalidate the proceedings at any General Meeting.

30. All business shall be deemed special that is transacted at an Extraordinary General Meeting, and also all that is transacted at an Annual General Meeting, with the exception of declaring a dividend, the consideration of the accounts, balance sheet and the reports of the Directors and auditors, the election of Directors, the appointment of and the fixing, of the remuneration of the auditors.

31. No business shall be transacted at any General Meeting unless a Quorum of members is present at that time when the meeting proceeds to business. Two members present personally who represent not less than twenty five per cent of the total voting power, either on their own account or as proxies shall be a quorum.

32. If within half an hour from the time appointed for the 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 the 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, shall be a quorum.

33. The Chairman of the Board of Directors, if any, shall preside as Chairman at every General Meeting of the Company, but if there is no such Chairman, or if at any meeting he is not present within fifteen minutes after the time appointed for the meeting, or is unwilling to act as Chairman, anyone of the Directors present may be elected to be Chairman, and if none of the Directors is present, or willing to act as Chairman, the members present shall choose one of their member to be Chairman.

34. The Chairman may, with the consent of any 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.

35. At any General Meeting a resolution put to the vote of the meeting shall be decided on a show of hands unless a poll is (before or on the declaration of the result of the show of hands) demanded. Unless a poll is so demanded, a declaration by the Chairman that a resolution has, on a show of hands, been carried, or carried unanimously, or by a particular majority, or lost, and an entry to that effect in the book of the proceedings of the Company shall be conclusive evidence of the fact, without proof of the number or proportion or the votes recorded in favor of, or against, that resolution.

36. A Poll may be demanded only in accordance with the provisions of Section.

37. If a Poll is duly demanded it shall be taken in accordance with the manner laid down in Section 168 and the result of the Poll shall be deemed to be the resolution of the meeting at which the Poll was demanded.

38. A Poll demanded on the election of Chairman or on a question of adjournment shall be taken at once.

39. In the case of an equality of Votes, whether on a show of hands or on a poll, the Chairman of the meeting at which the show of hands takes place, or at which the Poll is demanded, shall have and exercise a second or Casting Vote.

VOTES OF MEMBERS

40. On a show of hands every member present in person shall have one Vote except for election of Directors in which case the provisions of Section 178 shall apply. On a Poll every member shall have voting rights as laid down in Section 160.

41. 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.

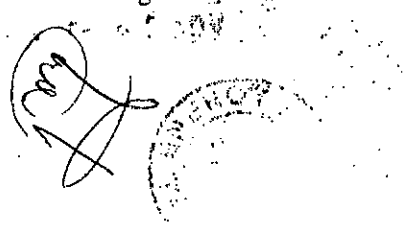
42. A member of unsound mind, or in respect of whom an order has been made by any Court having jurisdiction in lunacy, may vote, whether on show of hands or on a poll, by his committee or other legal guardian, and any such committee or guardian, on a poll vote by proxy.

43. On a poll vote may be given either personally or by proxy. Provided that nobody corporate shall vote by proxy as long as a resolution of its Directors in accordance with the provisions of Section 162 is in force.

44. The instrument appointing a Proxy shall be in writing under the hand of the appointer or of his attorney duly authorized in writing. A Proxy must be a member of the Company.

45. The Instrument appointing a Proxy and the power of attorney or other authority (if any) under which it is signed, or a materially certified copy of that power or authority, shall be deposited at the Registered Office not less than forty eight 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.

46. An instrument appoint" as near thereto as may be. In the following form, or a form as near thereto as may be,



MUGHAL ENERGY LIMITED

47. I/We ----------of ----------
----------full+ address) being the member(s) of MUGHAL ENERGY LIMITED hereby appoint Mr. /Mrs./Miss. ----------
----------of ----------(who is

also member of the Company vide Registered Folio No.----------
----(being the Company) as my / our Proxy to attend at and vote for my / us on my / our behalf at the ----------Annual /Extra Ordinary General Meeting of the Company to be held at ----------on ----------
---at----------and at any adjournment thereof.

48. A vote given in accordance with the terms of an instrument of 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 transfer of the share in respect of which the proxy is given, provided that no intimation in writing of such death, insanity, revocation or transfer as aforesaid shall have been received by the Company at the office before the commencement of the meeting or adjourned meeting at which the proxy is used.

DIRECTORS

49. Unless otherwise determined by the Company in General Meeting the number of Directors shall not be less than three and if the Company applies for listing on Stock Exchanges, then the number of Directors shall not be less than seven.

50. The following are the Present Directors of the Company.

1. MIRZA JAVAID IQBAL
2. KHURRAM JAVAID
3. MUHAMMAD MUBEEN BIN TARIQ MUGHAL
4. JAMSHED IQBAL

51. Save as provided in Section 187, no person shall be appointed as a Director unless he is a member of the Company and holds shares of the minimum value of Rs. 1,000/- in his own name relaxable in the case of Director representing interest holding shares.

52. The remuneration of a Director for performing extra services, including holding of the office of Chairman, and the remuneration to be paid to any Director for attending the meetings of the Directors or a committee of Directors shall from time to time be determined by the Board of Directors in accordance with law.

CHAIRMAN

53. The Directors may from time to time appoint one of their members to be the Chairman of the Company for a period not exceeding three years on such terms and conditions as they deem fit. The Chairman shall preside over the meetings of the Board of Directors and members of the Company. In his absence, the Directors may elect one of them to preside over the Board Meeting. The questions arising at the meeting of the Directors shall be decided by a majority of votes. In the case of equality of votes, the Chairman, or the Director presiding over the meeting, as the case may be, shall have a casting vote.

CHIEF EXECUTIVE

54. The first Chief Executive of the Company will be appointed by the Board of Directors within fifteen days from the date of incorporation of the Company who shall hold office till the first Annual General Meeting.

POWERS AND DUTIES OF DIRECTORS

55. 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 any statutory modification thereof for the time being in force, or by these regulations, required to be exercised by the Company in General Meeting, subject nevertheless to the provisions of the Ordinance or to any of these regulations, and such regulations being not inconsistent with the aforesaid provisions, as may be prescribed by the Company in General Meeting but 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.

BORROWING POWERS

56. The Board may borrow from time to time, subject to section 146, any money for the purposes of the Company from its members or from any other person, firms, companies, corporations, Government Agencies, institutions or the Directors may themselves lend moneys to the Company.

57. The Board may raise and secure payment of such sums of money in such manner and upon such terms and conditions in all respects as it may think fit, and in particular by the issue of TFC's bonds, perpetual or redeemable debentures or by mortgage or charge or other security on the whole or any part of the property, assets and rights of the Company (both present and future), of the Company.

58. Any TFC's, bonds, debentures or other securities issued or to be issued by the Company shall be under the control of the Board which may issue them upon such terms and conditions and in such manner and for such consideration as shall be considered to be for the benefit of the Company.

59. Any TFC's, bonds, debentures or other securities may be issued with any special privileges as to redemption, surrender, drawing, convertibility into shares, attending and voting at General Meetings of the Company, appointment of Directors, and otherwise, provided that debentures with the right to vote or to be converted into shares shall be issued with the consent of the Company in General Meeting in terms of Section 114 of the Ordinance.

60. The Directors may from time to time, by Power of Attorney under the Company's seal, appoint any person or persons to be the Attorneys of the Company for such purposes and with such powers, authorities, and discretions (not exceeding those vested in, or exercisable by, the Directors under these presents) and for such period and subject to such conditions as the Directors may from time to time think fit. Any such attorney(s) may, if authorized by the Directors, delegate all or any of the powers vested in him/them.

61. The Directors shall duly comply with the provisions of the Ordinance and in particular with the provisions in regard to the registration of the particulars of mortgages and charges affecting the property of the Company or created by it, to the keeping of a register of the Directors, and to the sending to the Registrar of an annual list of members and a summary of particulars relating thereto and notice of any consolidation or increase of share capital, or sub-division of shares, and copies of Special Resolutions and a copy of the register of Directors and notifications of any changes therein.

62. The Director shall cause minutes to be made in books provided for the purpose of :

a) all appointments of officers made by the Directors;

b) the names of the Directors present at each meeting of the Directors and of any Committee of the Directors;

c) all resolutions and proceedings at all meetings of the Company and of the Directors and of Committees of Directors;

d) and every Director present at any meeting or Directors of Committee of Directors shall sign his name in a book to be kept for that purpose.

DISQUALIFICA TION OF DIRECTORS

63. No person shall become a Director of the Company if he suffers from any of the disabilities or disqualifications mentioned in Section 187 and, if already a Director, shall cease to hold such office from the date he so becomes disqualified or disabled or provided, however, that no Director shall vacate his office by reason only of his being a member of any company which has entered into contracts with, or done any work for the Company but such Director shall not vote in respect of any such contract or work, and if he does so his vote shall not be counted.

PROCEEDINGS OF DIRECTORS

64. The Directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. The quorum for a meeting of Directors shall not be less than one-third or two, whichever is greater. Questions arising at any meeting shall be decided by a majority of votes. In case of an equality of votes, the Chairman shall have and exercise a second or casting vote. A Director may, and the secretary on the requisition of a Director shall, at any time, summon a meeting of Directors. It shall not be necessary to give notice of a meeting of Directors to any Director for the time being absent from Pakistan.

65. The Directors may elect a Chairman of their meetings and determine the period for which he is to hold office but, if no such Chairman is elected, or if at any meeting the Chairman is not present within ten 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.

66. The Directors may delegate any of their powers not required to be exercised in their meeting to Committees consisting of such member or members of their body as they think fit. Any Committee so formed shall, in the exercise of the powers so delegated, conform to any restrictions that may be imposed on them by the Directors.

67. A Committee may elect a Chairman of its meetings, but, if no such Chairman is elected, or if at any meeting the Chairman is not present within ten minutes after the time appointed for holding the same or is unwilling to act as Chairman, the members present may choose one of their numbers to be Chairman of the meeting.

68. A Committee may meet and adjourn as it thinks proper. Questions arising at any meetings shall be determined by a majority of votes of the members present. In case of an equality of votes, the Chairman shall have and exercise a second or casting vote.

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

70. A resolution in writing circulated to all the Directors signed by all the Directors or affirmed by them through telex or telegram shall be as valid and effectual as if it had been passed at a meeting of the Directors duly convened and held.

ELECTION AND REMOVAL OF DIRECTORS

71. At the first Annual General Meeting of the Company, all the Directors shall stand retired from office, and thereafter shall be re-elected in their place in accordance with Section 178 for a term of three years.

72.. A retiring Director shall be eligible for re-election.

73. The Directors of the Company, unless the number of persons who offer themselves to be elected is not more than the number of Directors fixed by the Board of Directors, shall be elected to office by the members in General Meeting in the following manner:

(a) 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.

(b) 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.

(c) 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.

74. Subject to the provisions of the Ordinance, the Company may from time to time in General Meeting increase or decreases the number of Directors.

75. Any Casual vacancy occurring on the Board of Directors may be filled up by the Directors, but the person so chosen shall be subject to retirement at the same time as if he had become a Director on the day on which the Director in whose place he is chosen was last elected as Director.

76. The Company may remove a Director but only in accordance with the provisions of the Ordinance.

NOMINEE DIRECTOR

77. In addition to the elected Directors, the Financial Institutions shall be entitled, during the currency of their respective loan(s) to the Company, to appoint one person on the Board of Directors of the Company to be called Nominee Director and to recall and/or replace such a person from time to time. Such Nominee Director on the Board of Directors of the Company may not be holder of Share(s) in the Capital of the Company and the Articles 67 to 72 and other regulations and or rules pertaining to the election, retirement, qualification and/or disqualification of the Director shall not apply to him.

THE SEAL

78. The Directors shall provide a Common Seal of the Company which shall not be affixed to any instrument except by the authority of a resolution of the Board or by a committee of Directors authorized in that behalf by the Directors, and two Directors of one Director and the secretary of the Company shall sign every instrument to which the Common Seal is affixed.

79. The Directors may provide for the use in any territory, district or place not situated in Pakistan, of an Official Seal which shall be a facsimile of the Common Seal of the Company, with the addition on its face of the name of every territory, district or place

where it is to be used. The provisions of Section 213 shall apply to the use of the Official Seal.

DIVIDENDS AND RESERVES

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

81. 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.

82.No dividend shall be paid otherwise than out of profits of the year or any other undistributed profits.

83. Subject to the rights of persons (if any) entitled to shares, all dividends shall be declared and paid according to the amounts paid on the shares, but if and so long as nothing is paid upon any of the shares in the Company, dividends may be declared and paid according to the amounts of the shares.

84. 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, either 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, from time to time think fit.

85. The Directors may carry forward any profits which they may think prudent not to distribute, without setting them aside as a reserve.

86. Any General Meeting may resolve that any moneys, investments, or other assets

forming part of the undivided profits of the Company standing to the credit of any reserve or other fund or in the hands of the Company and available for dividend (or representing premiums received on the issue of shares and standing to the credit of the shares premium account) be capitalized and distributed amongst such of the shareholders as would be entitled to receive the same if distributed by way of dividend and in the same proportions on the footing that they become entitled thereto as capital and that all or any part of such capitalized fund be applied on behalf of such shareholders in paying up in full, any unissued shares, debentures or debenture-stock of the Company which shall be distributed accordingly and that such distribution or payment shall be accepted by such shareholders in full satisfaction of their interest in the said capitalized sum.

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

88. If several persons are registered as joint holders of any share, anyone of them may give effectual receipt for any dividend payable on the shares.

89. Notice of any dividend that may have been declared shall be given in the manner hereinafter mentioned to the persons entitled to share therein.

90. The dividend shall be paid within the period laid down in Section 251.

91. All dividends unclaimed for six years after having been declared shall be kept in trust by the Company but may be invested or otherwise made use of by the Directors for the benefit of the Company until claimed.

ACCOUNTS

92. The Directors shall cause to be kept proper Books of Account as required under Section 230.

93. The Books of Account shall be kept at the Registered Office of the Company or at such other place as the Directors shall think fit and shall be open to inspection by the Directors during business hours.

94. The Directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or regulations the accounts and books or papers of the Company or any of them shall be open to the inspection of members not being Directors, and no member (not being a Director) shall have any right of inspecting any Account and Book or papers of the Company except as conferred by law or authorized by the Directors or by the Company in General Meeting.

95. The Directors shall as required by Sections 233 and 236 causes to be prepared and to be laid before the Company in General Meeting such Profit and Loss Accounts and Balance Sheets and reports as are referred to in those sections.

96. A Balance Sheet, Profit and Loss Account, and other reports referred to in the preceding Article shall be made out in every year and laid before the Company in the Annual General Meeting made up to a date not more than four months before such meeting. The Balance Sheet and Profit and Loss Account shall be accompanied by a report of the auditors of the Company and the report of Directors.

97. A copy of the Balance Sheet and Profit and Loss Account and reports of Directors and auditors shall, at least twenty one days preceding the meeting, be sent to the persons entitled to receive notices of General Meetings in the manner in which notices are to be given as hereinafter provided.

98. Every Account of the Directors when audited and approved by a General Meeting shall be conclusive except as regards any errors discovered therein within three months next after the approval thereof. Whenever any such error is discovered within that period the account shall forthwith be corrected and thenceforth shall be conclusive.

99. The Directors shall in all respect comply with the provisions of Sections 230 to 236.

AUDIT

100. Once at least every year the accounts of the Company shall be audited and the correctness of Profit and Loss Account and Balance Sheet ascertained by one or more Auditors. The Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255 of the Companies Ordinance 1984.

SECRETARY

101. The Board may appoint a Secretary of the Company who shall perform such functions and duties as are required in these Articles, or as may be directed by the Board.

NOTICES

102. Notices shall be given by the Company to Members and Auditors of the Company and other persons entitled to receive notices in accordance with Section 50.

SECRECY

103. Every Director, Manager, Adviser, Auditor, Trustee, Member of a Committee, Officer, Servant, Agent, Accountant or other person employed in the business of the Company shall, if so, required by the Directors, before entering upon his duties, sign a declaration pledging himself to observe a strict secrecy respecting all transactions of the Company with its customers and the state of accounts with individuals and in matters relating thereto, and shall by such declaration pledge himself not to reveal any of the matters which may come to his knowledge in the discharge of his duties except when required to do so by the Directors or by any General Meeting or by any Court of Law and except so far as may be necessary in order to comply with any of the provisions in these presents.

104. No member or other person (not being a Director) shall be entitled to enter upon the

property of the Company or examine the Company's premises or properties without the permission of the Directors, and to require discovery of or 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 of any matter whatsoever which may relate to the conduct of the business of the Company and which in the opinion of the Directors will be inexpedient, in the interest of the members of the Company to communicate.

RECONSTRUCTION

105. On any sale of the undertakings of the Company the Directors or the liquidators on a winding up may, if authorized by a Special Resolution, accept fully paid shares, debentures or securities of any other company, either then existing or to be formed for the purchase in whole or in part of the property of the Company, and the Directors (if the profits of the Company permit), or the liquidators (in a winding up), may distribute such shares or securities, or any other properties of the Company amongst the members without realization, or vest the same in trustees for them and any Special Resolution may provide for the distribution or appropriation of the cash, shares or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the members or contributories of the Company for the valuation of any such securities or property at such price and in such manner as the meeting may approve and all holders of shares shall be bound to accept and shall be bound by any valuation or distribution so authorized and waive all rights in relation thereto save only such statutory rights (if any) as are, in case the Company is proposed to be or in the course of being wound up, incapable of being varied or excluded by these presents.

WINDING UP

106. 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 Ordinance, divide amongst the members in specie or kind the whole or any part of the assets of the Company (whether they consist of property of same kind or not) and may, for such purpose, 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 or different classes of members. The liquidator may, with the like sanction, vest the whole or any part of such assets in trustees upon such trust for the benefit of the contributories, as the liquidator with the like sanction, shall think fit, but so that no member shall be compelled to accept any shares or other securities whereon there is any liability.

INDEMNITY

107. Every officer or agent for the time being of the Company may be indemnified out of the assets of the Company against any liability incurred by him in defending any proceedings, whether civil or criminal, arising out of his dealings in relation to the affairs of the Company, except those brought by the Company against him, in which judgment is given in his favor or in which he is acquitted, or in connection with any application under Section 488 in which relief is granted to him by the Court.

ARBITRATION

108. Whenever any difference arises between the Company on the one hand and any of the members, their executors, administrators or assignees on the other hand, touching the true intent or construction, or the incident or consequences of these Articles or of the statutes or touching anything there or thereafter done, executed, omitted or suffered in pursuance of these Articles or of the statutes or touching any breach or alleged breach of these Articles, or any claim on account of any such breach or alleged breach, or otherwise relating to the premises, or to these Articles or to any statute affecting the Company or to any of the affairs of the Company, every such difference shall, as a condition precedent to any other action at law be referred in conformity with the Arbitration Act, 1940, or any statutory modification thereof and any rules made there under, to the decision of an Arbitrator to be appointed by the parties in difference or if they cannot agree upon a single Arbitrator to the decision of two Arbitrators of whom one shall be appointed by each of the parties in difference, or in the event of the two Arbitrators not agreeing, then of an umpire to be appointed by the two Arbitrators, in writing, before proceeding on the reference, and such decision shall be final and binding on the parties.

We the several persons whose names and addresses are given below subscribed are desirous of being formed into a company, in pursuance of this Article 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 & Former) in Full (in Block Letter)	Father's/ Husband's Name in full	CNIC	Nationality with any former Nationality	Occupation	Residential address in full	Number of shares taken by each subscriber	Signature
Mirza Javaid Iqbal	Mirza Bashir Ahmed	35202-9761226-7	Pakistani	Business	House No. 31, Shadman Colony 1, Race Course Road Lahore.	1000	
Khurram Javaid	Mirza Javaid Iqbal	35202-9750871-7	Pakistani	Business	House No. 130-F, Phase - V DHA Lahore.	670	
Muhammad Mubeen Bin Tariq Mughal	Muhammad Tariq Iqbal Mughal	35201-0221455-5	Pakistani	Business	House No. 111-E, Phase-I, Defence Housing Authority Lahore.	1670	
Jamshed Iqbal	Bashir Ahmed	35201-2176101-7	Pakistani	Business	House No. 1, Phase-1, Defence Housing Authority Lahore.	1670	
	TOTAL SHARE					5010	

Dated the 19th day of **June 2012**

Witness to above signature

Full Name: National Institutional Facilitation Technologies (Pvt) Ltd.

Signature: _____

Occupation: Services (Public/Private) Ltd.

Full Address: 5th Floor, AWT Plaza

I.I. Chundrigar Road, Karachi, Pakistan

CERTIFIED TO BE TRUE COPY

28/8/14

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

3(5)(g)(a)
Type of Technology

* Plant Details & Other Details

1. **Plant Configuration**

- Type of turbines ..... Steam Turbines Thermal on Coal Operation
- Capacity of the Power Plant.....55 MW (Gross) / Net 50 MW (Net Power Output)
- Type of Technology .....Steam Unit with CFBC Boiler
- Number of Units / Capacity .....55 MW Coal Fired Power Project
- Power Plant Make and Model .....Provided later

2. **Fuel Details**

- Type of Fuel.....Coal (Imported / Indigenous) Indigenous
- Fuel Supplier.....Will be selected through bidding process

3. Expected Life of the Facility .....30 years

4. **Plant Characteristics**

- Generating Voltage .....11 KV
- Frequency.....50 Hz
- Automatic Generation Control .....No
- Ramping Rate.....to be provided later on
- Alternative Fuel.....No
- Time required to Synchronize .....to be provided later on COD

Technical parameters of the coal plant as are under:-

-	Plant Capacity:	55 MW
-	Boiler Technology:	Circulating Fluidized Bed Combustion (CFBC)
-	Coal Source : blended	Imported coal - South African / Indonesian or indigenous coal
-	Plant gross efficiency:	37.58%

Boiler technologies namely pulverized combustion (PC) and circulating fluidized bed combustion (CFBC) have been studied along with their relative merits and demerits. One of CFBC's key advantages is its ability to use a wider range of fuels, from indigenous coal to imported Indonesian and South African coal.

* The power generated will be dispersed to the utility i.e LESCo and which will be subsequently wheeled to diffent locations of Mugal steels Limited.

Steam Turbine and Auxiliaries

The steam turbine will consists of proven single casing turbine straight condensing, horizontally split machine with uncontrolled extractions for two (2) LP heaters, Two (2) HP heaters and One(1) De-aerator. The TG set will be designed for a maximum throttle steam flow at turbine valve wide open (VWO) condition of 105% of turbine rated conditions. The major turbine cycle parameters at 100% TMCR are as given below:

S.N	Parameters	Values
1	Turbine MCR output at generator terminals	55 MW
2	Main Steam Inlet Pressure	14 MPa
3	Main Steam Inlet Temperature	545 °C
4	Exhaust pressure	0.0074 Mpa
5	Turbine speed	3000 rpm
6	DM water make up requirement to thermal cycle	Max. 3%; zero considered in Guarantee case
7	Condenser type	Surface type Water cooled
8	Cooling Type	By 1 no. Induced Draft Cooling Tower

Generator and Excitation System

The Generator will be capable of continuous safe operation at rated output and power factor under any of the following conditions for system compatibility:

- Terminal voltage variation of +/- 5% of the rated value.
- Frequency variation within 47.5 to 51.5 Hz.
- Absolute sum of combined voltage & frequency variation of not beyond 5%.

The Generator winding will be star connected with the phase & neutral terminals brought out for connection to isolated phase bus duct. The star neutral point will be grounded through a transformer ground resister in the secondary circuit.

Coal parameters

The power plant will be operated with a mixture of several types of coal as a basic fuel. The basic fuel for the first ca. five years of power plant operation will be imported coal only. The coal is planned to be imported from South Africa and Indonesia. After first ca. five years of power plant operation it is anticipated to utilize mixture of imported and local fuel. The mixture is presumed at maximum ratio 50:50. Preliminary parameters of imported and local coal are specified in following chapters. The parameters are considered as preliminary and are not sufficient for Conceptual Design elaboration.

Imported coal

Preliminary imported coal analyses see in Tab. 1: Imported coal parameters (Indonesian coal – type INDO A and Coal from South Africa – type RB1 or RB2).

Tab. 1: Imported coal parameters

BASIC IMPORTED COAL ANALYSIS					
Parameter	**Name**	**Unit**	**Indonesian Coal – INDO A**	**South Africa Coal – RB1**	**South Africa Coal – RB2**
Q_i^r	Lower heating value	kcal/kg	6 000	6 000	6 000
Q_i^r	Lower heating value	MJ/kg	25.12	25.12	25.12
W_t^r	Total moisture	% by weight	15.0	12.0	12.0
A^r	Ash	% by weight	15.0	15.0	15.0
S_t^r	Sulphur	% by weight	1.0	1.0	1.0
Size 90%	-	mm	50	50	50

Local coal

Preliminary local coal analyses:

Basic limits for fluidized bed technology (circulating fluidized bed):

Lower heating value (as received) Q_i^r min. 5 300 kcal/kg, max. 6 900 kcal/kg

Total moisture W_t^r max 40 %

Ash (as received) A_r min 10 %

Sulphur (as received) Combustion of a local coal with imported coal at ratio 50:50 – max S_r = 5.7 % (concentration higher than the value (5.7 %) – Necessary installation of semi dry method for reduction SO_2)

Maximum grain size 50 mm

The input data are taken from document: "Coal Characteristics in Pakistan" – Punjab locality – mine "Salt range" (reserve 213 mil. tones – 30 mil. tones are mineable) summarized in Tab. 2: Local coal parameters.

Tab. 2: Local coal parameters

BASIC COAL ANALYSIS				
Parameter	Name	Unit	Coal quality	Conceptual design
Q_i^r	Lower heating value	kcal/kg	5 300 ÷ 8 800	6 200
Q_i^r	Lower heating value	MJ/kg	22.03 ÷ 36.75	25.95
W_t^r	Total moisture	% by weight	3.2 ÷ 10.8	9
A^r	Ash	% by weight	12.3 ÷ 44.2	21
S_t^r	Sulphur	% by weight	2.6 ÷ 10.7	6
Size 90 %	-	Mm	-	-

Mixing of the imported and local coal

The following mixture ratios are assumed as limiting values (after ca 5 years of the power plant operation):

Maximum ratio of a local coal: 50 % of the imported coal x 50 % of a local coal

The boiler will not be designed for combustion of 100 % local coal.

Both types of the coal will be imported by trucks to the site.

The start-up and stabilization fuel

LFO will be used as a start-up and stabilization fuel. LFO parameters are specified in the following Tab. 3.

Tab. 3: LFO parameters

Component	Unit	Value
Specific Gravity 60/60 °F	-	0.87
Flash point (min.)	°C	54
Sulphur content (max.)	% mass	1.0
Copper strip corrosion 3 hrs. at 50 °C (max.)	-	1.0
Kinematic viscosity at 50 °C	mm^2/s,cSt	1.5 ÷ 5.0
Kinematic viscosity at 37.8 °C	mm^2/s,cSt	1.8 ÷ 6.0
Kinematic viscosity at 5 °C	mm^2/s,cSt	3.8 ÷ 29
Cloud point (max.)	°C	6.0
Pour point (max.)	°C	3.0
Carbon residue (max.) on 10 % distillation residue	% mass	0.2
Ash (max.)	% mass	0.01
Water (max.)	% vol	0.05
Sediment (max.)	% mass	0.01
Cetan Index (min.)	-	45
Total Acid No. (max.)	mg KOH/g	0.5
Calorific value (min.)	BTU/Lb	19,000
HCV	MJ/Kg	44.15
LCV	MJ/Kg	40.14
Operational temperature	°C	3÷44

Limestone

The additive considers a slightly milled limestone with content of 94 - 96 % of $CaCO_3$ (wt. %, dry) for conceptual design is considered 94 % of $CaCO_3$.

The size of finely milled a limestone is 100 ÷ 300 μm (ratio size for fluidization in fluidized bed). The maximum size is 500 μm.

The grain size distribution shall be in between minimum and maximum limit area specified by following diagram:

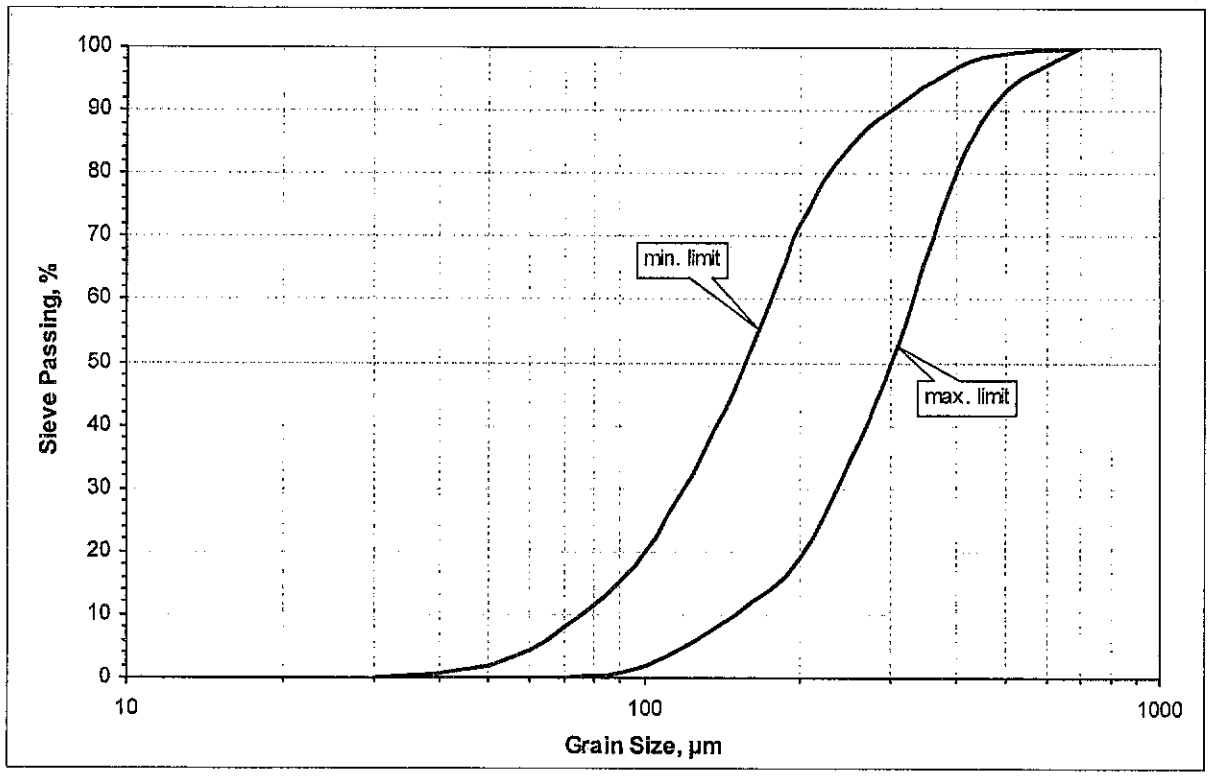


Fig. 1: Grain size diagram

Sand

Quartz sand will be used as bed material in the CFB boiler for first start up. Sand shall be dry, washed and not crushed.

Sand parameters are as following:

Initial deformation temperature:	> 1400 °C
K_2O a Na_2O content	< 2 % w
Residual moisture	< 0.1 % w

Employer

MUGHAL ENERGY

Mughal Energy 55 MWe CFPP

Conceptual Design – 1st part

TECHNICAL FEASBILITY STUDY REPORT

Change	Date	Designed by	Reviewed by	Approved by	PM	Rev.

Copy No.

Project: **Mughal Energy 55 MWe CFPP**

Designed by	ÚJV EGP designers	Coordinated by	ÚJV EGP project coordinators	Date	Serial No.
Reviewed by	Z. Vlček	PM	J. Petrů	03/2015	002
Design Level	El. file: TR_MEL_1st_phase_CD.docx		Contract No. 35-5237-30-001		Rev.
			Document No.: EGP 5100-F-150237		0

Consultant

ÚJV Řež, a. s.

Division ENERGOPROJEKT PRAHA

CONTENT

List of abbreviations

Abbreviation	Title
BOP	Balance of Plant
BMCR	Boiler maximal continuous rate
BOP	Balance of plant
CFB	Circulation Fluidized Bed Boiler
CO	Civil Object
CWTP	Chemical water treatment plant
DBT	Dry bulb temperature
EDI	Electro-deionization
EPRI	Electric power research institute
ESP	Electrostatic precipitator
FAS	Fire alarm system
FDPS	Fire detection and protection system
FGD	Flue gas desulphurization
GE	General electric
HP	High pressure
HVAC	Heating, ventilation, air condition
LFO	Light fuel oil
LHV	Lower heating value
LP	Low pressure
NEQS	National Environmental Quality Standards
NEPRA	The National Electric Power Regulatory Authority
PM	Particulates matter
PS	Process system
RB	Richards Bay Coal Terminal in South Africa
RO	Reverse osmosis

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1. IDENTIFICATION DATA

1.1. Project identification data

Project title: MUGHAL ENERGY 55 MWe Coal Fired Power Plant (CFPP)

Site locality: Mughal Steel, Lahore, Pakistan

1.2. Identification data of the Employer

MUGHAL ENERGY LIMITED

Address: 31 Shadman -1, Colony
Lahore, Pakistan

1.3. Identification data of the Consultant

ÚJV Řež, a. s.
Division ENERGOPROJEKT PRAHA
Address: Na Žertvách 2247/29
180 00 Prague 8, Czech republic

ÚJV EGP Project team – responsible persons			Profession Designers
Project management	Project director	Lucie Židová	
	Project manager	Jiří Petrů	
Technical conception development and supervision	Project technical director	Zdeněk Vlček	
Heat balance computations	Coordination of heat balance data	Zdeněk Hrdina	
Mechanical profession	Coordination of mechanical part	Jakub Vyvadil	Pavel Rejmon Lukáš Pilař Tomáš Hroch Světlana Kozlova Jindřich Kulíř
Electrical profession	Coordination of electrical part Electro part expert supervision	Pavel Fajgl Jan Anděl	Jiří Randa Jan Beránek
I&C profession	Coordination of I&C part	Pavel Černý	Vít Makovský Martin Rojdl
Civil profession and special design works	Coordination of Civil profession and special design work part	Jan Staníček	Michal Krásný Jan Malý M. Smrčková
Legal services	Commercial and contracting specialist	Karel Ort	

2. CONCEPTUAL DESIGN, 1ST PART - INTRODUCTION OF THE DOCUMENTATION

The 1st part of the Conceptual Design is the summary of inputs for the Conceptual Design level; the main objectives of this part of documentation are as follows:

- Summarization of available input data and information
- Summarization of basic requirements on the power plant
- Introduction of main principles of approach to the technical conception development

The input data are evaluated related to the Conceptual Design level, it means, input data necessary for the conception development. This level allows some rate of inaccuracy which cannot affect the technical conception.

In case of missing data is necessary to agree the approach for the Conceptual Design elaboration. Some data and parameters are not possible and reasonable to be estimated, for example the coal parameters. This kind of data is necessary to provide.

Some input data is possible to substitute in this project stage with some provisional data, for example the geotechnical data can be used from the near Mughal Steel site, etc.

The main requirements on the power plant operation specified by the Client were summarized and considered in the main operating modes proposal. The main operating modes are necessary to be confirmed as a base input for the power plant dimensioning.

In other cases is necessary to decide the preferred variant - for example the general layout is proposed in two basic variants – it is necessary to select the preferred one to be developed in the 2nd stage of the Conceptual Design.

The 1st part of CD is assumed to be used as a basic material for the regular technical meeting before starting of the 2nd part of CD elaboration.

3. BASIC DATA CHARACTERIZING THE PROJECT

3.1. Coal parameters

The power plant will be operated with a mixture of several types of coal as a basic fuel. The basic fuel for the first ca. five years of power plant operation will be imported coal only. The coal is planned to be imported from South Africa and Indonesia. After first ca. five years of power plant operation it is anticipated to utilize mixture of imported and local fuel. The mixture is presumed at maximum ratio 50:50. Preliminary parameters of imported and local coal are specified in following chapters. The parameters are considered as preliminary and are not sufficient for Conceptual Design elaboration.

3.1.1. Imported coal

Preliminary imported coal analyses see in Tab. 1: Imported coal parameters (Indonesian coal – type INDO A and Coal from South Africa – type RB1 or RB2).

Tab. 1: Imported coal parameters

BASIC IMPORTED COAL ANALYSIS					
Parameter	Name	Unit	Indonesian Coal – INDO A	South Africa Coal – RB1	South Africa Coal – RB2
Q_i^r	Lower heating value	kcal/kg	6 000	6 000	6 000
Q_i^r	Lower heating value	MJ/kg	25.12	25.12	25.12
W_t^r	Total moisture	% by weight	15.0	12.0	12.0
A^r	Ash	% by weight	15.0	15.0	15.0
S_t^r	Sulphur	% by weight	1.0	1.0	1.0
Size 90%	-	mm	50	50	50

3.1.2. Local coal

Preliminary local coal analyses:

Basic limits for fluidized bed technology (circulating fluidized bed):

Lower heating value (as received) Q_i^r min. 5 300 kcal/kg, max. 6 900 kcal/kg

Total moisture W_t^r max 40 %

Ash (as received) A_r min 10 %

Sulphur (as received) Combustion of a local coal with imported coal at ratio 50:50 – max S_r = 5.7 % (concentration higher than the value (5.7 %) – Necessary installation of semi dry method for reduction SO_2)

Maximum grain size 50 mm

The input data are taken from document: "Coal Characteristics in Pakistan" – Punjab locality – mine "Salt range" (reserve 213 mil. tones – 30 mil. tones are mineable) summarized in Tab. 2: Local coal parameters.

Tab. 2: Local coal parameters

BASIC COAL ANALYSIS				
Parameter	Name	Unit	Coal quality	Conceptual design
Q_i^r	Lower heating value	kcal/kg	5 300 ÷ 8 800	6 200
Q_i^r	Lower heating value	MJ/kg	22.03 ÷ 36.75	25.95
W_t^r	Total moisture	% by weight	3.2 ÷ 10.8	9

A^r	Ash	% by weight	12.3 ÷ 44.2	21
S_t^r	Sulphur	% by weight	2.6 ÷ 10.7	6
Size 90 %	-	mm	-	-

Mixing of the imported and local coal

The following mixture ratios are assumed as limiting values (after ca 5 years of the power plant operation):

Maximum ratio of a local coal: 50 % of the imported coal x 50 % of a local coal

The boiler will not be designed for combustion of 100 % local coal.

Both types of the coal will be imported by trucks to the site.

The start-up and stabilization fuel

LFO will be used as a start-up and stabilization fuel. LFO parameters are specified in the following Tab. 3.

Tab. 3: LFO parameters

Component	Unit	Value
Specific Gravity 60/60 °F	-	0.87
Flash point (min.)	°C	54
Sulphur content (max.)	% mass	1.0
Copper strip corrosion 3 hrs. at 50 °C (max.)	-	1.0
Kinematic viscosity at 50 °C	mm^2/s,cSt	1.5 ÷ 5.0
Kinematic viscosity at 37.8 °C	mm^2/s,cSt	1.8 ÷ 6.0
Kinematic viscosity at 5 °C	mm^2/s,cSt	3.8 ÷ 29
Cloud point (max.)	°C	6.0
Pour point (max.)	°C	3.0
Carbon residue (max.) on 10 % distillation residue	% mass	0.2
Ash (max.)	% mass	0.01
Water (max.)	% vol	0.05
Sediment (max.)	% mass	0.01
Cetan Index (min.)	-	45
Total Acid No. (max.)	mg KOH/g	0.5
Calorific value (min.)	BTU/Lb	19,000
HCV	MJ/Kg	44.15
LCV	MJ/Kg	40.14
Operational temperature	°C	3÷44

3.2. Limestone

The additive considers a slightly milled limestone with content of 94 - 96 % of $CaCO_3$ (wt. %, dry) for conceptual design is considered 94 % of $CaCO_3$.

The size of finely milled a limestone is 100 ÷ 300 μm (ratio size for fluidization in fluidized bed). The maximum size is 500 μm.

The grain size distribution shall be in between minimum and maximum limit area specified by following diagram:

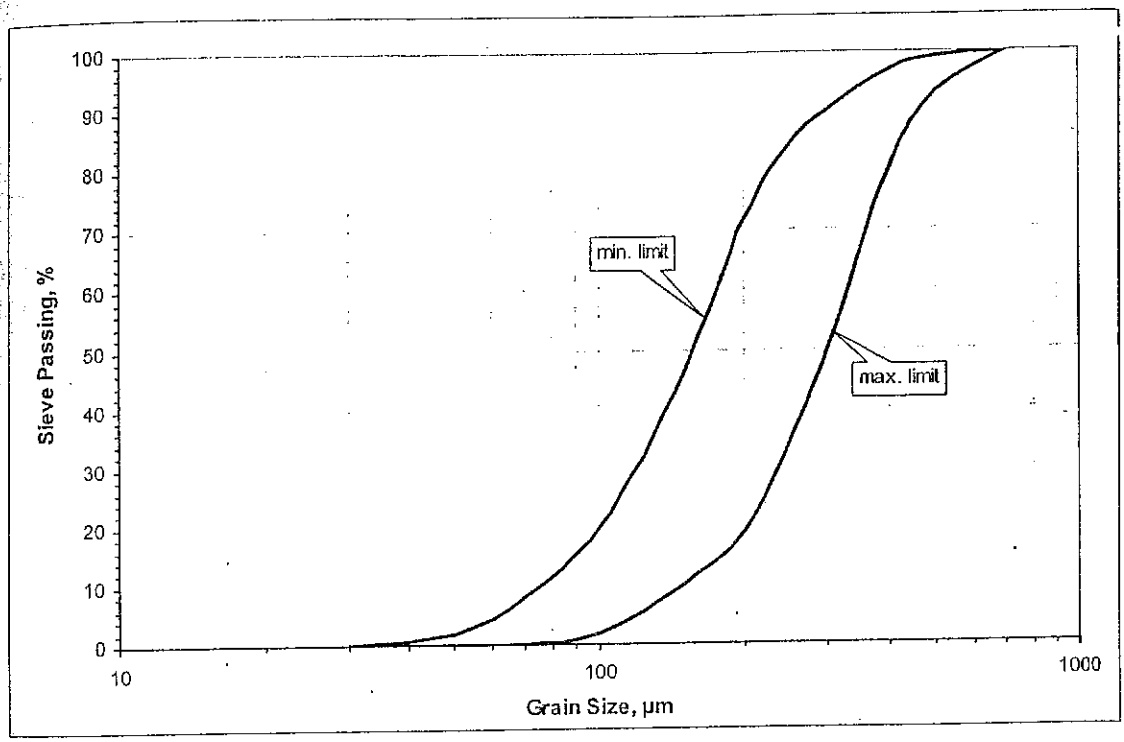


Fig. 1: Grain size diagram

3.3. Sand

Quartz sand will be used as bed material in the CFB boiler for first start up. Sand shall be dry, washed and not crushed.

Sand parameters are as following:

Initial deformation temperature:	> 1400 °C
K_2O a Na_2O content	< 2 % w
Residual moisture	< 0.1 % w

3.4. Emission limits

The power plant shall be designed to achieve lower emission values than are currently established by the Pakistan legislation.

The actual emission limits according to the Pakistan legislation are as following:

SO_2	1 700 mg/Nm^3
NO_x	1 200 mg/Nm^3
CO	800 mg/Nm^3
PM	500 mg/Nm^3

3.5. Raw water source

Wells at the site will be used as a source of the raw water for the power plant. The wells will be realized as a part of the new power plant. The raw water requirement to cover the power plant operation is max 200 m^3/h.

The raw water main consumption in the power plant is mainly comprised of the condenser cooling system and additional water required for the water treatment for the steam cycle.

The wet cooling system (mechanical draft wet cooling tower) is assumed to be used.

Cooling water consumption:	ca. 165 m^3/h (for concentration factor 3)
CWTP consumption	ca. 12 ÷ 14 m^3/h (production 8 m^3/h of demiwater)
Total raw water consumption:	ca. 180 m^3/h

The raw water consumption is calculated for the highest summer monthly average temperature 35 °C DBT and relative humidity 60 %.

Max (at most for a few days) CWTP water consumption is estimated 24 ÷ 28 m^3/h (production 16 m^3/h of demiwater).

Draft of the raw water analysis is presented in **Annex 6**. The document is still under development, for next design stage will be released revised version of the document.

4. INITIAL STATE AND SITE DATA

4.1. Local climatic conditions

The area and project site lies in the tropical climate zone that is characterized by hot summers between March and October. The monsoon spell spans the major summer season. The winters (November to February) are mild and accompanied by sporadic mild rains.

Basic meteorological data for the period of 30 years until 2013 are available from Lahore meteorological station. Following recorded data were provided for the design:

- Dry bulb temperatures
- Wet bulb temperatures
- Humidity

- Monthly total rain
- Monthly highest rain in a day
- Date of highest rain
- Atmospheric pressure on sea level

Rainfall

Heaviest rainfall (24 hrs) 189.7 mm
Wettest Month July
Average July rainfalls 204.7 mm

Temperature

Extreme Maximum Air Temperature 50.0 °C
Extreme Minimum Air Temperature 3.0 °C

Relative Humidity

Maximum relative humidity 90 %
Minimum relative humidity 27 %
Average Annual maximum humidity 76 %

Design Wind Speed

Maximum recorded Wind Speed 47 m/s (wind gust)
Prevailing wind direction north – west

4.2. Local seismic conditions

According to the seismic zones map of Pakistan, the proposed Site lies in a zone of minor damage. For such intensity, a maximum value of 0.066 g may be assumed for horizontal acceleration, which is reference peak ground acceleration for rock subsoil. According to Eurocode EN 1998-1 "Design of structures for earthquake resistance" soil factor S = 1.35 (type 1 spectrum and soil type D) and importance factor for buildings decisive for plant operation can be 1.4, for ordinary buildings importance factor can be 1.0.

Final value of horizontal acceleration at free field level and for importance factor 1.4 is 0.125 g and for ordinary buildings with importance factor 1.0 is 0.09 g. Design values can be updated based on results of detail geological site investigation.

4.3. Existing infrastructure

The site for the power plant construction is nearby the Mughal Steel Industry site. The existing infrastructure available for the Mughal Steel operation is available for the new power plant – roads, electricity grid. The capacity of the basic existing infrastructure will be sufficient for the new 50 MW power plant operation.

Fuel (coal) transport:	Coal will be transported by trucks to the site
Limestone transport:	Limestone will be transported by trucks to the site
By - products transport:	Ash will be transported by trucks from the site

Raw water transport:	Connection to the water source (river) is not possible. The new wells will be realized on the power plant site as a raw water source
Drinking water:	Drinking water will be delivered from the existing Mughal steel factory
Waste water:	After sufficient treatment waste water will be conducted to the existing water channel
Electricity during construction:	Electricity supply will be from the existing Mughal steel factory.
Water during construction:	Water wells will be already in operation during construction phase. In case of delay, water will be delivered from the existing Mughal steel factory

4.4. Interconnection with National grid

The power plant will be connected into the National grid on level 132 kV. A new 132 kV outdoor switchyard will be built within the premises of power plant. The power plant and switchyard will be designed according to requirements of NEPRA Grid code.

It is supposed that switchyard will be designed as two system switchyard with bus bar coupler (it should be confirmed with WAPDA – see also chapter 9). Short circuit withstand capability of switchyard 132 kV is supposed 40/100 kA and maximal operation voltage should be 145 kV.

Switchyard is planned with 5 bays in total:

- 2 bays for 132 kV lines
- 1 bay for connection of power outlet line from new power plant
- 1 combined bay for voltage measurement and bus bar coupler.
- 1 bay for connection of transformer 132/11 kV for power supply of Mughal Steel

The interconnection of the switchyard (power plant) with National grid will be made by the 132 kV line from Attabad to Green view which will be split and both ends will be connected to the new switchyard in the power plant. It is supposed that this connection will be made by 132 kV cables (it should be confirmed with WAPDA). The proposed connection diagram of the power plant to the grid is shown in **Annex 7**.

The power outlet system and interconnection with National grid will be designed in a way that there will be possibility to outlet whole power of the power plant into the grid in case of technological outage in the Mughal steel factory.

It is supposed that data transmission between power plant and the Grid dispatch centre will be provided by PLC system through overhead power lines 132 kV (it should be confirmed with WAPDA – see also chapter 9).

4.5. Data on existing, civil objects, services, infrastructure, distributions and installations

Chosen site for new power plant is a green field without any civil objects, services, infrastructure etc. However nearby located Mughal Steel factory can provide all necessary connections important for construction such as electricity and water. The site is easily accessible by existing roads. For more detail information about infrastructure see chapter 4.3.

4.6. Analysis of realized surveys, impacts on technical solution

- Geodetic survey – see chapter 4.8
- Geotechnical survey – see chapter 4.7 and 4.9

4.6.1. Raw water quality

The basic and the only currently available document which defines the source, quality and quantity of water for the needs of the new power plant is the document, "HYDROGEOLOGICAL STUDY for the POWER PLANT at MUGHAL INUSTRIES HEIKHUPIRA ROAD LAHORE" (electronic version: 2nd interim report. dox). From this study it is clear that in various places of designated territory were drilled 9 underground wells. At different depths in wells there were examined various parameters of ground water (temperature according to depth, conductivity, etc.). Complete chemical analysis of the water was made only for a sample from one well designated as "Prob 5" without specification of the depth of sampling (Table 3 and Annex B of the study).

This document can be sufficient to obtain general knowledge about the quality and quantity of water wells in the location. For the correct specification of a consumption and design a water treatment plant it is important to perform more detailed analysis and defining the conditions.

Conceptual Project design in the scope of water treatment requires clarify/determine the following parameters:

- Defined well (or wells), from which water will be drawn into the raw water storage tank;
- Check the capacity of these raw water sources (wells);
- Perform the chemical analysis of mixed in the ratio of wells water within the scope of the chemical parameters in the selected well/wells (min – max – design) according to the changes in these values, depending on the season, or other climate change (for example, to monitor the impact of monsoon on water quality);
- The results of the studies specify in scope of the **Annex 10**.

In the case that the Customer will not be able to provide required information specified in **Annex 10**, as base for Conceptual Project will be used the Table 3 and Annex B of the study "HYDROGEOLOGICAL STUDY for the POWER PLANT at MUGHAL INUSTRIES HEIKHUPIRA ROAD LAHORE" (electronic version: 2nd interim report. dox) with some corrections in accordance with the agreement with the Customer (see Tab. 4).

Tab. 4: Raw water quality

Parameter		Unit		
Raw water source		Groundwater	Groundwater(tubewells)	
Temperature at the raw water source				
Minimum		°C		
Normal		°C	more than 5	
Maximum		°C		
Design		°C	5	
Raw water flow rate				
Normal flow rate		m^3/h	152 * 3 = 305	
Maximum available flow rate		m^3/h	Sustainable 305 cms as required ****	
Minimum flow rate		m^3/h	Sustainable 305 cms as required ****	
RAW WATER CHEMICAL ANALYSIS				
		Maximum	Design sample	Unit
Cations	Calcium	9	9	mg/l
	Magnesium	7	7	
	Iron (Fe^{2+})***	BDL	0.03	
	Sodium	145	145	
	Others(potassium)	7.9	7.9	
Anions	Bicarbonate	262	262	mg/l as $CaCO_3$*
	Carbonate	BDL	BDL	
	Chloride	49	49	
	Sulfate	44	44	mg/l
	Nitrates	BDL	BDL	
	Phosphates	BDL	BDL	
m - alkalinity	Methyl Orange	262	262	mg/l as $CaCO_3$
p - alkalinity	Phenolphthalein	BDL	BDL	
Total Hardness		52	52	mg/l as $CaCO_3$
Silica		4.8	4.8	mg/l as SiO_2
Organic Matter ($K_2Cr_2O_7$ consumed)		227	227	mg/l
Total Organic Carbon (TOC)		5	5	mg/l
pH		8.26	8.26	-
CO_2		1.01	1.01	mg/l
Turbidity		2.64	2.64	NTU
Arsenic		45.2	45.2	ppb
Copper		BDL	BDL	mg/l
Zinc		0.04	0.04	mg/l
Manganese		BDL	BDL	mg/l
Chromium		BDL	BDL	ppb

Lead	BDL	BDL	ppb
Color (and system used)	Colorless	Colorless	-
Total Suspended Solids**	BDL	0,5	mg/l
Conductivity	681	681	µS/cm
Total dissolved solids	375	375	mg/l
Other	NA	NA	

* changed under agreement

** the concentration of the TSS under agreement will be determined according to the limit of detection apparatus (0.5 mg/l)

*** the concentration of the total Fe as Fe^{2+} under agreement will be determined according to the limit of detection apparatus (0.03 mg/l)

**** necessary to specify units "cms" and flow rate in m3/h

4.7. Required surveys

4.7.1. Geotechnical investigation

For conceptual design preliminary investigation performed for near site of Mughal Steel Mills in 2006 by Soil cone foundation masters, is used. It is supposed to use flat foundations or shallow foundations supported by piles depending on the geology loading conditions and acceptance criteria for settlement. Shallow type foundations can be constructed on layer of compacted foundation cushion, improper soils under foundations will be removed. Another possibility is using the pile foundation for heavy structures or for structures sensitive to the settlement.

Geotechnical investigation should be performed in two steps:

- Preliminary investigation that can be carried out to assess general suitability of the site and to estimate the changes that may be caused by the proposed works. Preliminary investigation serves also for preparation of detail investigation and for identification of borrow areas, number and depth of soil borings. Conclusions from this investigation should be available at the beginning of works on Basic design and thus performed by Investor or EPC Contractor at the beginning of his works.
- Detail (Design) investigation that should provide sufficient data concerning the ground and the ground-water conditions at and around the construction site for a proper description of the essential ground properties and a reliable assessment of the characteristic values of the ground parameters to be used in design calculations. Field investigation should comprise drilling for sampling, groundwater measurements and field tests. Laboratory tests of samples have to will be performed selection of samples should cover the range of index properties of each relevant stratum. Conclusions from this investigation should be available at the beginning of works on Detail design and thus performed by EPC Contractor.

4.7.2. Radon occurrence

In case of radon occurrence in the soil special protection should be taken in the buildings with permanent personnel activity. Conclusions from this investigation should be available at the beginning of works on Basic design.

4.8. Applied geodetic input data

The field measurement started on December 27, 2015 and was completed on December 29, 2014. Following requirements were met during geodetic survey:

- Each unevenness in topography was measured (trenches, mounds, channels, path etc.)
- Net of points 10 m x 10 m was used for measurement.
- Accuracy class – inaccuracy of 12 cm in horizontal direction, 5 cm in vertical direction (elevation).
- System of coordinates – values x, y, z are given, geodetic points were connected to the existing system of coordinates commonly used in Pakistan.

Detailed Topographic Survey was conducted using Sokkia 530R bearing No. 146599. The raw data were processed for map and contour generation. A 0.25 meter contour interval was used to generate contour lines. The survey confirmed the flatness of the site with the general slope of 1 m per 1 km.

The field data were exported to AutoCad together with contours and represent a basis for general layout drawings.

4.9. Evaluation of actual state of site

4.9.1. Geography and Topography

The area is about 31 Km north-west of Lahore on Lahore - Shekhupar road. The coordinates are 423150-422900E and 3502700-3503000N. The area is a part of Indus Plain with very even terrain - the general slope is 1 m per 1 km. This is important for initial phase of construction because preparatory works such as terrain levelling can be reduced to minimum.

4.9.2. Climate, meteorological conditions

The area has a semiarid and arid subtropical continental climate. The main features of the climate are two well-defined seasons, a hot summer with late monsoon rains and relatively mild winter. The mean annual rainfall in the area is about 670 mm but the differences in years are quite significant (from 333.7 mm in 2002 up to 1232.5 mm in 1997). More than half of the rainfall is received in the form of high intensity down pours during July and August. The hottest months are May and June, with the average temperatures of 34.0°C and 34.3°C. The winters are generally frost free except for a short period of 10 to 15 days in December and January when sever fog in the morning and evening is seen.

4.9.3. Geological conditions

Geological survey was not performed for the site. Technical report on geotechnical investigation for the construction of Mughal Steel Mills which are located in the same region is available. Conclusions from this technical report will be used in the initial phase of the project:

- Prior to providing foundation concrete, the foundation soil after excavation may be thoroughly compacted for better stability
- Drainage must be kept efficient and no surplus water will be allowed to penetrate into foundation soil from any source

- The required raising may be done preferably with organic and salt free sandy soil, which should be thoroughly compacted up to the sufficient state of compaction

According to the seismic zones map of Pakistan (Figure 1), the proposed Site lies in a zone of minor damage.

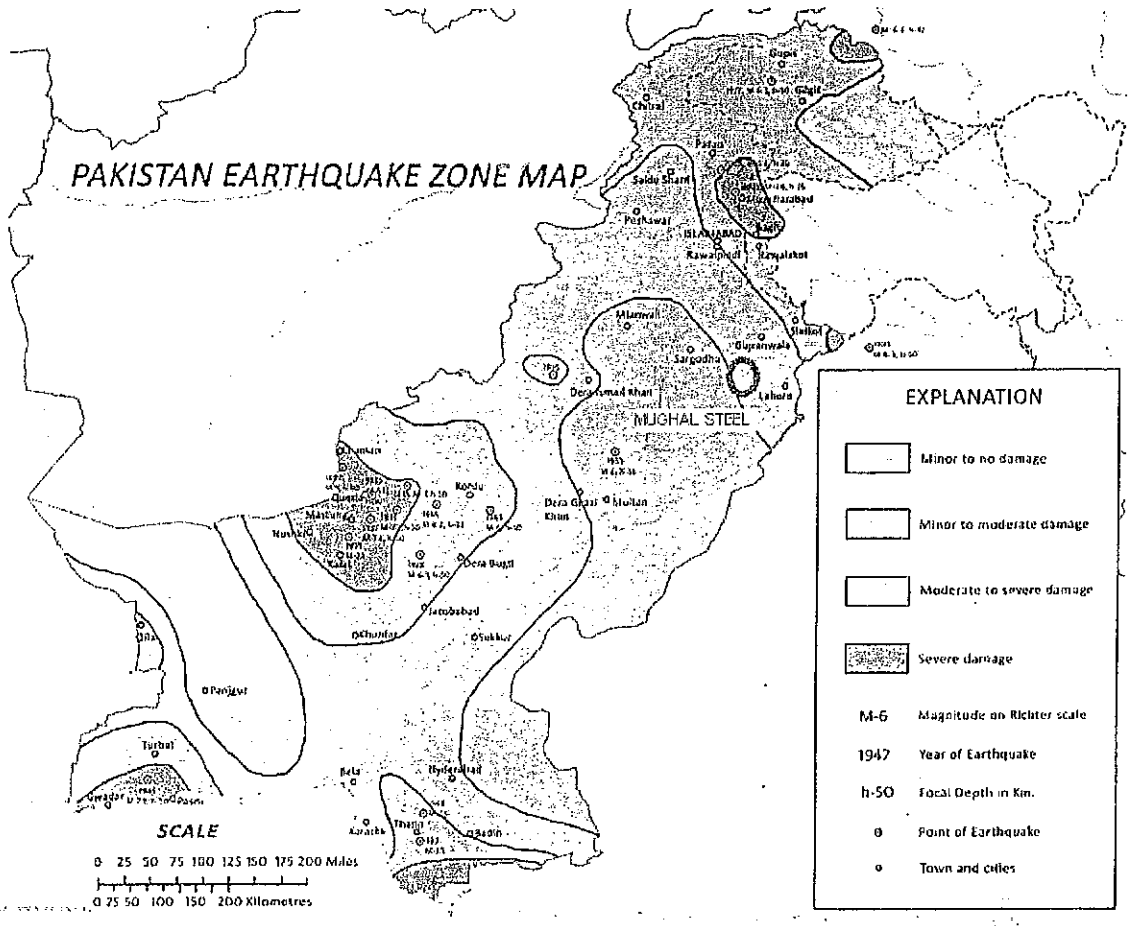


Fig. 2: Seismic zones in Pakistan

4.9.4. Infrastructure

All necessary connections are possible via nearby located Mughal Steel factory as mentioned in the previous chapters.

4.9.5. Evaluation of the site

The site is a green field without any facilities to be removed. Special attention must be paid during foundation design because of the geological situation which is rather complicated. Important will be also drainage system design with regards to clayish subsoil and monsoon down pours. Apart from these difficulties the site is suitable for new coal power plant construction.

5. POWER PLANT SEISMIC DESIGN

5.1. Power plant seismic design

5.1.1. Power plant seismic design – technological part

Technological equipment is designed in such a way, that protection of personnel health and lives as well as minimization of the property damages were restricted in case of a seismic event.

Technological equipment is designed as seismic resistant only from the viewpoint of personnel protection and restriction of damages of the equipment decisive for power production. In the course of a seismic event and immediately after its end, the power generation process will not be ensured, functionality of single equipment just after earthquake will not be ensured, too. Selection of components and systems, which will be designed with respect to their integrity and stability at a seismic event, will be carried out with consideration of their possible repair and quick putting into operation.

5.1.2. Power plant seismic design - civil part

Seismic design of the plant will be based on national standards describing the site seismic hazard. According to the seismic zones map of Pakistan, the proposed Site lies in a zone of minor damage. Due to the earthquake situation, proper measures should be taken in case of seismic design of buildings. The design conditions are determined by soil condition, acceleration level for vertical and horizontal components and by elastic site response spectrum. Design and construction of buildings and civil engineering works will be performed in accordance with Eurocodes or proper national standards for design in seismic regions. Design is to ensure, that in the event of earthquake human lives are protected, damage of buildings are limited and structures important for plant operation remain stable or can be easily repaired. The extent of protection will be given by means of importance classes for buildings and corresponding importance factors.

According to general rules for seismic design, following provisions have to be considered in building design in seismic regions.

- To keep design construction simplicity, hence calculations and design is simple, force distribution is clearly visible and design contains minimal amounts of uncertainties
- Construction uniformity, symmetry and static indeterminacy hence stress concentration in sensitive areas is eliminated
- structural resistance and rigidity in both directions hence building is resistant to horizontal seismic forces in all directions
- To ensure torsional strength and stiffness hence uneven stress is suppressed.
- Floor structures act as diaphragms hence inertia forces are redistributed to vertical bearing system. which then works as one unit
- It is maintained using of reasonable foundations hence whole construction is uniformly excited by seismic forces

6. DESIGN INPUT DATA SUMMARY AND EVALUATION

6.1. Data and information about Mughal Steel operation

6.1.1. Electrical part

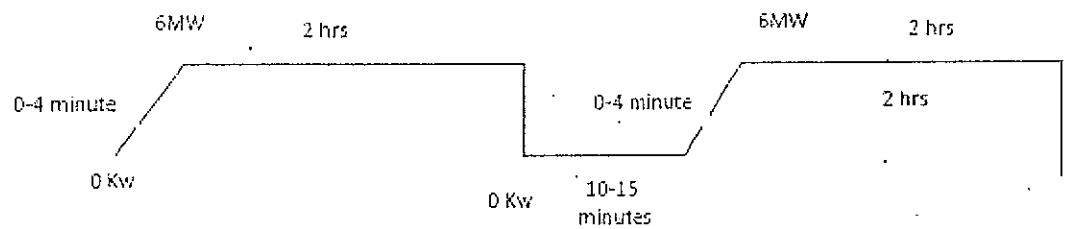
The new power plant will be able to supply the consumers (furnaces, mill) according to the following electrical diagram, which was handed over as a basis for the conceptual design (enclosed as **Annex 12** - Electrical Single Line Diagram of Mughal steel).

The following consumers could be supplied from the new power plant according to this diagram:

- Electrical Induction Furnace (EIF G1 – 10 MW)
- Electrical Induction Furnace (EIF G2 – 10 MW)
- Electrical Induction Furnace (EIF G3 – 7.5 MW)
- Electrical Induction Furnace (EIF B1 – 6 MW)
- Electrical Induction Furnace (EIF B2 – 6 MW)
- Electrical Induction Furnace (EIF B3 – 7.5 MW)
- Girder Mill

If it is possible to supply all of these appliances in a same time will be specified in the next phase of project when more precise information about loads will be clear, including load of power plant auxiliaries.

The following typical load profile of induction furnaces is expected:



This load profile should be clarified together with power supply of girder mill (see chapter 9).

6.1.2. Data and information about gas engine plant operation (Jenbacher)

Gas engines are used as backup power sources in case of loss of power supply from 132 kV. Their purpose will not be changed.

6.2. Operational requirements on the power plant, etc.

6.2.1. Static operating modes

Proposal of the power production plan for the power plant 55 MW gross:

Mode 1: Power output to the grid with power supply for Mughal Steel factory

0 – 49 MWe to the grid (132 kV)

0 – 49 MWe to Mughal Steel factory

Amount of power output supplied to the grid depends on Mughal Steel factory Load and operational range of the power plant (min. 22 MW – max. 55 MW).

22 MW gross – minimal power production estimated based on the minimal possible power of the boiler (see Note 2 below).

55 MW gross – maximal power output of the power plant guaranteed in the nominal operating mode

Sum of power output to the Grid and Mughal Steel factory load will be in range **18 MWe – 49 MWe.**

***Note 1**: When the whole power from power plant (maximal possible power supply) is used completely for Mughal Steel factory consumption (49 MW), no power can be supplied to the grid 132 kV.*

Mode 2: Power output to the grid 132 kV only (without supplying Mughal Steel Industry)

Minimal power output to the grid is **18 MWe** (minimal power output of generator is 22 MW, related minimal power plant auxiliary consumption is 4 MW)

Maximal power output to the grid is **49 MWe** (maximal related power plant auxiliary consumption is 6 MW)

***Note 2:** The original Mughal requirement was 15 MW directly to the grid all the time. 18 MW is a limit given by estimated technical minimal power production based on the minimal load of the boiler safe operation, which is achievable without any additional stabilization technical measures and is generally assumed as 40 % of a nominal boiler power.*
The technical limits of particular equipment are preliminarily estimated based on relevant experiences and provisional communication with manufacturers. Estimated data will be specified during the design works in cooperation with manufacturers.

Mode 3: Power output to the Mughal Steel Industry only (Island operation mode, no power output to the grid 132 kV, grid is temporarily unavailable)

Min. load to Mughal Steel Industry is **18 MWe** (minimal power output of generator is 22 MW, min. related power plant auxiliary consumption is 4 MW)

Maximal possible power which can be supplied to Mughal Steel factory is **49 MWe** (maximal related power plant auxiliary consumption is 6 MW)

6.2.2. Dynamic operating modes

The assumed abnormal modes of unit during loss of connection with external grid (transition to island governor – speed control) are as follows:

Surplus power

After disconnection from external grid is TS (turbine set) control switched to the island mode (speed) proportional control. In case of surplus power (increase of TS speed/frequency) are turbine control valves partly closed by intervention of the speed governor and therefore are the generator power decreasing until the reference speed is reached. The surplus steam is led to a condenser at first, after condenser filling is the steam blown through PSA into the atmosphere.

a) If the loss of connection with external grid is short-term and if it is expected that the needed power will soon return to the original value the boiler stays at original power. Initially (before loss of connection with external grid) is the steel factory partly supplied from power plant (the rest of power plant's power is exported to the grid) and rest of power consumption of steel factory is supplied from grid. After loss of grid connection are the assured power sources started in the steel factory and following gradual switching of the consumers (originally supplied from external grid) to the power supply from power plant according to available power plant's power.

b) In case of long-term loss of external grid is the power of boiler decreased or in a given case is shutdown of whole power plant (the power consumption is lower than the lowest allowed power of the power plant) based on technological abilities of the power plant and amount of power consumption in formed island.

Deficiency of power

If there is a loss of grid connection (steel factory and power plant) together with power plant's operation with reduced power of the boiler and TS when the part of factory consumption is supplied from external grid are the assured power sources (gas engines, DG) started. These assured power sources temporarily replace the power from grid until the boiler power is increased to the required value and the power plant is able to be gradually loaded by the consumers supplied by gas engines.

Operational changes

In case of operational changes in power consumption (technological break of furnace) is expected that the turbine set power is partly decreased but the boiler stays on original power. The surplus power is led to the condenser or to the atmosphere.

6.2.3. Own consumption

The power consumers considered to the own consumption are defined according to the experience from similar projects. It shall be noted that efficiency (i.e. consumption) of each consumer depends on individual supplier and can differ in order of dozens of percent. Therefore each of presented consumers shall be evaluated individually with sufficient margins.

The design of power output of the power plant shall be based on certain initial presumptions and approaches including evaluation of own consumption parameter.

The power plant own consumption is defined by the main consumers as specified in Tab. 5.

The table is divided into the two sections, the first section summarize main consumers which are in operation continuously during normal operation of the power plant. The second section summarizes main consumers which are in operation periodically according to the requirements and operation instructions of the power plant, but these are all included in parameter of own consumption.

Tab. 5: Main own consumers of the power plant

Assumed power plant main consumers	
Continuously running technologies / consumers + transformer losses	**Boiler House**
	Primary air fan
	Secondary air fan
	I. D. fans
	HP blower
	Rotary feeders to furnace
	Water cooled screw conveyors
	Machine Hall
	Condensate pumps
	Feed water pumps
	Accessories
	Cooling Circuit
	Cooling water pumps
	Cooling tower fans
	ESP
	FGD
	Limestone milling
	Raw water
	Compressed air for instrument and service air
	Transformer losses
Other **periodically running** technologies / consumers	Limestone crushing
	Coal handling with crushers
	Demineralized water production station
	Water treatment
	LFO pumps
	Air compressors for fly ash conveying system
	Miscellaneous essential consumers (lighting, UPS)

6.3. Steam-water cycle design

The steam-water cycle should be designed to maximal thermal efficiency (minimal fuel consumption) with economical legitimate investment costs. For given conditions and unit size it means non reheat Rankine – Clausius cycle with high steam parameters, water cooled condenser and regenerative feedwater heating. Number of feedwater heaters should be as high as possible (min. 4, deaerator included) - it will be limited by number of practicable steam extractions from one cylinder steam turbine.

For supposed unit major operation mode near nominal load it is recommended steam turbine with no governing stage and throttle / sliding pressure control. Both geared and direct connection design of turbogenerator is possible for 55 MWe unit, in any case, turbogenerator design with higher overall efficiency should be preferred.

Recommended water / steam cycle design is shown on Heat Balance Diagrams (HBDs) presented in **Annex 1, 2 and 3**. Sample cycle is based on non-geared one cylinder condensing steam turbine with five uncontrolled steam extractions for feedwater heating. Steam parameters at boiler outlet are 14 MPa / 545°C in BMCR (Boiler Maximum Continuous Rating) operation mode and could be considered as maximal for this size unit.

Steam cycle configuration, basic input data and main equipment parameters were assumed to reach required value of coal consumption (0,38 kg/kWh$_{brutto}$ for coal LHV 6000 kcal/kg) and were determined on the basis of experience with similar projects. Steam cycle design and parameters will be progressively specified according to information from boiler and steam turbine potential suppliers directly for Mughal Energy CFPP project. During steam cycle finalization it will be taken into consideration investment costs of given solution besides CFPP thermal efficiency / coal consumption.

HBDs presented in this documentation describe supposed unit operational modes with nominal and minimal power output at annual average climatic conditions and guaranteed power output at ambient temperature 45°C.

Main parameters of proposed power plant water / steam cycle at above mentioned operation modes were computed by means of a computing model established in the specialized software environment GateCycle ver. 6.1.2.

The basic input data and main equipment parameters for model establishment were taken from the informative bids of potential suppliers or were determined on the basis of experience with similar projects.

Main power plant parameters computed by GateCycle model are as follows:

Operation mode Nominal (for annual average climatic conditions)

Ambient air parameters:	25°C , relative humidity 70%
Cooling water temperature:	27°C
Power output at generator terminals:	55 MWe
Condensation pressure:	0.0074 MPa
Boiler thermal output:	134.6 MWt (Nominal)
Steam parameters at boiler outlet	13.5 MPa / 545°C

Boiler steam production:	194.7 t/h
Operating mode:	sliding pressure
Plant thermal efficiency, gross	37.58 %

Minimal operation mode (for annual average climatic conditions)

Ambient air parameters:	25°C , relative humidity 70%
Cooling water temperature:	27 °C
Power output at generator terminals:	21.25 MWe
Condensation pressure:	0.0049 MPa
Boiler thermal output (min. without stabilization):	55.86 MWt
Steam parameters at boiler outlet	5.19 MPa / 545 °C
Boiler steam production:	72.8 t/h
Operating mode:	sliding pressure
Plant thermal efficiency, gross	34.61 %

Operation mode Summer (for performance guarantee at annual max. ambient temp.)

Ambient air parameters:	45 °C , relative humidity 50 %
Cooling water temperature:	39 °C
Power output at generator terminals:	55 MWe
Condensation pressure:	0.014 MPa
Boiler thermal output:	139.7 MWt (BMCR)
Steam parameters at boiler outlet	14.0 MPa / 545 °C
Boiler steam production:	202.8 t/h
Operating mode:	full pressure
Plant thermal efficiency, gross	36.23 %

6.4. General layout proposal

Draft general layout consists of objects to each other functionally related and based on the area (Power output, points and wastewater connection to the existing communication).

The first function unit is a handling system of coal and limestone. The coal handling system consists of indoor coal storage with capacity for 3 months of the power plant operation, crushing and handling coal to the boiler. The coal storage allows simultaneous unloading of eight trucks with coal. Supply unit of limestone consists of limestone storage, limestone crushing and handling to the boiler.

The second function unit is the main power unit, which is connected to the supply and limestone. Main power unit consists of machine hall, boiler house with fluidized bed boiler, electrostatic precipitator and fuel gas stack. Between boiler house and electrostatic precipitator is space reserve for possible additional installation desulphurization plant.

Auxiliary units for operation of the main power unit are located in close proximity so that the pipelines lengths are optimized and pressure losses in the pipeline are minimized. Auxiliary units include the auxiliary boiler house, fuel oil unloading and storage, compressor station and storage and disposal of bed ash and fly ash.

The water management which includes water wells, raw water storage and chemical water treatment is predominantly located in one common area. Waste water treatment is located near to connection point and it is located as far as possible from administration building, canteen and operating building.

Power output from generator is designed in a direction to line 132kV trough transformers and switchyard.

Support services for operation of the power plant (administration building, central maintenance workshops, canteen and parking) are linked to the main entry of the power plant site and are located close to the main power unit in order to shorten walkable distance between the main entry and main power unit.

Access to the power plant is via the main entry, which is used for the entry of personnel and traffic. Trucks for transportation of: coal, limestone, removal of bed ash and fly ash enter the area of the power plant through the auxiliary gatehouse. Auxiliary gatehouse is located near the coal storage and truck minimizes movement through the power plant site. Auxiliary gatehouse is equipped with truck a scale that weighs each truck on arrival and departure from the power plant.

General layout for area C (92 419 m^2) as presented in **Annex 4** is designed for one main power unit. Future extension of the power plant by the power unit of a similar performance will be quite complicated.

General layout for area C and D (150 369 m^2) as presented in **Annex 5** is designed for one main power unit. Future extension of the power plant for by the power unit of a similar performance will be possible.

Both general layouts are designed considering optimized pipelines design, which reduces the pressure losses in the pipe, separating dusty and dirty areas from clean areas, optimizing truck roads between the entrance to the site and storages coal, limestone, fuel oil storage.

6.5. Structuring of the power plant into Process Systems and Civil Objects

6.5.1. List of Process system

The power plant shall be structured into main process system, see **Annex 6**. The more detailed and complete structure will be defined based on this list in next design stage (2nd stage of CD).

6.5.2. List of Civil Objects

Civil object are divided into groups according to their function, see **Annex 6**.

7. LIST OF PROFESSIONS IN THE POWER PLANT

Three-shift operation (1 shift = 12 hours) is presumed for operation of the single power plant Unit 55 MW. As far as total number of employees is concerned, 3+1 shifts are proposed + backup personnel covering sufficient personnel capacity – e.g. during holidays and/or leaves, sickness, etc. and for necessary repairs during operation.

The proposed total power plant operational staff is 125 people, the HR and economical department staff, etc. is ca 54 people.

For the detailed list of workplaces in the power plant, see **Annex 8**.

The major shift is the morning one and thus number of personnel in this shift will be taken as basis for capacity sizing.

The mentioned number of workplaces is used as a base for dimensioning of related spaces, consumption and production figures (workplaces, water, waste water, etc.) in the design.

8. LEGISLATION, NORMS AND STANDARDS

8.1. Grid Code 2005, NEPRA

The enclosed version of NEPRA Grid Code from 2005 (handed over by Mughal Energy – see **Annex 13**) will be used as a basis for design of connection of the new power plant into external grid.

8.2. Distribution Code 2005, NEPRA

The enclosed version of NEPRA Distribution Code from 2005 (handed over by Mughal Energy see **Annex 14**) will be used as a basis for design of connection of the new power plant into external grid.

8.3. National Environmental Quality Standards for Ambient Air

The immission (air pollution) limits valid for this project are specified in Tab. 6:

Tab. 6: The immission limits according to the NEQS

Pollutants (Immission limits)	**Time weighted average**	**Concentration in Ambient Air** (The values according to NEQS for Ambient Air /Effective from 1.1.2012/)
Sulphur dioxide (SO_2)	Annual average	80 $\mu g/m^3$
	24 hours	120 $\mu g/m^3$
NO_x	Annual arithmetic mean	-
Oxides of nitrogen as (NO)	Annual average	40 $\mu g/m^3$

	24 hours	40 μg/m^3
Oxides of nitrogen as (NO_2)	Annual average	40 μg/m^3
	24 hours	80 μg/m^3
Suspended particulate matter (SPM)	Annual average	360 μg/m^3
	24 hours	500 μg/m^3
Respirable particulate matter (PM_{10})	Annual average	120 μg/m^3
	24 hours	150 μg/m^3
Respirable particulate matter ($PM_{2,5}$)	Annual average	15 μg/m^3
	24 hours	35 μg/m^3
	1 hour	15 μg/m^3
Lead (Pb)	Annual average	1 μg/m^3
	24 hours	1.5 μg/m^3
Carbon monoxide (CO)	8 hours	5 mg/m^3
	1 hour	10 mg/m^3

Source document for immission (air pollution) limits values see **Annex 15**.

8.4. Design of technology

EU standards will be used beside those stated above.

8.5. Design of civil part

The EN Eurocodes system will be used for civil design. Eurocodes were issued by CEN (European Committee for Standardization) and are the reference design codes in the construction.

8.6. Fire protection

EU standards will be used.

9. REQUIRED INPUT DATA FOR THE 2ND STAGE OF THE CONCEPTUAL DESIGN

9.1. Coal

For elaboration of the Conceptual Design it is necessary to provide detailed parameters of both imported (Indonesian and South African) and local coal. Specification of required parameters for each type of coal is provided in **Annex 9**.

9.2. Limestone

The Customer shall provide information if it is possible to supply finely milled limestone directly or limestone supply will be in form of a grain size of up to 50 mm.

9.3. Electric part

For the next stages of conceptual design is necessary to clarify or complete the following information:

- clarification of consumption of Girder mill system
- information about placement of new change over switches
- information about placement of supplied furnaces and girder mill
- confirmation the load profile of furnace
- complete information about frequency load shedding of Mughal Steel loads if existing
- It is assumed that connection between switchyard 132 kV and overhead power line 132 kV (Attabad – Green View) will be done by cables 132 kV. It is necessary clarify with WAPDA including border point of delivery.
- Clarify with WAPDA, whether is required the telecommunication system for voice and data information transmission through 132 kV lines (PLC system for data transmission between power plant and the Grid dispatch centre). In electrical part is considered coupling capacitors and inductors for this system in phase L1 and L2.

9.4. I&C part

I & C part will consist mainly of enter from technological and electrical part. Maximum level of automation is assumed based on the consultant experience. The level of automation is possible to modify according to the Client requirement.

For example emission monitoring according to European standards must be independent of the control system power plant and data are transmitted to the needs of state control. It should be confirmed for Mughal Energy case.

Basic questions related to the communication and security systems design are in **Annex 11**.

3(5)(i)
Prospectus

Project Sponsor

The forefathers of the current sponsors ventured in to the steel business in 1950 under the title of "Mughal Traders". The entity then imported Iron and steel products for local consumption.

With a history of over 50 years of excellence to its credit, Mughal Iron & Steel Industries Limited ("MISIL") is one of the leading companies of Pakistan in the iron and steel sector. The company was incepted in the early 1950 in the form of a proprietorship firm with a purpose to uplift trade, contribute to national economy and ensure industrial growth of the country. In the turmoil that surrounded the newly independent country, the sponsors came up with a strong vision and devoted entirely to trade and industry; their dedication is truly appreciated by their commendable clientele.

The Company is involved in multidimensional activities from making billets of Mild Steel, Spring Steel, Deformed bar, Re-bar, Cold Twisted Rebar and a huge range of Sections such as I.Beams, L.Sections, C.Section, H.Beam, T.Bar etc. in the downstream industry.

Over the years Mughal Steel has emerged as a thriving progressive steel enterprise due to its ability to transform itself rapidly to meet the challenges of a highly competitive global economy. Constant modernization, introduction of state-of-the-art technology and being manned by the highly efficient and dynamic team of employees, has enabled the Company to stay ahead in the industry and successfully meet the expectations of all customers.

The Project

The coal-fired power generation facility is expected to be installed at 17-km on Sheikhupura Road, Lahore, within seismic zone IV. The proposed site is 1000ft above sea level. Using Circulating Fluidized Bed (CFB) coal utilization techniques, this plant will allow Mughal Steel Mills to run its plant at full capacity through uninterrupted supply of Electricity. The company intends to use 70% imported coal with 2% sulfur content, while the rest will be local coal with sulfur content up-to 5%. The company intends to install one condensing steam type turbine that will generate 11KV, 3 phase, and 50 Hz alternating current. For cooling purposes, both water and air cooled condensers are under consideration. Ground water is proposed to be used for the water cooled condensers.

The plant will evacuate power to the national grid through 132kV transmission lines located at the site. The power generated by the project is proposed to be dispatched to the Load Center of LESCO. Further, the power injected into the transmission system of LESCO will be wheeled to Bulk Power Consumers. Project shall be implemented on a fast track basis, provided there are no unforeseen delays during project implementation.

The salient features of project site are delineated as below;

- Access to roads and railways
- Uninterrupted power supply, water and natural gas
- Easy availability of semi-skilled and skilled labour
- Clean title of land

Salient Features of the Project

Project Name	55 MW Coal Power Project
Location	17-km on Sheikhupura Road, Lahore
Project Company	Mughal Energy Limited
Legal Status	Limited Liability Company
Sponsors	Mughal Steel Mills is the second largest steel manufacturing concern in Pakistan; therefore, it has extensive power requirements for which it is currently dependent on WAPDA. The company has an estimated power requirement of 39 MW at its peak load production capacity. However, given the prevailing energy shortages and the ever increasing cost of electricity, the board of Mughal Group of Industries is assessing and evaluating the prospects of setting up a coal power generation facility with a gross capacity of 55 MW.
Thermal Efficiency	37.58%
Power Generation	55 MW

Project Costs

Description	USD
EPC Cost	103,774,639
Non-EPC Cost	16,920,059
Project Development Cost	2,260,436
Pre-COD Insurance	860,686
Interest During Construction	12,124,534
Financial Fees and Charges	1,026,008
Total	**136,966,362**

Financing Plan

Description	USD
Debt	34,241,590
Equity	102,724,771
Total	**136,966,362**

Construction Period	18 Months
Project Life	25 Years
Annual Energy Production	392,000,000 kWh

Environmental and Social Considerations

The Consultants for Environmental Impact Assessment has documented all major environmental concerns associated with the project. The main environmental concerns are:

- Air quality issues
- Occupational health and safety management during construction

A series of mitigation and monitoring measures have been included to address the concerns for these measures. Assuming effective implementation of the mitigation measures and monitoring requirements the adverse environmental and social impacts of the proposed Project are likely to be within the acceptable limits.

Location maps, site maps, land

Location 17-km on Sheikhupura Road, Lahore

Site Map

Technology, size of plant, number of units

Plant Details & Other Details

1. **Plant Configuration**

- Type of turbines ..... Steam Turbines Thermal on Coal Operation
- Capacity of the Power Plant.....55 MW (Gross) / Net 50 MW (Net Power Output)
- Type of Technology .....Steam Unit with CFBC Boiler
- Number of Units / Capacity .....55 MW Coal Fired Power Project
- Power Plant Make and Model .....Provided later

2. **Fuel Details**

- Type of Fuel.....Coal (Imported / Indigenous) Indigenous
- Fuel Supplier.....Will be selected through bidding process

3. Expected Life of the Facility .....30 years

4. **Plant Characteristics**

- Generating Voltage .....11 KV
- Frequency.....50 Hz
- Automatic Generation Control .....No
- Ramping Rate.....to be provided later on
- Alternative Fuel.....No
- Time required to Synchronize .....to be provided later on COD

Technical parameters of the coal plant as are under:-

-	Plant Capacity:	55 MW
-	Boiler Technology:	Circulating Fluidized Bed Combustion (CFBC)
-	Coal Source : blended	Imported coal - South African / Indonesian or indigenous coal
-	Plant gross efficiency:	37.58%

Boiler technologies namely pulverized combustion (PC) and circulating fluidized bed combustion (CFBC) have been studied along with their relative merits and demerits. One of CFBC's key advantages is its ability to use a wider range of fuels, from indigenous coal to imported Indonesian and South African coal.

Steam Turbine and Auxiliaries

The steam turbine will consists of proven single casing turbine straight condensing, horizontally split machine with uncontrolled extractions for two (2) LP heaters, Two (2) HP heaters and One(1) De-aerator. The TG set will be designed for a maximum throttle steam flow at turbine valve wide open (VWO) condition of 105% of turbine rated conditions. The major turbine cycle parameters at 100% TMCR are as given below:

S.N	Parameters	Values
1	Turbine MCR output at generator terminals	55 MW
2	Main Steam Inlet Pressure	14 MPa
3	Main Steam Inlet Temperature	545 °C
4	Exhaust pressure	0.0074 Mpa
5	Turbine speed	3000 rpm
6	DM water make up requirement to thermal cycle	Max. 3%; zero considered in Guarantee case
7	Condenser type	Surface type Water cooled
8	Cooling Type	By 1 no. Induced Draft Cooling Tower

Generator and Excitation System

The Generator will be capable of continuous safe operation at rated output and power factor under any of the following conditions for system compatibility:

- Terminal voltage variation of +/- 5% of the rated value.
- Frequency variation within 47.5 to 51.5 Hz.
- Absolute sum of combined voltage & frequency variation of not beyond 5%.

The Generator winding will be star connected with the phase & neutral terminals brought out for connection to isolated phase bus duct. The star neutral point will be grounded through a transformer ground resister in the secondary circuit.

Coal parameters

The power plant will be operated with a mixture of several types of coal as a basic fuel. The basic fuel for the first ca. five years of power plant operation will be imported coal only. The coal is planned to be imported from South Africa and Indonesia. After first ca. five years of power plant operation it is anticipated to utilize mixture of imported and local fuel. The mixture is presumed at maximum ratio 50:50. Preliminary parameters of imported and local coal are specified in following chapters. The parameters are considered as preliminary and are not sufficient for Conceptual Design elaboration.

Imported coal

Preliminary imported coal analyses see in Tab. 1: Imported coal parameters (Indonesian coal – type INDO A and Coal from South Africa – type RB1 or RB2).

Tab. 1: Imported coal parameters

BASIC IMPORTED COAL ANALYSIS					
Parameter	**Name**	**Unit**	**Indonesian Coal – INDO A**	**South Africa Coal – RB1**	**South Africa Coal – RB2**
Q_i^r	Lower heating value	kcal/kg	6 000	6 000	6 000
Q_i^r	Lower heating value	MJ/kg	25.12	25.12	25.12
W_t^r	Total moisture	% by weight	15.0	12.0	12.0
A^r	Ash	% by weight	15.0	15.0	15.0
S_t^r	Sulphur	% by weight	1.0	1.0	1.0
Size 90%	-	mm	50	50	50

Local coal

Preliminary local coal analyses:

Basic limits for fluidized bed technology (circulating fluidized bed):

Lower heating value (as received) Q_i^r min. 5 300 kcal/kg, max. 6 900 kcal/kg

Total moisture W_t^r max 40 %

Ash (as received) A_r min 10 %

Sulphur (as received) Combustion of a local coal with imported coal at ratio 50:50 – max S_r = 5.7 % (concentration higher than the value (5.7 %) – Necessary installation of semi dry method for reduction SO_2)

Maximum grain size 50 mm

The input data are taken from document: "Coal Characteristics in Pakistan" – Punjab locality – mine "Salt range" (reserve 213 mil. tones – 30 mil. tones are mineable) summarized in Tab. 2: Local coal parameters.

Tab. 2: Local coal parameters

BASIC COAL ANALYSIS				
Parameter	**Name**	**Unit**	**Coal quality**	**Conceptual design**
Q_i^r	Lower heating value	kcal/kg	5 300 ÷ 8 800	6 200
Q_i^r	Lower heating value	MJ/kg	22.03 ÷ 36.75	25.95
W_t^r	Total moisture	% by weight	3.2 ÷ 10.8	9
A^r	Ash	% by weight	12.3 ÷ 44.2	21
S_t^r	Sulphur	% by weight	2.6 ÷ 10.7	6
Size 90 %	-	Mm	-	-

Mixing of the imported and local coal

The following mixture ratios are assumed as limiting values (after ca 5 years of the power plant operation):

Maximum ratio of a local coal: 50 % of the imported coal x 50 % of a local coal

The boiler will not be designed for combustion of 100 % local coal.

Both types of the coal will be imported by trucks to the site.

The start-up and stabilization fuel

LFO will be used as a start-up and stabilization fuel. LFO parameters are specified in the following Tab. 3.

Tab. 3: LFO parameters

Component	Unit	Value
Specific Gravity 60/60 °F	-	0.87
Flash point (min.)	°C	54
Sulphur content (max.)	% mass	1.0
Copper strip corrosion 3 hrs. at 50 °C (max.)	-	1.0
Kinematic viscosity at 50 °C	mm^2/s,cSt	1.5 ÷ 5.0
Kinematic viscosity at 37.8 °C	mm^2/s,cSt	1.8 ÷ 6.0
Kinematic viscosity at 5 °C	mm^2/s,cSt	3.8 ÷ 29
Cloud point (max.)	°C	6.0
Pour point (max.)	°C	3.0
Carbon residue (max.) on 10 % distillation residue	% mass	0.2
Ash (max.)	% mass	0.01
Water (max.)	% vol	0.05
Sediment (max.)	% mass	0.01
Cetan Index (min.)	-	45
Total Acid No. (max.)	mg KOH/g	0.5
Calorific value (min.)	BTU/Lb	19,000
HCV	MJ/Kg	44.15
LCV	MJ/Kg	40.14
Operational temperature	°C	3÷44

Limestone

The additive considers a slightly milled limestone with content of 94 - 96 % of $CaCO_3$ (wt. %, dry) for conceptual design is considered 94 % of $CaCO_3$.

The size of finely milled a limestone is 100 ÷ 300 μm (ratio size for fluidization in fluidized bed). The maximum size is 500 μm.

The grain size distribution shall be in between minimum and maximum limit area specified by following diagram:

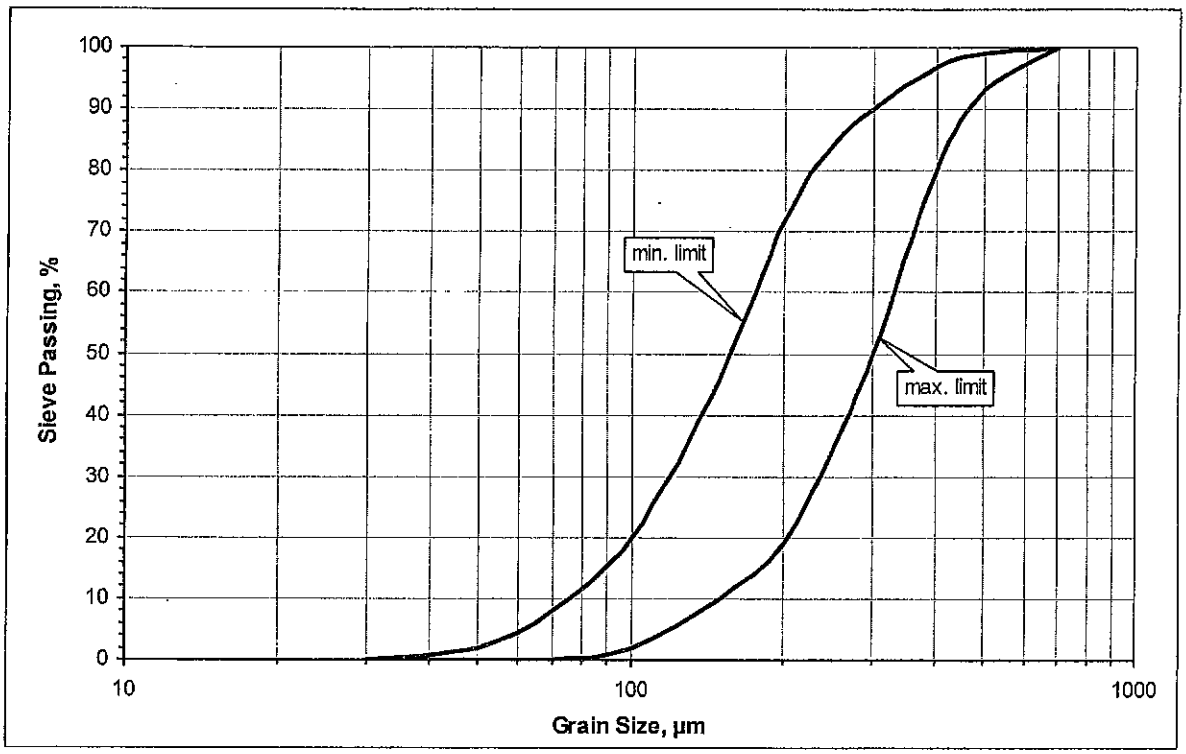


Fig. 1: Grain size diagram

Sand

Quartz sand will be used as bed material in the CFB boiler for first start up. Sand shall be dry, washed and not crushed.

Sand parameters are as following:

Initial deformation temperature:	> 1400 °C
K_2O a Na_2O content	< 2 % w
Residual moisture	< 0.1 % w

Fuel:

type, imported/indigenous, supplier, logistics, pipelines etc.

Sr	Description	Values
1	Fuel	Imported and Indigenous Coal

Supplier -

Transport

Emission values

Emission Values

Parameters	Units	Value
CO	mg/Nm^3	800
SO_2	mg/Nm^3	1700
NO_x	mg/Nm^3	1200
PM_{10}	mg/Nm^3	500

Cooling water source: tube wells, sea/river/canal, distance from source, etc.

Description

Wells at the site will be used as a source of the raw water for the power plant. The wells will be realized as a part of the new power plant. The raw water requirement to cover the power plant operation is max 200 m^3/h.

The raw water main consumption in the power plant is mainly comprised of the condenser cooling system and additional water required for the water treatment for the steam cycle.

The wet cooling system (mechanical draft wet cooling tower) is assumed to be used.

Cooling water consumption: ca. 165 m^3/h (for concentration factor 3)

CWTP consumption ca. 12 ÷ 14 m^3/h (production 8 m^3/h of demiwater)

Total raw water consumption: ca. 180 m^3/h

The raw water consumption is calculated for the highest summer monthly average temperature 35 °C DBT and relative humidity 60 %.

Max (at most for a few days) CWTP water consumption is estimated 24 ÷ 28 m^3/h (production 16 m^3/h of demiwater).

The basic and the only currently available document which defines the source, quality and quantity of water for the needs of the new power plant is the document, "HYDROGEOLOGICAL STUDY for the POWER PLANT at MUGHAL INUSTRIES HEIKHUPIRA ROAD LAHORE" (electronic version: 2nd interim report. dox). From this study it is clear that in various places of designated territory were drilled 9 underground wells. At different depths in wells there were examined various parameters of ground water (temperature according to depth, conductivity, etc.). Complete chemical analysis of the water was made only for a sample from one well designated as "Prob 5" without specification of the depth of sampling (Table 3 and Annex B of the study).

This document can be sufficient to obtain general knowledge about the quality and quantity of water wells in the location. For the correct specification of a consumption and design a water treatment plant it is important to perform more detailed analysis and defining the conditions.

Conceptual Project design in the scope of water treatment requires clarify/determine the following parameters:

- Defined well (or wells), from which water will be drawn into the raw water storage tank;
- Check the capacity of these raw water sources (wells);
- Perform the chemical analysis of mixed in the ratio of wells water within the scope of the chemical parameters in the selected well/wells (min – max – design) according to the changes in these values, depending on the season, or other climate change (for example, to monitor the impact of monsoon on water quality);

Interconnection with National Grid Co. distance and name of nearest grid, voltage level (single line diagram)

Grid Interconnection

The power plant will be connected into the National grid on level 132 kV. A new 132 kV outdoor switchyard will be built within the premises of power plant. The power plant and switchyard will be designed according to requirements of NEPRA Grid code.

It is supposed that switchyard will be designed as two system switchyard with bus bar coupler. Short circuit withstand capability of switchyard 132 kV is supposed 40/100 kA and maximal operation voltage should be 145 kV.

Switchyard is planned with 5 bays in total:

- 2 bays for 132 kV lines
- 1 bay for connection of power outlet line from new power plant
- 1 combined bay for voltage measurement and bus bar coupler
- 1 bay for connection of transformer 132/11 kV for power supply of Mughal Steel
-

The interconnection of the switchyard (power plant) with National grid will be made by the 132 kV line from Attabad to Green view which will be split and both ends will be connected to the new switchyard in the power plant. It is supposed that this connection will be made by 132 kV cables.

The power outlet system and interconnection with National grid will be designed in a way that there will be possibility to outlet whole power of the power plant into the grid in case of technological outage in the Mughal steel factory.

It is supposed that data transmission between power plant and the Grid dispatch centre will be provided by PLC system through overhead power lines 132 kV.

Infrastructure: roads, rail, staff colony, amenities

Infrastructure

The site for the power plant construction is nearby the Mughal Steel Industry site. The existing infrastructure available for the Mughal Steel operation is available for the new power plant – roads, electricity grid. The capacity of the basic existing infrastructure will be sufficient for the new 50 MW power plant operation.

Fuel (coal) transport:	Coal will be transported by trucks to the site
Limestone transport:	Limestone will be transported by trucks to the site
By - products transport:	Ash will be transported by trucks from the site
Raw water transport:	Connection to the water source (river) is not possible. The new wells will be realized on the power plant site as a raw water source
Drinking water:	Drinking water will be delivered from the existing Mughal steel factory
Waste water:	After sufficient treatment waste water will be conducted to the existing water channel
Electricity during construction:	Electricity supply will be from the existing Mughal steel factory.
Water during construction:	Water wells will be already in operation during construction phase. In case of delay, water will be delivered from the existing Mughal steel factory

Chosen site for new power plant is a green field without any civil objects, services, infrastructure etc. However nearby located Mughal Steel factory can provide all necessary connections important for construction such as electricity and water. The site is easily accessible by existing roads.

Project cost, information regarding sources and amounts of equity, debt.

Project Cost and Financing Plan

Project Cost	USD
EPC Cost	103,774,639
Non-EPC Cost	16,920,059
Project Development Cost	2,260,436
Pre-COD Insurance	860,686
Interest During Construction	12,124,534
Financial Fees and Charges	1,026,008
Total	**136,966,362**

Financing Plan	USD
Debt (25% of Total)	34,241,590
Equity (75% of total)	102,724,771
Total	**136,966,362**

Project commencement and completion schedule with milestones

Project Timeline:

The expected COD date for 55 MW Coal Fired Power Project is 18 months from date of financial close of the project and the same is anticipated to be March 31, 2021

ESSA (Environmental and Social Soundness Assessment)

Attach Study

IEE Study here

ENVIRONMENT PROTECTION DEPARTMENT

Government of the Punjab
National Hocky Stadium, Lahore.

NO. DD (EIA)/EPA/F-834(IEE)/ 1601/2018/ 326
Dated: 10 /05/ 2019

To

Mr. Shakeel Ahmed,
31-Shadman 1, Lahore

Subject: **DECISION OF EPA PUNJAB REGARDING PROJECT "INSTALLATION OF 55-MW COAL FIRED POWER PLANT BY M/S MUGHAL STEEL INDUSTRY, 17-KM LAHORE – SHEIKHUPURA ROAD, DISTRICT SHEIKHUPURA"**

1.	Description of Project:	Installation of 55-MW Coal Fired Power Plant.
2.	Location of Project:	17-KM Lahore – Sheikhupura Road, District Sheikhupura
3.	Date of filing of IEE:	19.11.2018

4. EPA Punjab has reviewed the Initial Environmental Examination (IEE) Report and considered Site Inspection Report received from Deputy Director (Environment), Sheikhupura vide letter No. 1417/DDE/SKP/2018 dated 29.12.2018. EPA Punjab has also considered the recommendations of **Committee of Experts** (Meeting dated 16.01.2019) and other relevant record to take the lawful decision.

5. **Environmental Protection Agency, Punjab accords Environmental Approval under Section 12 of Punjab Environmental Protection Act, 1997 for construction / installation of your aforesaid Project subject to the following conditions:**

i. The proponent shall install new and state of the art systems, machinery, equipment, instruments that are most efficient and latest in their development cycles, like super critical / ultra-super critical boiler etc.
ii. The proponent shall comply with the Punjab Environmental Quality Standards (PEQS) by installing appropriate pollution control equipment and/or treatment plants where necessary.
iii. The proponent shall submit detailed modeling study of emissions to ensure PEQS compliance with respect to both emission and ambient air standards within the reach of the emitted pollutants before commencement of the project.
iv. Mitigation measures suggested in the IEE and Environmental Management and Monitoring Plan (EMMP) of the IEE shall be strictly adhered to. The proponent shall detail expert(s) to monitor, ensure, and report compliance of the EMMP.
v. Monitoring shall be carried out during the entire period of the project activities. Monitoring reports of the whole operation shall be submitted to EPA Field office on quarterly basis.
vi. The proponent shall install online air pollution monitoring analyzers for regulated pollutants like particulate matter, CO, SO2, NOx, HC, and Mercury and provide EPA Punjab continuous online access to these analyzers.
vii. The proponent shall ensure that the project, when operational, is in full compliance of Minamata Convention for control of mercury emissions.
viii. The proponent shall install wastewater treatment plant and shall dispose of the treated wastewater in compliance with PEQS.
ix. The solid waste shall be retained within the unit boundary / premises and shall be disposed of in environment friendly way at a designated disposal facility.
x. The proponent shall submit detailed plan for handling and ultimate disposal of solid waste generated.
xi. The proponent shall take measures for safe storage of fuel as per the governing laws.
xii. This environmental approval for the project does not absolve the proponent of the responsibility of obtaining necessary permissions from any other concerned authority which may be required under the law.
xiii. The project-affected people, if any, shall be compensated as per the governing law of the land.
xiv. The project proponent shall ensure proper collection and safe disposal of fly ash and bottom ash of the plant.
xv. The proponent shall installed Electrostatic precipitator, bag filters and other necessary equipment to ensure compliance of PEQS.

P.T.O

xvi. Ash must be disposed of an proper scientific way in consultation with EPA after proper management plan.

xvii. The proponent shall plant at least 10,000 trees of minimum height 7-8 feet especially of indigenous species in consultation with EPA Field office. The proponent shall also take measures for the protection and maintenance of these trees.

xviii. Any change in capacity or any other characteristics of the project, the proponent shall seek prior approval of EPA Punjab.

xix. The proponent shall follow the SOPs regarding dengue larvae eradication and shall ensure removal of stagnant water on daily basis.

xx. The proponent shall install Ambient Air Quality Station within 6 months with online access to EPA Punjab. The proponent shall install SCADA with access in EPA Punjab.

xxi. This approval can be withdrawn at anytime without any prior notice if deemed necessary in the public / national interest.

6. The Proponent shall, before commencing construction of the Project, acknowledge acceptance of the stipulated conditions by executing an Undertaking in the form prescribed in Schedule VII of Review of IEE/EIA Regulations 2000.

7. The Proponent shall be liable for correctness and validity of information supplied to this Department by the Environmental Consultant.

8. This approval is accorded only for the construction phase of the Project. The Proponent shall apply for confirmation of compliance under Regulation 14 of IEE / EIA Regulation, 2000 by submitting Environmental Management Plan for operational phase along with compliance status report of the Environmental Approval of the construction phase of the project.

9. The Proponent shall be liable for compliance of Regulations 13, 14, 18 and 19 of IEE/EIA Regulations, 2000, regarding Approval, Confirmation of Compliance, Entry, Inspections and Monitoring.

10. EPA reserves the right to impose any other condition based on its monitoring.

11. Any change in the approval Project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

12. This approval shall be treated as null and void if all or any of the conditions mentioned above, is/are not complied with. This approval does not absolve the proponent of the duty to obtain n any other approval or consent that may be required under any law in force and is subjudice to legal proceedings in any legal for a / court.

13. This approval shall be valid (for commencement of construction) for a period of Three Years from the date of issue under the Regulation 16 of IEE/ EIA Regulations, 2000.

14. This approval can be withdrawn at anytime without any prior notice if deemed necessary in the Public/ National interest.

15. This decision is issued with approval of Director General, EPA, Punjab.

ASSISTANT DIRECTOR (EIA)

NO. & DATE EVEN:

A copy is forwarded to the Deputy Director (Environment), Sheikhupura w.r.t. letter No. 1417/DDE/SKP/2018 dated 29.12.2018. He is requested to:

i. Obtain Undertaking from the Project Proponent mentioned at Para 6 for the record of EPA Headquarter and Field Office.

ii. Ensure compliance of the conditions mentioned in the Environmental Approval and maintain the file / record of correspondence with the Project Proponent properly.

ASSISTANT DIRECTOR (EIA)

Safety plans, emergency plans

1. Safety

During the construction period Contractor shall ensure safety. Conformance to standards and codes will be ensured.

After Commissioning during and after 2year O&M Period safety will be followed as per safety plans developed as per applicable laws and regulations.

2. Emergency Plans

During Commissioning period and after commissioning emergency plan will be followed as per above mentioned (Safety Plan) principle.

System studies, load flow, short circuit, stability, reliability

Employer

MUGHAL ENERGY

Mughal Energy 55 MWe CFPP

GRID INTERCONNECTION STUDY

Draft Report

Change	Date	Designed by		Reviewed by		Approved by		PM		Rev.

Project	**Mughal Energy 55 MWe CFPP**				Copy No.
Prepared by	ÚJV EGP designers	Coordinated by	ÚJV EGP project coordinators	Date	Serial No.
Reviewed by	Ing. Jan Anděl	PM	Lucie Židová	01/2016	003
Design Level	El. file: 150116_Interconection_Study_Mughal Energy 55 MWe CFPP.docx		Contract No. 35-5237-30-001		Rev.
			Document No. EGP 5100-F-150237		0

Consultant

ÚJV Řež, a. s.
Division ENERGOPROJEKT PRAHA

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Executive Summary

Mughal Energy Limited (MEL) intends to setup a 55 MW coal fired power generation plant at 17-km Sheikhupura road, Lahore, Pakistan with expected Commercial Operation Date (COD) of September 2018.

The grid interconnection scope for power transfer of 55 MW MEL power plant to the Lahore Electric Supply Company (LESCO) power system network is projected with;

- 132 kV double circuit transmission line, approximately 0.5 km length of ACSR Rail conductor is connected to the nearby Attabad – Rustam transmission line at the 132 kV switchyard of 55 MW MEL coal power plant by making In-and-Out connection arrangement.

LESCO grid system, after addition of the coal power plant was analyzed for load flow, short circuit, and dynamic stability studies to determine whether the plant connection with the LESCO grid meets the NEPRA Grid Code requirements.

The latest and up-to-date network model base cases have been used. Steady state, sequence and dynamic data for the coal power plant is processed to build the steady state, short circuit and dynamic models in PSS/E software format.

The analysis has been performed for September 2018 peak case of the interconnection year 2018-19 of studies. The power flow analysis shows that the bus voltages and line loadings in all the cases, with and without addition of the coal power plant are within acceptable limit of defined planning criteria. The results were also validated as per the standards of line loading and bus voltage limits in associated N-1 post-contingency conditions.

Maximum short circuit levels at HV bus of MEL power plant in the horizon year 2019-20 was computed. Moreover, in order to see the short circuit current contribution of MEL power plant, maximum short circuit levels at the substations located in vicinity of the project are also computed. The results show that fault levels are within the circuit breaker duties with the addition of the subject project to the 132 kV network of LESCO.

Dynamic stability studies were carried out to check the dynamic impact on the coal power plant due to potential faults in LESCO grid system and, in turn, the impact of disturbances in the coal power plant on LESCO grid system. Power plant is found to meet all the dynamic stability requirements as per defined by the NEPRA Grid Code. The results of stability analysis shows that the power system is stable for the suggested interconnection scheme of the MEL power plant and it fulfils all the criteria for the generation connection with the power system.

Based on the study results, overall it is concluded that proposed generation connection for 55 MW MEL coal power plant meets the NEPRA Grid Code and planning criteria.

1. Introduction

1.1 Project Background

MEL intends to setup a 55 MW coal fired power generation project at 17-km Sheikhupura road, Lahore, Pakistan with expected Commercial Operation Date (COD) of September 2018. This report covers the connection assessment studies for 55 MW MEL coal fired power generation project.

Detailed interconnection scheme and related potential issues regarding the proposed power evacuation through a point of common coupling are addressed in the subsequent sections.

MEL power generation project can be interconnected with the power system network of Lahore Electric Supply Company (LESCO) at 132 kV voltage level.

1.2 Objective of the Study

The principal objective of this Grid Interconnection Study of 55 MW coal power plant to the national grid system of Pakistan is to assess the impact of the suggested interconnection for the power plant on the LESCO transmission system and vice versa. In this study a most appropriate interconnection with the LESCO network is presented for the project.

The following studies and tests are carried out in order to check the robustness of coal power plant and the interconnection strategy of the desired system.

1. Load flow analysis.
2. Short circuit analysis.
3. Dynamic stability analysis.

The above studies were carried out to demonstrate that the proposed connection plan of this plant meets the National Electric Power Regulatory Authority (NEPRA) Grid Code Planning Criteria.

The system operational capability was analyzed by the steady state analysis under normal and contingency conditions. This particular assignment also aims at investigating that the connection of the power plant with the LESCO system fulfils the criteria of dynamic stability. The criteria is that the system should be stable enough that it should return to the normal state following the fading of a momentary actions in current, voltage or frequency, without losing connectivity.

2. Methodology and Assumptions

2.1 Methodology

The methodology of the gird interconnection study follows the NEPRA Grid Code planning criteria and the studies are carried out in following sequence:

All the technical data, relating to the specification of power plant is collected from MEL and is attached with this report as Appendix A.

- The information and data regarding the interconnection arrangements for the power plant involves discussion made with subject plant engineers and site surveys.
- The power plant data is processed and then modelled in the overall LESCO network model. Updated system network is then reviewed and tested for its validity.
- Multiple options for power transfer of subject power plant are prepared and analyzed; however, the most appropriate interconnection proposal is adopted on the basis of results obtained by system studies.
- Comprehensive load flow, short circuit and transient stability analysis have been carried out to determine the adequacy of the proposed interconnection arrangement as per NEPRA Grid Code planning criteria.
- Results are compiled and analyzed in detail for above simulations effectively in order to conclude the study and complete the report accordingly.
- Conclusions are submitted based on study results and findings.
- All the system data processing, modeling and simulations are carried using PSS/E software.

2.2 General assumptions

Following are the important assumptions used for this study:

- The transmission expansion plans of LESCO are the optimal ones as per load demand and generation requirements.
- Steady state and dynamic data for power plant is provided by MEL. Else otherwise, reasonable assumptions are made based on prudent industry practices for any missing or unavailable data.
- Applicable seasonal conditions and appropriate study year for the subject system study are incorporated, which is;
    - **Year 2018-19:**

      September 2018 peak case of the interconnection year 2018-19 is selected as base year case for this study.

3. Interconnection Scope

The particular objective of this study is to develop and simulate a connection plan for the power plant with a nearby transmission line/substation such that there is no physical limitation regarding the Right Of Way (ROW) and free available capacity is accessible at the substation. Multiple options for power evacuation of 55 MW coal power plant were analysed and on the basis of system studies the most feasible interconnection proposal is suggested.

The grid interconnection scope for power transfer of 55 MW coal power plant to the LESCO power system network is projected with;

- 132 kV double circuit transmission line, approximately 0.5 km length of ACSR Rail conductor is connected to the nearby Attabad – Rustam transmission line at the 132 kV switchyard of 55 MW MEL coal power plant by making In-and-Out connection arrangement.

4. Field Survey and Data Processing

4.1 Site Survey

55 MW coal fired power generation by MEL is located at 17-km Sheikhupura road, Lahore, Pakistan. The field survey of site was carried out in order to ensure the Right of Way (ROW) and space availability at interconnection points.

4.2 Collection of Data

Power plant's location with coordinates, generation units and transformation requirements, steady state and dynamic data of power plant is provided by MEL. However, reasonable assumptions were made by to complete the study and the report, whenever certain information was unavailable or needed correction in the provided steady state and dynamic data.

4.3 Processing of Power Plant Data

The received raw data has been processed into the PSS/E software format in order to model the power plant in PSS/E and to perform the simulation studies.

This processed plant data is modelled in the overall LESCO network model as per proposed connection scheme. Updated LESCO network base case is then simulated by considering the N-1 contingency analysis for each case using standard checks like convergence, mismatch, number of iterations, voltage and thermal limits, and 10 seconds drift-run tests for dynamics run.

Plant data is processed to build the following basic models in PSS/E software format:

i. Steady state data for load flow analysis.

ii. Sequence data for short circuit analysis.

iii. Dynamic data for transient stability analysis.

4.3.1 Steady State System Modelling

MEL coal power plant would have the gross generation output of 55 MW, however plant's own consumption is approximately 6 MW, therefore net active power output will be 49 MW as communicated by MEL.

Steady state models of generator and transformers at MEL power plant in PSS/E software as under:

- MEL coal power plant has been modelled with 1 synchronous generator having Pmax= 55 MW, Qmax= 34.0860 MVAR @ 0.85 lagging power factor, Qmin= -26.6380 @ 0.9 leading power factor and base MVA of 65 MVA.
- 1 generator step-up transformer (G.S.U) of apparent power 65 MVA, 10.5% reactance and transformation voltage level of HV/LV (132/11.5 kV).
- 132 kV double circuit transmission line of ACSR Rail conductor for interconnection of 55 MW MEL coal power plant has been modelled having its per unit (p.u) resistance, reactance & susceptance according to 0.5 km line length and 202 MVA rating.

- Positive sequence parameters are employed in the steady state model of the under study power plant.

4.3.2 Sequence Data Modelling

The short circuit model of the power plant is used to carry out short circuit studies at its own switchyard and existing adjacent substations.

Short circuit model has been prepared by representing:

- One generator having 65 MVA rating
- One generator step-up transformer 65 MVA rating, YN/d winding connection.
- One equivalent step-down transformer with the same characteristics as generator step-up transformer. This equivalent transformer represents the group of 132/11.5 kV transformers connecter to the MEL 132 kV substation.

Short circuit model has been prepared by representing:

- Positive sequence data.
- Negative sequence data.
- Zero sequence data.

4.3.3 Dynamic Data Modelling of Power Plant

PSS/E dynamic stability model is developed to simulate performance of the coal power plant connected to the grid.

The generic thermal power plant model comprises of the following 3 modules. These modules are conventionally designated as generic thermal modules as indicated below:

- **GENROU:** Generator Module
- **EXST1:** Excitation System
- **TGOV:** Speed Governing System

(Reference: Program Application Guide of PSSE Version 32, Volume-II, October 2010).

5. Load Flow Analysis

5.1 Load Flow Study Objectives

A power flow study (or load flow study) is an analysis of the magnitude of bus voltages, line loadings, phase angles of the bus voltages and power flows in a power system under steady-state conditions.

The main goal of load flow analysis is to develop a reliable connection arrangement between the power plant and the LESCO grid system, for the evacuation of 55 MW power from the coal power plant thus satisfying the N-1 contingency conditions.

A base case model has been prepared, consisting of all 500kV, 220kV and 132kV system, and studies for the entire system have been carried in order to assure that the proposed connection of the coal power plant is realistic for the maximum load settings.

The analysis has been performed for September 2018, peak case of the interconnection year 2018-19 of studies. The power flow conditions are studied on the system study cases that include up-to-date generation, transmission facilities, and load forecast representing the queue position applicable to this project.

Following are the important objectives of load flow analysis:

- Confirmation that no voltage and thermal loading limits are exceeded as per NERPA Grid Code Planning criteria.
- Voltage profile of LESCO system.
- Transmission line loadings in terms of Active (MW) and Reactive Power (MVAR) flows.
- Active Power (MW) loss in the network.
- Transmission network and transformation reactive losses (MVAR).
- Proposal of remedial solutions to any identified limitations or issues.

A relative approach has been used in the power flow analysis in order to determine the impact of the power plant project on the performance of the LESCO power system network. First, performance of the base case system without the power plant project was evaluated in order to establish the baseline. Later, the analysis was performed with the addition of the power plant and plotted on single line diagrams.

5.2 Load Flow Study Criteria

Load flow analysis is performed under the following conditions;

- Steady state normal (N) operating conditions.
- N-1 contingency operating conditions around the plant.

The gird interconnection studies are carried out by considering the operational data defined by NEPRA Grid Code, which is listed as under;

5.2.1 Voltage limits

For the purpose of system planning, following voltage limits are defined for steady-state load flow analysis;

i. Under normal operating conditions (N condition) all bus voltages shall be within the bandwidth of ±5 % of Nominal System Voltage.
ii. Under N-1 contingency conditions all bus voltages shall be within the bandwidth of ± 10 % of Nominal System Voltage.

5.2.2 Component loading limits

Loading criteria for current carrying components (transmission circuits, transformers, substation bus bars, circuit breakers, disconnect switches and auxiliary equipment) for the purpose of evaluating steady-state load flow studies is as follows;

i. Under normal operating conditions (N conditions), all components shall be loaded below their Normal Continuous Maximum Ratings.
ii. Under contingency conditions (N-1 conditions), all components shall be loaded below their Emergency Ratings.

5.2.3 Frequency limits

The frequency of the LESCO transmission system shall be nominally 50Hz and shall be maintained within the following limits defined for exceptional circumstances.

i. Frequency Sensitive Mode shall be 49.8 Hz - 50.2 Hz. Such a variation is permissible to allow frequency variations while ramping up generation and load pick-up.
ii. Protected periods of operation of the system at the frequency in the range of 49.5 Hz - 50.5 Hz (Tolerance Frequency Band).
iii. Minimum/Maximum Acceptable Frequency Band shall be 49.4 Hz - 50.5 Hz (Load Shedding Threshold or Contingency Frequency Band), which is well within the applicable IEC Standards.

5.2.4 Power factor

Power plant will manage reactive power control to maintain the power factor within the range of 0.8 lagging and 0.9 leading, at full active power output at its interconnection point.

(Reference: NEPRA Grid Code).

5.3 Load Flow Analysis without MEL Coal Power Plant

The power flow analysis without connecting the power plant to the base year 2018-19 power network of LESCO system was simulated first. This section summarizes the pre-contingent steady state analysis for the LESCO system load flow study.

System study case of following scenario was analyzed and presented on single line diagrams (SLDs);

- September 2018 peak load conditions.

The results of the system are presented for normal (N condition) only, which shows that the power flows on all the circuits are within their defined current carrying capacity and the bus voltages are in the permissible range.

Normal (N) load flow study without addition of MEL power plant is attached in Figure B-1 of Appendix B.

It is observed that prior to connecting the power plant to the LESCO power network all the current carrying capacities are within the range. No limitation is seen in any of the MW and MVAR flows.

5.4 Load Flow Analysis with MEL Coal Power Plant

55 MW coal power plant is then modelled in power flow. The updated power flow cases are developed in order to determine the impacts resulted from this generator addition with proposed interconnection. The analysis has been performed for the following year and plotted on SLDs.

- Base Year 2018-19.

5.4.1 Base Year 2018-19.

Base year case is considered for the system impact study that is;

- September 2018 peak load conditions.

5.4.1.1 September 2018 Peak Load conditions

The results of the power flow after connecting the power plant to power system shows that all the MW and MVAR power flows on all the circuits are within the rated capacities and lies within the allowable range.

Normal (N) load flow study of September 2018 Peak Load conditions is attached in Figure C-1 of Appendix C.

Contingency analysis was also carried out to evaluate the power system network under the standard functioning conditions. Contingency conditions were simulated for numerous selected outages. N-1 contingency analysis ensures a power system's capability to meet the demands as well as remain in specified voltage and flow limits even after outage of any one component.

Following are some selected contingency simulations that are carried out while performing contingency analysis and results of the analysis are presented on SLDs with referred figure numbers below:

- Mughal Energy – Rustam 132 kV single circuit out. (Figure C-2)
- Mughal Energy – Attabad 132 kV single circuit out. (Figure C-3)
- Green View – Rustam 132 kV one circuit out. (Figure C-4)
- Green View – Attabad 132 kV one circuit out. (Figure C-5)
- Attabad – EMCO 132 kV single circuit out. (Figure C-6)
- Attabad – K.S.K 132 kV one circuit out. (Figure C-7)

Results of contingency analysis demonstrate that the resulting MW and MVAR power flows on the circuits and transformers after N-1 outage of selected components are within the rated capacities.

N-1 contingency load flow study of September 2018 Peak Load conditions is attached in Figure C-2 to C-7 of Appendix C.

5.5 Conclusions of Load Flow Analysis

No incremental pre-contingent system overloads or voltage violations resulting from interconnection of 55 MW MEL coal power plant were found within the local study area or across LESCO transmission system. This finding was also validated through associated pre-contingent steady state system and post-contingency steady state system, overload and voltage violation screening outputs generated for the system model.

Thus, it can be concluded that the power flow on all the circuits in all the cases with and without connecting 55 MW MEL coal power plant is within defined limits and the voltages and loadings are in acceptable range of defined study criteria.

6. Short Circuit Analysis

6.1 Short Circuit Study Objectives

This section covers the short circuit analysis performed for 55 MW MEL coal power plant. When generation is added to a system, the available fault current of that system increases. Therefore, short circuit study has been performed to determine if the circuit breakers of existing substations near the new generation have adequate short circuit interruption duties.

Short circuit analysis includes the three-phase and single phase-to-ground fault simulations at LV and HV bus bars in the switchyard of subject power plant. The fault currents computed at the power plant buses would be used for selection of circuit breaker ratings.

Short circuit studies would determine the following;

- Maximum fault current levels at the coal power plant.
- Total fault currents and contribution from the associated network.
- Adequacy of short circuit capacity of switchgears at neighboring existing substations.

6.2 Short Circuit Study Assumptions and Criteria

Short circuit studies were carried out for evaluating the following short circuit levels of power plant's 11.5 kV bus bar, 132 kV bus bar of switchyard and contiguous network;

- Balanced 3 phase and fault levels.
- Unbalanced single phase to ground fault levels.

Analysis was performed for horizon year scenario of 2019-20, as the future case would have all the planned generation and transmission systems components in service, which would produce the worst scenario with extreme fault level calculations.

Short circuit currents were calculated for maximum fault levels according to International Electro technical Commission (IEC) standard IEC-909, with the following assumptions;

- For calculations of maximum fault levels;
  - Bus voltage has been assumed as 1.10 per unit (p.u) i.e. 10 % above the nominal.
  - Maximum dispatch of all the generation in the system has been taken.
- Taps ratios of all the transformers to be assumed at unity.
- Charging of all the transmission lines to be assumed at zero.
- All the shunt compensations to be assumed at zero in positive sequence.

6.3 Maximum Short Circuit Study

In order to analyze the impact of the power plant on the system, Short circuit analysis is performed after connecting the power plant. The horizon year scenario of 2019-20 is simulated for the subject study.

The total maximum short circuit levels at the bus bars of substations located in the electrical vicinity of the area of interest have been calculated and are tabulated below;

Table: Maximum Short circuit levels with addition of MEL coal power plant in horizon year 2019-20.

	Substation	Bus bar Voltage (kV)	3 Phase Short Circuit Level (kA)	Single Phase Short Circuit Level (kA)
1.	MEL HV bus	132	19.086	13.988
2.	MEL Generator LV bus	11.5	54.619	37.782
3.	Rustam	132	34.920	22.331
4.	Attabad	132	39.686	27.590
5.	Green View	132	37.291	23.847
6.	EMCO	132	26.958	17.296

Maximum Short Circuit Study Report of horizon year 2019-20 is attached in Appendix D.

Note:
In the attached short circuit study reports, both three phase and single phase fault currents with polar coordinates and detailed output showing contribution from adjoining sources (i.e. lines and transformers connected to the bus bar) to the fault currents are included.

6.4 Conclusions of Short Circuit Analysis

Maximum short circuit levels in horizon year are computed at the coal power plant for selection of circuit breaker ratings. Moreover, in order to see the short circuit current contribution of 55 MW MEL coal power plant, maximum short circuit levels at the substations located in electrical vicinity of the project are also calculated. The findings show that with addition of this project, fault levels do not exceed the standard circuit breaker ratings of existing installed equipment at the neighboring substations. Therefore it is concluded that the proposed interconnection scheme holds good on the basis of short circuit analysis as well.

7. Dynamic Stability Analysis

7.1 Dynamic Stability Study Objectives

The stability studies are carried out to check the dynamic impact on the coal power plant due to faults or disturbance in national grid system and, in turn, the impact of disturbances in national grid system on the coal power plant.

The studies involved choice of equipment and optimum regulation through control strategies which allows the system to remain in stable conditions under potential risks. Dynamic stability studies provide the basis of power system for the subject power plant as it determines the following;

- Dynamic stability of the power plant after any fault occurs in the system by damping of fluctuations in voltage and frequency etc.
- Risk of dynamic instability (loss of synchronization between the generators).
- The capability of system to damp the oscillations timely.
- Operating limits of frequency and voltage for power plant as imposed by the NEPRA Grid Code standards.
- Proposal of remedial solutions in the event of a problem.

7.2 Dynamic Stability Study Criteria

The benchmark criteria for dynamic stability analysis are;

- Three phase short circuit fault application at important and selected buses (for N-1 fault contingencies locations) is evaluated as per standards of NEPRA stability criteria.
- Dynamic stability analysis is simulated for normal 5 cycles fault, with opening of the faulted system component.

7.3 Dynamic Stability Performance of MEL Power Plant

In order to study the dynamic behavior of power plant and system towards the disturbances, following faults are subjected:

I. 3 Phase fault at MEL power plant cleared in 5 cycles.
II. 3 Phase fault at far end cleared in 5 cycles.

Important parameters / quantities are monitored and plotted for these faults in the stability studies. In order to obtain the results, every simulation is carried for the steady state condition for one second, to ensure that the system is completely stable and steady before the fault is applied in the system (pre fault conditions / drift run test). Then fault is applied and system is simulated for the fault clearance time. After the clearance of the fault from the system (post-fault conditions) followed by a certain contingency, the system is observed for 10 seconds to ensure that oscillations in various quantities are damped and the system has re-instated the stability conditions.

7.3.1 3 Phase fault at MEL Power Plant cleared in 5 cycles

Three phase fault is applied at MEL power plant, then each fault is removed in 5 cycles (100 m sec) accompanied by a particular N-1 contingency and stability response of the system is monitored, which is summarized in the table below:

Fault E-1: 3 Phase faults at MEL HV cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-1.1	132kV line from MEL to Rustam	Bus Voltages of MEL LV, 132kV MEL, Rustam and Attabad	E-1.1A	Stable
		Frequency at 132 kV MEL	E-1.1B	Stable
		MW and MVAR output of MEL Generator	E-1.1C	Stable
		Rotor Angles of MEL, Saphire, Halmore and Saba Power Plants w.r.t. Muzaffargarh Swing Bus	E-1.1D	Stable
		MW and MVAR flows at 132kV line from MEL to Attabad	E-1.1E	Stable
E-1.2	132kV line from MEL to Attabad	Bus Voltages of MEL LV, 132kV MEL, Rustam and Attabad	E-1.2A	Stable
		Frequency at 132 kV MEL	E-1.2B	Stable
		MW and MVAR output of MEL Generator	E-1.2C	Stable
		Rotor Angles of MEL, Saphire, Halmore and Saba Power Plants w.r.t. Muzaffargarh Swing Bus	E-1.2D	Stable
		MW and MVAR flows at 132kV line from MEL to Rustam	E-1.2E	Stable

7.3.2 3 Phase fault at Rustam cleared in 5 cycles

Three phase fault has been applied at Rustam bus, fault has been cleared in 100 msec (5 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-2: 3 Phase faults at Rustam cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-2.1	132kV line from MEL to Rustam	Bus Voltages of MEL LV, 132kV MEL, Rustam and Attabad	E-2.1A	Stable
		Frequency at 132 kV MEL	E-2.1B	Stable

No.	Contingency	Monitored Element	Figure No.	System Response
		MW and MVAR output of MEL Generator	E-2.1C	Stable
		Rotor Angles of MEL, Saphire, Halmore and Saba Power Plants w.r.t. Muzaffargarh Swing Bus	E-2.1D	Stable
		MW and MVAR flows at 132kV line from MEL to Attabad	E-2.1E	Stable

7.3.3 3 Phase fault at Attabad cleared in 5 cycles

Three phase fault has been applied at Attabad bus, fault has been cleared in 100 msec (5 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-3: 3 Phase faults at Attabad cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-3.1	132kV line from MEL to Attabad	Bus Voltages of MEL LV, 132kV MEL, Rustam and Attabad	E-3.1A	Stable
		Frequency at 132 kV MEL	E-3.1B	Stable
		MW and MVAR output of MEL Generator	E-3.1C	Stable
		Rotor Angles of MEL, Saphire, Halmore and Saba Power Plants w.r.t. Muzaffargarh Swing Bus	E-3.1D	Stable
		MW and MVAR flows at 132kV line from MEL to Rustam	E-3.1E	Stable

7.4 Conclusions of Dynamic Stability Analysis

Dynamic stability studies are carried out to check the dynamic impact on the coal power plant due to faults or disturbance in national grid system and, in turn, the impact of disturbances in the coal power plant on national grid system. The results of stability analysis shows that the power system is stable for the suggested interconnection scheme of the MEL 55 MW coal power plant for the faults on the substations that might be near to or distant from the coal power plant.

It is therefore concluded that, with the addition of the 55 MW coal power plant in the grid, there are no stability issues seen and it fulfils all the criteria for the generation connection with the power system.

8. Conclusions

MEL 55 MW coal power plant has been proposed a generation connection scheme through a POI at 132 kV High Voltage (HV) network of LESCO by constructing a 132 kV double circuit transmission line, approximately 0.5 km length of ACSR Rail conductor, connected to the nearby Attabad – Rustam transmission line by making In-and-Out connection arrangement.

MEL 55 MW coal power plant is designed in compliance with requirements of NEPRA Grid Code. It particularly means that power plant is designed to meet voltage and frequency deviation changes in the grid and it is able to support the grid during faults (power plant is equipped with needed power, speed and voltage controls, automatons and protections).

LESCO grid system with inclusion of the coal power plant was analyzed by studies of load flow, short circuit and dynamic stability. The power flow outputs depicts that the power on all the circuits in all the cases with and without connecting coal power plant are within the defined range and the voltages that appears at the bus bars are within acceptable limit of defined study criteria. Load flow analysis is also validated as per the given standards of line loading and bus voltage limits in associated N-1 post-contingency conditions.

The short circuit studies have been carried out in order to see the contribution of MEL 55 MW coal power plant to the fault levels of the existing substations in its electrical vicinity, the maximum fault levels in the horizon years, with connecting the coal plant are calculated. The findings show that with addition of this project, fault levels do not exceed the standard circuit breaker ratings of existing installed equipment at the neighboring substations. The study has also quantified the maximum short circuit levels at LV and HV (POI) buses of MEL 55 MW coal power plant.

The impact of possible disturbances occurring on the system are analyzed by the dynamic stability analysis and the results of stability analysis shows that the power system is stable for the suggested interconnection scheme of MEL 55 MW coal power plant for the faults on the substations that might be near to or distant from the coal power plant. Thus, there are no constraints found in the stability of the system and it fulfils all the criteria for the generation connection with the power system.

Therefore, it is concluded that the proposed generation connection for MEL 55 MW coal power plant is appropriate on the basis of results of all the system studies.

Employer

MUGHAL ENERGY

Mughal Energy 55 MWe CFPP

Conceptual Design – 1st part

TECHNICAL FEASBILITY STUDY REPORT

Change	Date	Designed by	Reviewed by	Approved by	PM	Rev.

Copy No.

Project: **Mughal Energy 55 MWe CFPP**

Designed by	ÚJV EGP designers	Coordinated by	ÚJV EGP project coordinators	Date	Serial No.
Reviewed by	Z. Vlček	PM	J. Petrů	03/2015	002
Design Level	El. file: TR_MEL_1st_phase_CD.docx		Contract No. 35-5237-30-001		Rev.
			Document No.: EGP 5100-F-150237		0

Consultant

ÚJV Řež, a. s.

Division ENERGOPROJEKT PRAHA

CONTENT

List of abbreviations

Abbreviation	Title
BOP	Balance of Plant
BMCR	Boiler maximal continuous rate
BOP	Balance of plant
CFB	Circulation Fluidized Bed Boiler
CO	Civil Object
CWTP	Chemical water treatment plant
DBT	Dry bulb temperature
EDI	Electro-delonization
EPRI	Electric power research institute
ESP	Electrostatic precipitator
FAS	Fire alarm system
FDPS	Fire detection and protection system
FGD	Flue gas desulphurization
GE	General electric
HP	High pressure
HVAC	Heating, ventilation, air condition
LFO	Light fuel oil
LHV	Lower heating value
LP	Low pressure
NEQS	National Environmental Quality Standards
NEPRA	The National Electric Power Regulatory Authority
PM	Particulates matter
PS	Process system
RB	Richards Bay Coal Terminal in South Africa
RO	Reverse osmosis

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1. IDENTIFICATION DATA

1.1. Project identification data

Project title: MUGHAL ENERGY 55 MWe Coal Fired Power Plant (CFPP)

Site locality: Mughal Steel, Lahore, Pakistan

1.2. Identification data of the Employer

MUGHAL ENERGY LIMITED

Address: 31 Shadman -1, Colony
Lahore, Pakistan

1.3. Identification data of the Consultant

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	Project manager	Jiří Petrů	
Technical conception development and supervision	Project technical director	Zdeněk Vlček	
Heat balance computations	Coordination of heat balance data	Zdeněk Hrdina	
Mechanical profession	Coordination of mechanical part	Jakub Vyvadil	Pavel Rejmon Lukáš Pilař Tomáš Hroch Světlana Kozlova Jindřich Kullr
Electrical profession	Coordination of electrical part Electro part expert supervision	Pavel Fajgl Jan Anděl	Jiří Randa Jan Beránek
I&C profession	Coordination of I&C part	Pavel Černý	Vít Makovský Martin Rojdl
Civil profession and special design works	Coordination of Civil profession and special design work part	Jan Staníček	Michal Krásný Jan Malý M. Smrčková
Legal services	Commercial and contracting specialist	Karel Ort	

2. CONCEPTUAL DESIGN, 1ST PART - INTRODUCTION OF THE DOCUMENTATION

The 1st part of the Conceptual Design is the summary of inputs for the Conceptual Design level; the main objectives of this part of documentation are as follows:

- Summarization of available input data and information
- Summarization of basic requirements on the power plant
- Introduction of main principles of approach to the technical conception development

The input data are evaluated related to the Conceptual Design level, it means, input data necessary for the conception development. This level allows some rate of inaccuracy which cannot affect the technical conception.

In case of missing data is necessary to agree the approach for the Conceptual Design elaboration, Some data and parameters are not possible and reasonable to be estimated, for example the coal parameters. This kind of data is necessary to provide.

Some input data is possible to substitute in this project stage with some provisional data, for example the geotechnical data can be used from the near Mughal Steel site, etc.

The main requirements on the power plant operation specified by the Client were summarized and considered in the main operating modes proposal. The main operating modes are necessary to be confirmed as a base input for the power plant dimensioning.

In other cases is necessary to decide the preferred variant - for example the general layout is proposed in two basic variants – it is necessary to select the preferred one to be developed in the 2nd stage of the Conceptual Design.

The 1st part of CD is assumed to be used as a basic material for the regular technical meeting before starting of the 2nd part of CD elaboration.

3. BASIC DATA CHARACTERIZING THE PROJECT

3.1. Coal parameters

The power plant will be operated with a mixture of several types of coal as a basic fuel. The basic fuel for the first ca. five years of power plant operation will be imported coal only. The coal is planned to be imported from South Africa and Indonesia. After first ca. five years of power plant operation it is anticipated to utilize mixture of imported and local fuel. The mixture is presumed at maximum ratio 50:50. Preliminary parameters of imported and local coal are specified in following chapters. The parameters are considered as preliminary and are not sufficient for Conceptual Design elaboration.

3.1.1. Imported coal

Preliminary imported coal analyses see in Tab. 1: Imported coal parameters (Indonesian coal – type INDO A and Coal from South Africa – type RB1 or RB2).

Tab. 1: Imported coal parameters

BASIC IMPORTED COAL ANALYSIS					
Parameter	Name	Unit	Indonesian Coal – INDO A	South Africa Coal – RB1	South Africa Coal – RB2
Q_i^r	Lower heating value	kcal/kg	6 000	6 000	6 000
Q_i^r	Lower heating value	MJ/kg	25.12	25.12	25.12
W_t^r	Total moisture	% by weight	15.0	12.0	12.0
A^r	Ash	% by weight	15.0	15.0	15.0
S_t^r	Sulphur	% by weight	1.0	1.0	1.0
Size 90%	-	mm	50	50	50

3.1.2. Local coal

Preliminary local coal analyses:

Basic limits for fluidized bed technology (circulating fluidized bed):

Lower heating value (as received) Q_i^r min. 5 300 kcal/kg, max. 6 900 kcal/kg

Total moisture W_t^r	max 40 %
Ash (as received) A_r	min 10 %
Sulphur (as received)	Combustion of a local coal with imported coal at ratio 50:50 – max S_r = 5.7 % (concentration higher than the value (5.7 %) – Necessary installation of semi dry method for reduction SO_2)
Maximum grain size	50 mm

The input data are taken from document: "Coal Characteristics in Pakistan" – Punjab locality – mine "Salt range" (reserve 213 mil. tones – 30 mil. tones are mineable) summarized in Tab. 2: Local coal parameters.

Tab. 2: Local coal parameters

BASIC COAL ANALYSIS				
Parameter	Name	Unit	Coal quality	Conceptual design
Q_i^r	Lower heating value	kcal/kg	5 300 ÷ 8 800	6 200
Q_i^r	Lower heating value	MJ/kg	22.03 ÷ 36.75	25.95
W_t^r	Total moisture	% by weight	3.2 ÷ 10.8	9

A^r	Ash	% by weight	12.3 ÷ 44.2	21
S_t^r	Sulphur	% by weight	2.6 ÷ 10.7	6
Size 90 %	-	mm	-	-

Mixing of the imported and local coal

The following mixture ratios are assumed as limiting values (after ca 5 years of the power plant operation):

Maximum ratio of a local coal: 50 % of the imported coal x 50 % of a local coal

The boiler will not be designed for combustion of 100 % local coal.

Both types of the coal will be imported by trucks to the site.

The start-up and stabilization fuel

LFO will be used as a start-up and stabilization fuel. LFO parameters are specified in the following Tab. 3.

Tab. 3: LFO parameters

Component	Unit	Value
Specific Gravity 60/60 °F	-	0.87
Flash point (min.)	°C	54
Sulphur content (max.)	% mass	1.0
Copper strip corrosion 3 hrs. at 50 °C (max.)	-	1.0
Kinematic viscosity at 50 °C	mm^2/s,cSt	1.5 ÷ 5.0
Kinematic viscosity at 37.8 °C	mm^2/s,cSt	1.8 ÷ 6.0
Kinematic viscosity at 5 °C	mm^2/s,cSt	3.8 ÷ 29
Cloud point (max.)	°C	6.0
Pour point (max.)	°C	3.0
Carbon residue (max.) on 10 % distillation residue	% mass	0.2
Ash (max.)	% mass	0.01
Water (max.)	% vol	0.05
Sediment (max.)	% mass	0.01
Cetan Index (min.)	-	45
Total Acid No. (max.)	mg KOH/g	0.5
Calorific value (min.)	BTU/Lb	19,000
HCV	MJ/Kg	44.15
LCV	MJ/Kg	40.14
Operational temperature	°C	3÷44

3.2. Limestone

The additive considers a slightly milled limestone with content of 94 - 96 % of $CaCO_3$ (wt. %, dry) for conceptual design is considered 94 % of $CaCO_3$.

The size of finely milled a limestone is 100 ÷ 300 μm (ratio size for fluidization in fluidized bed). The maximum size is 500 μm.

The grain size distribution shall be in between minimum and maximum limit area specified by following diagram:

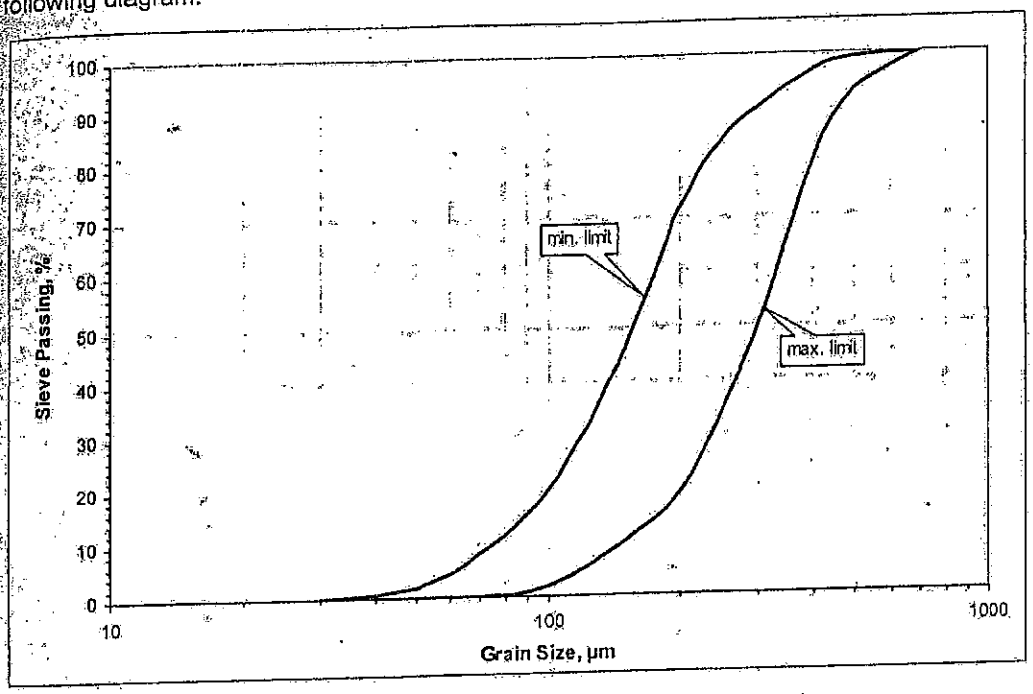


Fig. 1: Grain size diagram

3.3. Sand

Quartz sand will be used as bed material in the CFB boiler for first start up. Sand shall be dry, washed and not crushed.

Sand parameters are as following:

Initial deformation temperature:	> 1400 °C
K_2O a Na_2O content	< 2 % w
Residual moisture	< 0.1 % w

3.4. Emission limits

The power plant shall be designed to achieve lower emission values than are currently established by the Pakistan legislation.

The actual emission limits according to the Pakistan legislation are as following:

SO_2	1 700 mg/Nm^3
NO_x	1 200 mg/Nm^3
CO	800 mg/Nm^3
PM	500 mg/Nm^3

3.5. Raw water source

Wells at the site will be used as a source of the raw water for the power plant. The wells will be realized as a part of the new power plant. The raw water requirement to cover the power plant operation is max 200 m^3/h.

The raw water main consumption in the power plant is mainly comprised of the condenser cooling system and additional water required for the water treatment for the steam cycle.

The wet cooling system (mechanical draft wet cooling tower) is assumed to be used.

Cooling water consumption:	ca. 165 m^3/h (for concentration factor 3)
CWTP consumption	ca. 12 ÷ 14 m^3/h (production 8 m^3/h of demiwater)
Total raw water consumption:	ca. 180 m^3/h

The raw water consumption is calculated for the highest summer monthly average temperature 35 °C DBT and relative humidity 60 %.

Max (at most for a few days) CWTP water consumption is estimated 24 ÷ 28 m^3/h (production 16 m^3/h of demiwater).

Draft of the raw water analysis is presented in Annex 6. The document is still under development, for next design stage will be released revised version of the document.

4. INITIAL STATE AND SITE DATA

4.1. Local climatic conditions

The area and project site lies in the tropical climate zone that is characterized by hot summers between March and October. The monsoon spell spans the major summer season. The winters (November to February) are mild and accompanied by sporadic mild rains.

Basic meteorological data for the period of 30 years until 2013 are available from Lahore meteorological station. Following recorded data were provided for the design:

- Dry bulb temperatures
- Wet bulb temperatures
- Humidity

- Monthly total rain
- Monthly highest rain in a day
- Date of highest rain
- Atmospheric pressure on sea level

Rainfall

Heaviest rainfall (24 hrs) 189.7 mm
Wettest Month July
Average July rainfalls 204.7 mm

Temperature

Extreme Maximum Air Temperature 50.0 °C
Extreme Minimum Air Temperature 3.0 °C

Relative Humidity

Maximum relative humidity 90 %
Minimum relative humidity 27 %
Average Annual maximum humidity 76 %

Design Wind Speed

Maximum recorded Wind Speed 47 m/s (wind gust)
Prevailing wind direction north – west

4.2. Local seismic conditions

According to the seismic zones map of Pakistan, the proposed Site lies in a zone of minor damage. For such intensity, a maximum value of 0.066 g may be assumed for horizontal acceleration, which is reference peak ground acceleration for rock subsoil. According to Eurocode EN 1998-1 "Design of structures for earthquake resistance" soil factor S = 1.35 (type 1 spectrum and soil type D) and importance factor for buildings decisive for plant operation can be 1.4, for ordinary buildings importance factor can be 1.0.

Final value of horizontal acceleration at free field level and for importance factor 1.4 is 0.125 g and for ordinary buildings with importance factor 1.0 is 0.09 g. Design values can be updated based on results of detail geological site investigation.

4.3. Existing infrastructure

The site for the power plant construction is nearby the Mughal Steel Industry site. The existing infrastructure available for the Mughal Steel operation is available for the new power plant – roads, electricity grid. The capacity of the basic existing infrastructure will be sufficient for the new 50 MW power plant operation.

Fuel (coal) transport:	Coal will be transported by trucks to the site
Limestone transport:	Limestone will be transported by trucks to the site
By - products transport:	Ash will be transported by trucks from the site

Raw water transport:	Connection to the water source (river) is not possible. The new wells will be realized on the power plant site as a raw water source
Drinking water:	Drinking water will be delivered from the existing Mughal steel factory
Waste water:	After sufficient treatment waste water will be conducted to the existing water channel
Electricity during construction:	Electricity supply will be from the existing Mughal steel factory.
Water during construction:	Water wells will be already in operation during construction phase. In case of delay, water will be delivered from the existing Mughal steel factory

4.4. Interconnection with National grid

The power plant will be connected into the National grid on level 132 kV. A new 132 kV outdoor switchyard will be built within the premises of power plant. The power plant and switchyard will be designed according to requirements of NEPRA Grid code.

It is supposed that switchyard will be designed as two system switchyard with bus bar coupler (it should be confirmed with WAPDA – see also chapter 9). Short circuit withstand capability of switchyard 132 kV is supposed 40/100 kA and maximal operation voltage should be 145 kV.

Switchyard is planned with 5 bays in total:

- 2 bays for 132 kV lines
- 1 bay for connection of power outlet line from new power plant
- 1 combined bay for voltage measurement and bus bar coupler
- 1 bay for connection of transformer 132/11 kV for power supply of Mughal Steel

The interconnection of the switchyard (power plant) with National grid will be made by the 132 kV line from Attabad to Green view which will be split and both ends will be connected to the new switchyard in the power plant. It is supposed that this connection will be made by 132 kV cables (it should be confirmed with WAPDA). The proposed connection diagram of the power plant to the grid is shown in Annex 7.

The power outlet system and interconnection with National grid will be designed in a way that there will be possibility to outlet whole power of the power plant into the grid in case of technological outage in the Mughal steel factory.

It is supposed that data transmission between power plant and the Grid dispatch centre will be provided by PLC system through overhead power lines 132 kV (it should be confirmed with WAPDA – see also chapter 9).

4.5. Data on existing, civil objects, services, infrastructure, distributions and installations

Chosen site for new power plant is a green field without any civil objects, services, infrastructure etc. However nearby located Mughal Steel factory can provide all necessary connections important for construction such as electricity and water. The site is easily accessible by existing roads. For more detail information about infrastructure see chapter 4.3.

4.6. Analysis of realized surveys, impacts on technical solution

- Geodetic survey – see chapter 4.8
- Geotechnical survey – see chapter 4.7 and 4.9

4.6.1. Raw water quality

The basic and the only currently available document which defines the source, quality and quantity of water for the needs of the new power plant is the document, "HYDROGEOLOGICAL STUDY for the POWER PLANT at MUGHAL INUSTRIES HEIKHUPIRA ROAD LAHORE" (electronic version: 2nd Interim report. dox). From this study it is clear that in various places of designated territory were drilled 9 underground wells. At different depths in wells there were examined various parameters of ground water (temperature according to depth, conductivity, etc.). Complete chemical analysis of the water was made only for a sample from one well designated as "Prob 5" without specification of the depth of sampling (Table 3 and Annex B of the study).

This document can be sufficient to obtain general knowledge about the quality and quantity of water wells in the location. For the correct specification of a consumption and design a water treatment plant it is important to perform more detailed analysis and defining the conditions.

Conceptual Project design in the scope of water treatment requires clarify/determine the following parameters:

- Defined well (or wells), from which water will be drawn into the raw water storage tank;
- Check the capacity of these raw water sources (wells);
- Perform the chemical analysis of mixed in the ratio of wells water within the scope of the chemical parameters in the selected well/wells (min – max – design) according to the changes in these values, depending on the season, or other climate change (for example, to monitor the impact of monsoon on water quality);
- The results of the studies specify in scope of the **Annex 10**.

In the case that the Customer will not be able to provide required information specified in **Annex 10**, as base for Conceptual Project will be used the Table 3 and Annex B of the study "HYDROGEOLOGICAL STUDY for the POWER PLANT at MUGHAL INUSTRIES HEIKHUPIRA ROAD LAHORE" (electronic version: 2nd Interim report. dox) with some corrections in accordance with the agreement with the Customer (see Tab. 4).

Tab. 4: Raw water quality

Parameter	Unit	
Raw water source	Groundwater	Groundwater(tubewells)
Temperature at the raw water source		
Minimum	°C	
Normal	°C	more than 5
Maximum	°C	
Design	°C	5
Raw water flow rate		
Normal flow rate	m^3/h	152 * 3 = 305
Maximum available flow rate	m^3/h	Sustainable 305 cms as required ****
Minimum flow rate	m^3/h	Sustainable 305 cms as required ****

RAW WATER CHEMICAL ANALYSIS				
		Maximum	Design sample	Unit
Cations	Calcium	9	9	mg/l
	Magnesium	7	7	
	Iron (Fe^{2+})***	BDL	0.03	
	Sodium	145	145	
	Others(potassium)	7.9	7.9	
Anions	Bicarbonate	262	262	mg/l as $CaCO_3$*
	Carbonate	BDL	BDL	mg/l
	Chloride	49	49	
	Sulfate	44	44	
	Nitrates	BDL	BDL	
	Phosphates	BDL	BDL	
m - alkalinity	Methyl Orange	262	262	mg/l as $CaCO_3$
p - alkallnity	Phenolphthalein	BDL	BDL	
Total Hardness		52	52	mg/l as $CaCO_3$
Silica		4.8	4.8	mg/l as SiO_2
Organic Matter ($K_2Cr_2O_7$ consumed)		227	227	mg/l
Total Organic Carbon (TOC)		5	5	mg/l
pH		8.26	8.26	-
CO_2		1.01	1.01	mg/l
Turbidity		2.64	2.64	NTU
Arsenic		45.2	45.2	ppb
Copper		BDL	BDL	mg/l
Zinc		0.04	0.04	mg/l
Manganese		BDL	BDL	mg/l
Chromium		BDL	BDL	ppb

Lead	BDL	BDL	ppb
Color (and system used)	Colorless	Colorless	*
Total Suspended Solids**	BDL	0,5	mg/l
Conductivity	681	681	µS/cm
Total dissolved solids	375	375	mg/l
Other	NA	NA	

* changed under agreement

** the concentration of the TSS under agreement will be determined according to the limit of detection apparatus (0.5 mg/l)

*** the concentration of the total Fe as Fe^{2+} under agreement will be determined according to the limit of detection apparatus (0.03 mg/l)

**** necessary to specify units "cms" and flow rate in m3/h

4.7. Required surveys

4.7.1. Geotechnical investigation

For conceptual design preliminary investigation performed for near site of Mughal Steel Mills in 2006 by Soil cone foundation masters, is used. It is supposed to use flat foundations or shallow foundations supported by piles depending on the geology loading conditions and acceptance criteria for settlement. Shallow type foundations can be constructed on layer of compacted foundation cushion, improper soils under foundations will be removed. Another possibility is using the pile foundation for heavy structures or for structures sensitive to the settlement.

Geotechnical investigation should be performed in two steps:

- Preliminary investigation that can be carried out to assess general suitability of the site and to estimate the changes that may be caused by the proposed works. Preliminary investigation serves also for preparation of detail investigation and for identification of borrow areas, number and depth of soil borings. Conclusions from this investigation should be available at the beginning of works on Basic design and thus performed by Investor or EPC Contractor at the beginning of his works.
- Detail (Design) investigation that should provide sufficient data concerning the ground and the ground-water conditions at and around the construction site for a proper description of the essential ground properties and a reliable assessment of the characteristic values of the ground parameters to be used in design calculations. Field investigation should comprise drilling for sampling, groundwater measurements and field tests. Laboratory tests of samples have to will be performed selection of samples should cover the range of index properties of each relevant stratum. Conclusions from this investigation should be available at the beginning of works on Detail design and thus performed by EPC Contractor.

4.7.2. Radon occurrence

In case of radon occurrence in the soil special protection should be taken in the buildings with permanent personnel activity. Conclusions from this investigation should be available at the beginning of works on Basic design.

4.8. Applied geodetic input data

The field measurement started on December 27, 2015 and was completed on December 29, 2014. Following requirements were met during geodetic survey:

- Each unevenness in topography was measured (trenches, mounds, channels, path etc.)
- Net of points 10 m x 10 m was used for measurement.
- Accuracy class – inaccuracy of 12 cm in horizontal direction, 5 cm in vertical direction (elevation).
- System of coordinates – values x, y, z are given, geodetic points were connected to the existing system of coordinates commonly used in Pakistan.

Detailed Topographic Survey was conducted using Sokkia 530R bearing No. 146599. The raw data were processed for map and contour generation. A 0.25 meter contour interval was used to generate contour lines. The survey confirmed the flatness of the site with the general slope of 1 m per 1 km.

The field data were exported to AutoCad together with contours and represent a basis for general layout drawings.

4.9. Evaluation of actual state of site

4.9.1. Geography and Topography

The area is about 31 Km north-west of Lahore on Lahore - Shekhupar road. The coordinates are 423150-422900E and 3502700-3503000N. The area is a part of Indus Plain with very even terrain - the general slope is 1 m per 1 km. This is important for initial phase of construction because preparatory works such as terrain levelling can be reduced to minimum.

4.9.2. Climate, meteorological conditions

The area has a semiarid and arid subtropical continental climate. The main features of the climate are two well-defined seasons, a hot summer with late monsoon rains and relatively mild winter. The mean annual rainfall in the area is about 670 mm but the differences in years are quite significant (from 333.7 mm in 2002 up to 1232.5 mm in 1997). More than half of the rainfall is received in the form of high intensity down pours during July and August. The hottest months are May and June, with the average temperatures of 34.0°C and 34.3°C. The winters are generally frost free except for a short period of 10 to 15 days in December and January when sever fog in the morning and evening is seen.

4.9.3. Geological conditions

Geological survey was not performed for the site. Technical report on geotechnical investigation for the construction of Mughal Steel Mills which are located in the same region is available. Conclusions from this technical report will be used in the initial phase of the project:

- Prior to providing foundation concrete, the foundation soil after excavation may be thoroughly compacted for better stability
- Drainage must be kept efficient and no surplus water will be allowed to penetrate into foundation soil from any source

- The required raising may be done preferably with organic and salt free sandy soil, which should be thoroughly compacted up to the sufficient state of compaction

According to the seismic zones map of Pakistan (Figure 1), the proposed Site lies in a zone of minor damage.

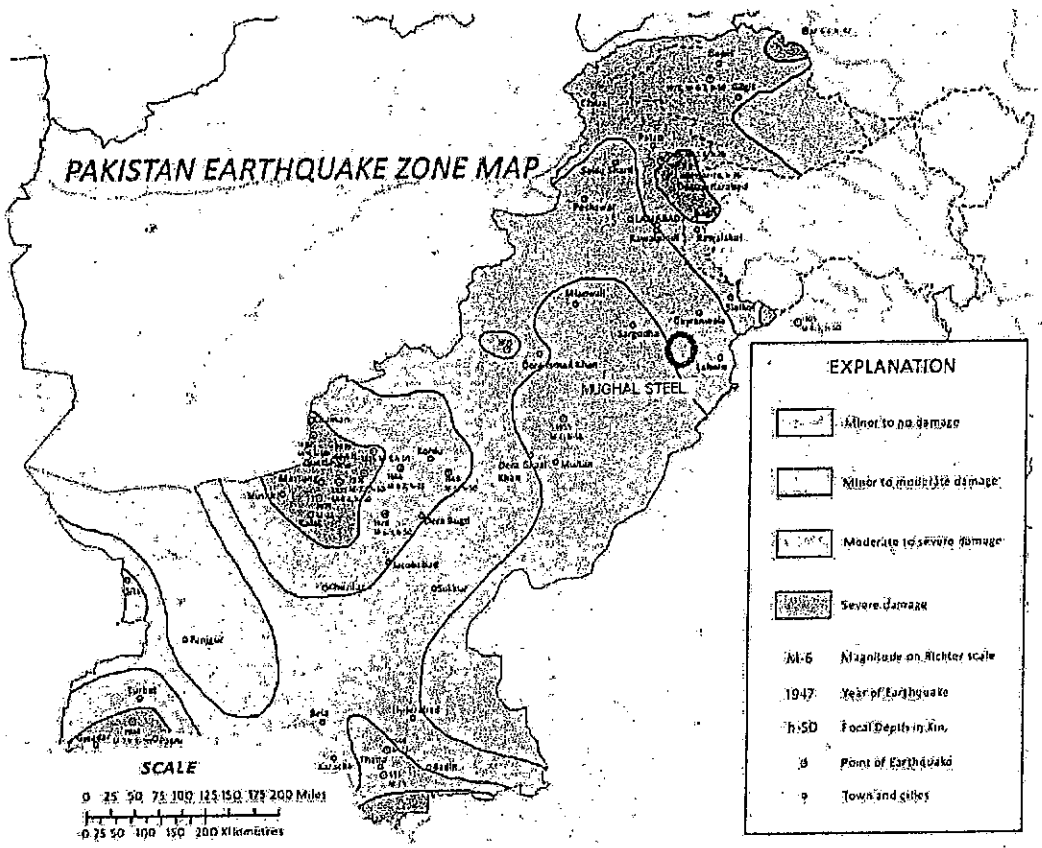


Fig. 2: Seismic zones in Pakistan

4.9.4. Infrastructure

All necessary connections are possible via nearby located Mughal Steel factory as mentioned in the previous chapters.

4.9.5. Evaluation of the site

The site is a green field without any facilities to be removed. Special attention must be paid during foundation design because of the geological situation which is rather complicated. Important will be also drainage system design with regards to clayish subsoil and monsoon down pours. Apart from these difficulties the site is suitable for new coal power plant construction.

5. POWER PLANT SEISMIC DESIGN

5.1. Power plant seismic design

5.1.1. Power plant seismic design – technological part

Technological equipment is designed in such a way, that protection of personnel health and lives as well as minimization of the property damages were restricted in case of a seismic event.

Technological equipment is designed as seismic resistant only from the viewpoint of personnel protection and restriction of damages of the equipment decisive for power production. In the course of a seismic event and immediately after its end, the power generation process will not be ensured, functionality of single equipment just after earthquake will not be ensured, too. Selection of components and systems, which will be designed with respect to their integrity and stability at a seismic event, will be carried out with consideration of their possible repair and quick putting into operation.

5.1.2. Power plant seismic design - civil part

Seismic design of the plant will be based on national standards describing the site seismic hazard. According to the seismic zones map of Pakistan, the proposed Site lies in a zone of minor damage. Due to the earthquake situation, proper measures should be taken in case of seismic design of buildings. The design conditions are determined by soil condition, acceleration level for vertical and horizontal components and by elastic site response spectrum. Design and construction of buildings and civil engineering works will be performed in accordance with Eurocodes or proper national standards for design in seismic regions. Design is to ensure, that in the event of earthquake human lives are protected, damage of buildings are limited and structures important for plant operation remain stable or can be easily repaired. The extent of protection will be given by means of importance classes for buildings and corresponding importance factors.

According to general rules for seismic design, following provisions have to be considered in building design in seismic regions.

- To keep design construction simplicity, hence calculations and design is simple, force distribution is clearly visible and design contains minimal amounts of uncertainties
- Construction uniformity, symmetry and static indeterminacy hence stress concentration in sensitive areas is eliminated
- structural resistance and rigidity in both directions hence building is resistant to horizontal seismic forces in all directions
- To ensure torsional strength and stiffness hence uneven stress is suppressed.
- Floor structures act as diaphragms hence inertia forces are redistributed to vertical bearing system. which then works as one unit
- It is maintained using of reasonable foundations hence whole construction is uniformly excited by seismic forces

6. DESIGN INPUT DATA SUMMARY AND EVALUATION

6.1. Data and information about Mughal Steel operation

6.1.1. Electrical part

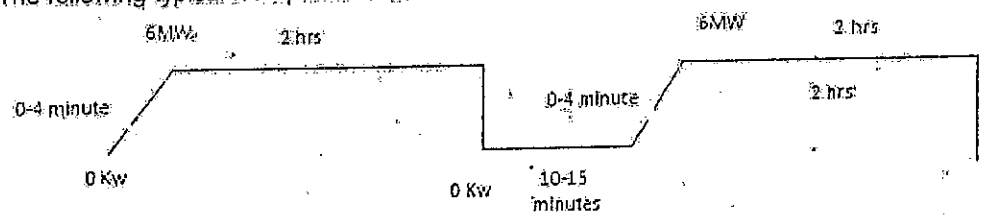
The new power plant will be able to supply the consumers (furnaces, mill) according to the following electrical diagram, which was handed over as a basis for the conceptual design (enclosed as **Annex 12** - Electrical Single Line Diagram of Mughal steel).

The following consumers could be supplied from the new power plant according to this diagram:

- Electrical Induction Furnace (EIF G1 – 10 MW)
- Electrical Induction Furnace (EIF G2 – 10 MW)
- Electrical Induction Furnace (EIF G3 – 7.5 MW)
- Electrical Induction Furnace (EIF B1 – 6 MW)
- Electrical Induction Furnace (EIF B2 – 6 MW)
- Electrical Induction Furnace (EIF B3 – 7.5 MW)
- Girder Mill

If it is possible to supply all of these appliances in a same time will be specified in the next phase of project when more precise information about loads will be clear, including load of power plant auxiliaries,

The following typical load profile of induction furnaces is expected:



This load profile should be clarified together with power supply of girder mill (see chapter 9).

6.1.2. Data and information about gas engine plant operation (Jenbacher)

Gas engines are used as backup power sources in case of loss of power supply from 132 kV. Their purpose will not be changed.

6.2. Operational requirements on the power plant, etc.

6.2.1. Static operating modes

Proposal of the power production plan for the power plant 55 MW gross:

Mode 1: Power output to the grid with power supply for Mughal Steel factory

0 – 49 MWe to the grid (132 kV)

0 – 49 MWe to Mughal Steel factory

Amount of power output supplied to the grid depends on Mughal Steel factory Load and operational range of the power plant (min. 22 MW – max. 55 MW).

22 MW gross – minimal power production estimated based on the minimal possible power of the boiler (see Note 2 below).

55 MW gross – maximal power output of the power plant guaranteed in the nominal operating mode

Sum of power output to the Grid and Mughal Steel factory load will be in range **18 MWe – 49 MWe.**

Note 1: When the whole power from power plant (maximal possible power supply) is used completely for Mughal Steel factory consumption (49 MW), no power can be supplied to the grid 132 kV.

Mode 2: Power output to the grid 132 kV only (without supplying Mughal Steel Industry)

Minimal power output to the grid is **18 MWe** (minimal power output of generator is 22 MW, related minimal power plant auxiliary consumption is 4 MW)

Maximal power output to the grid is **49 MWe** (maximal related power plant auxiliary consumption is 6 MW)

Note 2: The original Mughal requirement was 15 MW directly to the grid all the time. 18 MW is a limit given by estimated technical minimal power production based on the minimal load of the boiler safe operation, which is achievable without any additional stabilization technical measures and is generally assumed as 40 % of a nominal boiler power.
The technical limits of particular equipment are preliminarily estimated based on relevant experiences and provisional communication with manufacturers. Estimated data will be specified during the design works in cooperation with manufacturers.

Mode 3: Power output to the Mughal Steel Industry only (Island operation mode, no power output to the grid 132 kV, grid is temporarily unavailable)

Min. load to Mughal Steel Industry is **18 MWe** (minimal power output of generator is 22 MW, min. related power plant auxiliary consumption is 4 MW)

Maximal possible power which can be supplied to Mughal Steel factory is **49 MWe** (maximal related power plant auxiliary consumption is 6 MW)

6.2.2. Dynamic operating modes

The assumed abnormal modes of unit during loss of connection with external grid (transition to island governor – speed control) are as follows:

Surplus power

After disconnection from external grid is TS (turbine set) control switched to the island mode (speed) proportional control. In case of surplus power (increase of TS speed/frequency) are turbine control valves partly closed by intervention of the speed governor and therefore are the generator power decreasing until the reference speed is reached. The surplus steam is led to a condenser at first, after condenser filling is the steam blown through PSA into the atmosphere.

a) If the loss of connection with external grid is short-term and if it is expected that the needed power will soon return to the original value the boiler stays at original power. Initially (before loss of connection with external grid) is the steel factory partly supplied from power plant (the rest of power plant's power is exported to the grid) and rest of power consumption of steel factory is supplied from grid. After loss of grid connection are the assured power sources started in the steel factory and following gradual switching of the consumers (originally supplied from external grid) to the power supply from power plant according to available power plant's power.

b) In case of long-term loss of external grid is the power of boiler decreased or in a given case is shutdown of whole power plant (the power consumption is lower than the lowest allowed power of the power plant) based on technological abilities of the power plant and amount of power consumption in formed island.

Deficiency of power

If there is a loss of grid connection (steel factory and power plant) together with power plant's operation with reduced power of the boiler and TS when the part of factory consumption is supplied from external grid are the assured power sources (gas engines, DG) started. These assured power sources temporarily replace the power from grid until the boiler power is increased to the required value and the power plant is able to be gradually loaded by the consumers supplied by gas engines.

Operational changes

In case of operational changes in power consumption (technological break of furnace) is expected that the turbine set power is partly decreased but the boiler stays on original power. The surplus power is led to the condenser or to the atmosphere.

6.2.3. Own consumption

The power consumers considered to the own consumption are defined according to the experience from similar projects. It shall be noted that efficiency (i.e. consumption) of each consumer depends on individual supplier and can differ in order of dozens of percent. Therefore each of presented consumers shall be evaluated individually, with sufficient margins.

The design of power output of the power plant shall be based on certain initial presumptions and approaches including evaluation of own consumption parameter.

The power plant own consumption is defined by the main consumers as specified in Tab. 5.

The table is divided into the two sections, the first section summarize main consumers which are in operation continuously during normal operation of the power plant. The second section summarizes main consumers which are in operation periodically according to the requirements and operation instructions of the power plant, but these are all included in parameter of own consumption.

Tab. 5: Main own consumers of the power plant

Assumed power plant main consumers	
Continuously running technologies / consumers + transformer losses	**Boiler House**
	Primary air fan
	Secondary air fan
	I. D. fans
	HP blower
	Rotary feeders to furnace
	Water cooled screw conveyors
	Machine Hall
	Condensate pumps
	Feed water pumps
	Accessories
	Cooling Circuit
	Cooling water pumps
	Cooling tower fans
	ESP
	FGD
	Limestone milling
	Raw water
	Compressed air for instrument and service air
	Transformer losses
Other periodically running technologies / consumers	Limestone crushing
	Coal handling with crushers
	Demineralized water production station
	Water treatment
	LFO pumps
	Air compressors for fly ash conveying system
	Miscellaneous essential consumers (lighting, UPS)

6.3. Steam-water cycle design

The steam-water cycle should be designed to maximal thermal efficiency (minimal fuel consumption) with economical legitimate investment costs. For given conditions and unit size it means non reheat Rankine – Clausius cycle with high steam parameters, water cooled condenser and regenerative feedwater heating. Number of feedwater heaters should be as high as possible (min. 4, deaerator included) - it will be limited by number of practicable steam extractions from one cylinder steam turbine.

For supposed unit major operation mode near nominal load it is recommended steam turbine with no governing stage and throttle / sliding pressure control. Both geared and direct connection design of turbogenerator is possible for 55 MWe unit, in any case, turbogenerator design with higher overall efficiency should be preferred.

Recommended water / steam cycle design is shown on Heat Balance Diagrams (HBDs) presented in **Annex 1, 2 and 3**. Sample cycle is based on non-geared one cylinder condensing steam turbine with five uncontrolled steam extractions for feedwater heating. Steam parameters at boiler outlet are 14 MPa / 545°C in BMCR (Boiler Maximum Continuous Rating) operation mode and could be considered as maximal for this size unit.

Steam cycle configuration, basic input data and main equipment parameters were assumed to reach required value of coal consumption (0,38 kg/kWh$_{brutto}$ for coal LHV 6000 kcal/kg) and were determined on the basis of experience with similar projects. Steam cycle design and parameters will be progressively specified according to information from boiler and steam turbine potential suppliers directly for Mughal Energy CFPP project. During steam cycle finalization it will be taken into consideration investment costs of given solution besides CFPP thermal efficiency / coal consumption.

HBDs presented in this documentation describe supposed unit operational modes with nominal and minimal power output at annual average climatic conditions and guaranteed power output at ambient temperature 45°C.

Main parameters of proposed power plant water / steam cycle at above mentioned operation modes were computed by means of a computing model established in the specialized software environment GateCycle ver. 6.1.2.

The basic input data and main equipment parameters for model establishment were taken from the informative bids of potential suppliers or were determined on the basis of experience with similar projects.

Main power-plant parameters computed by GateCycle model are as follows:

Operation mode Nominal (for annual average climatic conditions)

Ambient air parameters:	25°C , relative humidity 70%
Cooling water temperature:	27°C
Power output at generator terminals:	55 MWe
Condensation pressure:	0.0074 MPa
Boiler thermal output:	134.6 MWt (Nominal)
Steam parameters at boiler outlet	13.5 MPa / 545°C

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Boiler steam production:	194.7 t/h
Operating mode:	sliding pressure
Plant thermal efficiency, gross	37.58 %

Minimal operation mode (for annual average climatic conditions)

Ambient air parameters:	25°C , relative humidity 70%
Cooling water temperature:	27 °C
Power output at generator terminals:	21.25 MWe
Condensation pressure:	0.0049 MPa
Boiler thermal output (min. without stabilization):	55.86 MWt
Steam parameters at boiler outlet	5.19 MPa / 545 °C
Boiler steam production:	72.8 t/h
Operating mode:	sliding pressure
Plant thermal efficiency, gross	34.61 %

Operation mode Summer (for performance guarantee at annual max. ambient temp.)

Ambient air parameters:	45 °C , relative humidity 50 %
Cooling water temperature:	39 °C
Power output at generator terminals:	55 MWe
Condensation pressure:	0.014 MPa
Boiler thermal output:	139.7 MWt (BMCR)
Steam parameters at boiler outlet	14.0 MPa / 545 °C
Boiler steam production:	202.8 t/h
Operating mode:	full pressure
Plant thermal efficiency, gross	36.23 %

6.4. General layout proposal

Draft general layout consists of objects to each other functionally related and based on the area (Power output, points and wastewater connection to the existing communication).

The first function unit is a handling system of coal and limestone. The coal handling system consists of indoor coal storage with capacity for 3 months of the power plant operation, crushing and handling coal to the boiler. The coal storage allows simultaneous unloading of eight trucks with coal. Supply unit of limestone consists of limestone storage, limestone crushing and handling to the boiler.

The second function unit is the main power unit, which is connected to the supply and limestone. Main power unit consists of machine hall, boiler house with fluidized bed boiler, electrostatic precipitator and fuel gas stack. Between boiler house and electrostatic precipitator is space reserve for possible additional installation desulphurization plant.

Auxiliary units for operation of the main power unit are located in close proximity so that the pipelines lengths are optimized and pressure losses in the pipeline are minimized. Auxiliary units include the auxiliary boiler house, fuel oil unloading and storage, compressor station and storage and disposal of bed ash and fly ash.

The water management which includes water wells, raw water storage and chemical water treatment is predominantly located in one common area. Waste water treatment is located near to connection point and it is located as far as possible from administration building, canteen and operating building.

Power output from generator is designed in a direction to line 132kV trough transformers and switchyard.

Support services for operation of the power plant (administration building, central maintenance workshops, canteen and parking) are linked to the main entry of the power plant site and are located close to the main power unit in order to shorten walkable distance between the main entry and main power unit.

Access to the power plant is via the main entry, which is used for the entry of personnel and traffic. Trucks for transportation of: coal, limestone, removal of bed ash and fly ash enter the area of the power plant through the auxiliary gatehouse. Auxiliary gatehouse is located near the coal storage and truck minimizes movement through the power plant site. Auxiliary gatehouse is equipped with truck a scale that weighs each truck on arrival and departure from the power plant.

General layout for area C (92 419 m^2) as presented in **Annex 4** is designed for one main power unit. Future extension of the power plant by the power unit of a similar performance will be quite complicated.

General layout for area C and D (150 369 m^2) as presented in **Annex 5** is designed for one main power unit. Future extension of the power plant for by the power unit of a similar performance will be possible.

Both general layouts are designed considering optimized pipelines design, which reduces the pressure losses in the pipe, separating dusty and dirty areas from clean areas, optimizing truck roads between the entrance to the site and storages coal, limestone, fuel oil storage.

6.5. Structuring of the power plant into Process Systems and Civil Objects

6.5.1. List of Process system

The power plant shall be structured into main process system, see **Annex 6**. The more detailed and complete structure will be defined based on this list in next design stage (2nd stage of CD).

6.5.2. List of Civil Objects

Civil object are divided into groups according to their function, see **Annex 6**.

7. LIST OF PROFESSIONS IN THE POWER PLANT

Three-shift operation (1 shift = 12 hours) is presumed for operation of the single power plant Unit 55 MW. As far as total number of employees is concerned, 3+1 shifts are proposed + backup personnel covering sufficient personnel capacity – e.g. during holidays and/or leaves, sickness, etc. and for necessary repairs during operation.

The proposed total power plant operational staff is 125 people, the HR and economical department staff, etc. is ca 54 people.

For the detailed list of workplaces in the power plant, see **Annex 8**.

The major shift is the morning one and thus number of personnel in this shift will be taken as basis for capacity sizing.

The mentioned number of workplaces is used as a base for dimensioning of related spaces, consumption and production figures (workplaces, water, waste water, etc.) in the design.

8. LEGISLATION, NORMS AND STANDARDS

8.1. Grid Code 2005, NEPRA

The enclosed version of NEPRA Grid Code from 2005 (handed over by Mughal Energy – see **Annex 13**) will be used as a basis for design of connection of the new power plant into external grid.

8.2. Distribution Code 2005, NEPRA

The enclosed version of NEPRA Distribution Code from 2005 (handed over by Mughal Energy see **Annex 14**) will be used as a basis for design of connection of the new power plant into external grid.

8.3. National Environmental Quality Standards for Ambient Air

The immission (air pollution) limits valid for this project are specified in Tab. 6:

Tab. 6: The immission limits according to the NEQS

Pollutants (Immission limits)	Time weighted average	Concentration in Ambient Air (The values according to NEQS for Ambient Air /Effective from 1.1.2012/)
Sulphur dioxide (SO_2)	Annual average	80 µg/m^3
	24 hours	120 µg/m^3
NO_x	Annual arithmetic mean	-
Oxides of nitrogen as (NO)	Annual average	40 µg/m^3

	24 hours	40 µg/m³
Oxides of nitrogen as (NO_2)	Annual average	40 µg/m³
	24 hours	80 µg/m³
Suspended particulate matter (SPM)	Annual average	360 µg/m³
	24 hours	500 µg/m³
Respirable particulate matter (PM_{10})	Annual average	120 µg/m³
	24 hours	150 µg/m³
Respirable particulate matter ($PM_{2,5}$)	Annual average	15 µg/m³
	24 hours	35 µg/m³
	1 hour	15 µg/m³
Lead (Pb)	Annual average	1 µg/m³
	24 hours	1.5 µg/m³
Carbon monoxide (CO)	8 hours	5 mg/m³
	1 hour	10 mg/m³

Source document for immission (air pollution) limits values see **Annex 15.**

8.4. Design of technology

EU standards will be used beside those stated above.

8.5. Design of civil part

The EN Eurocodes system will be used for civil design. Eurocodes were issued by CEN (European Committee for Standardization) and are the reference design codes in the construction.

8.6. Fire protection

EU standards will be used.

9. REQUIRED INPUT DATA FOR THE 2ND STAGE OF THE CONCEPTUAL DESIGN

9.1. Coal

For elaboration of the Conceptual Design it is necessary to provide detailed parameters of both imported (Indonesian and South African) and local coal. Specification of required parameters for each type of coal is provided in **Annex 9.**

9.2. Limestone

The Customer shall provide information if it is possible to supply finely milled limestone directly or limestone supply will be in form of a grain size of up to 50 mm.

9.3. Electric part

For the next stages of conceptual design is necessary to clarify or complete the following information:

- clarification of consumption of Girder mill system
- information about placement of new change over switches
- information about placement of supplied furnaces and girder mill
- confirmation the load profile of furnace
- complete information about frequency load shedding of Mughal Steel loads if existing
- It is assumed that connection between switchyard 132 kV and overhead power line 132 kV (Attabad – Green View) will be done by cables 132 kV. It is necessary clarify with WAPDA including border point of delivery.
- Clarify with WAPDA, whether is required the telecommunication system for voice and data information transmission through 132 kV lines (PLC system for data transmission between power plant and the Grid dispatch centre). In electrical part is considered coupling capacitors and inductors for this system in phase L1 and L2.

9.4. I&C part

I & C part will consist mainly of enter from technological and electrical part. Maximum level of automation is assumed based on the consultant experience. The level of automation is possible to modify according to the Client requirement.

For example emission monitoring according to European standards must be independent of the control system power plant and data are transmitted to the needs of state control. It should be confirmed for Mughal Energy case.

Basic questions related to the communication and security systems design are in **Annex 11.**

Efficiency Parameters

Efficiency Parameters

Designed Efficiency of power plant	37.58%
Gross Efficiency of power plant at Mean Site Conditions	As above
Net Efficiency of power plant at Mean Site Conditions	35.00 % (Approx)