



**HUNZA POWER PRIVATE
LIMITED**

**GENERATION LICENSE
APPLICATION FOR 49.8 MW
NEW BAGASSE BASED CO-
GENERATION POWER
PROJECT**



The Registrar

National Electric Power Regulator Authority (NEPRA)

NEPRA Office Building,
Sector G-5/1,
Ataturk Avenue (East),
Islamabad

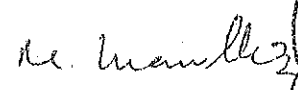
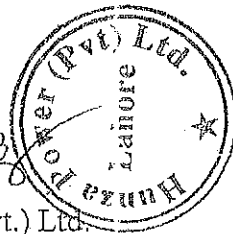
Subject: Application for a Generation License

I, Muhammad Saeed Ch, Chief Executive, Being the duly authorized representative of *Hunza Power Private Limited (HPPL)* by virtue of Resolution of Board of Directors dated 7/10/2016, hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to HPPL pursuant to Section 15 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

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

A Bank Draft No. 15705424 Dated 26/10/2016 drawn on Habib Bank Limited, Corporate Centre Lahore, in the sum of Rupees only 291,424/-, 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.

Thank you

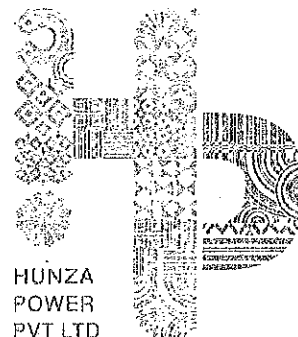



For Hunza Power (Pvt.) Ltd.
Chief Executive

Date 27/10/2016

GENERATION LICENSE CHECKLIST

Tab No.	Item	Comments
1 S	Application	Attached
2 S	Resolution of Board of Directors	Attached
3	Generation License Fee -- Bank Draft	Attached
4 S	Affidavit	Attached
5	Letter of Interest	Attached
6	Certified Copy of Certificate of Incorporation	Attached
7	Certified Copy of Memorandum of Association	Attached
8	Certified Copy of Articles of Association	Attached
9	Annual Return on same format as Form -A	Attached
10 S	Sponsor and Management team's experience in power industry	Attached
11 S	CVs of Senior Management, Technical and Professional staff	Attached
12	Plant Location, Layout and Characteristics	Attached
13	Single Line Diagram	Attached
14	Latest Audited Financial Statements	Attached
15	Indicative Term Sheet	Attached
16 S	Profile of Sub Contractors	Attached
17 S	Prospectus	Attached
18 S	Safety, Emergency, Training & Development Plan	Attached
19	Control, Metering, Instrumentation & Protection	Attached
20	IEF Submitted to EPA	Attached
21	Grid Study Submitted to CPPA-G	Attached
22 S	Feasibility Study	Attached
	Technical and financial proposals in reasonable detail for the operation, maintenance, planning and development of the generation	Included in Feasibility Study
	The type, technology, model, technical details and design of the facilities proposed to be acquired, constructed, developed or installed	Included in Feasibility Study



**EXTRACTS OF THE RESOLUTIONS OF BOARD OF DIRECTORS OF
HUNZA POWER PRIVATE LIMITED
PASSED IN THEIR MEETING HELD ON 07-10-2016
AT 1-A New Muslim Town, LAHORE**

The Board of Directors of HUNZA POWER PRIVATE LIMITED a public company duly formed and registered in the Islamic Republic of Pakistan having incorporation No. 0098818 (the **Company**) and having its registered office at 1-A New Muslim Town, Lahore, in their meeting held on 07-10-2016, passed the following resolutions:

UNANIMOUSLY RESOLVED that the Company should approach National Electric Power Regulatory Authority (NEPRA) for Generation License under the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

Further Resolved, that Mr. Muhammad Saeed Chaudry, Chief Executive, Mr. Mahboob Ali Qureshi, Senior General Manager Finance & Accounts, and Mr. Mahboob Ali Qureshi, Company Secretary, of the Company be and are hereby jointly and singly authorized to do any or all of the following acts, deeds and things, on behalf of the Company, in connection with this application to be filed with NEPRA under the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 and the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999:

- Represent the Company before NEPRA, and in doing so perform all lawful acts, deeds and things, including but not limited to filing, signing, presenting, modifying, amending, withdrawing applications and other documents, responding to any queries and meeting any objections, receiving notices and documents; and
- Do all acts, deeds and things, which are ancillary and incidental to the afore-said purposes.

“Further Resolved, that extracts of this resolution be provided to the NEPRA with the seal/stamp duly affixed thereon.”

Company Secretary

Chief Executive



A008684



SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE, LAHORE

CERTIFICATE OF INCORPORATION

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

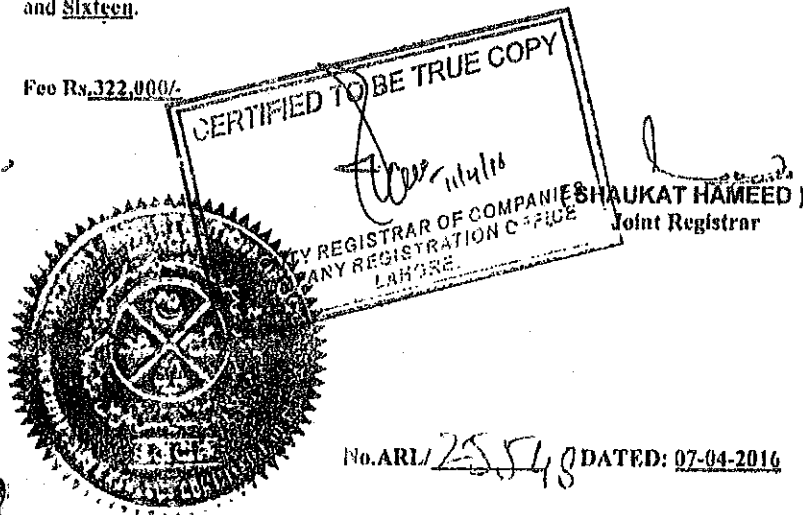
Corporate Universal Identification No. 0098818



I hereby certify that **HUNZA POWER (PRIVATE) 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 Seventh day of April, Two Thousand
and Sixteen.

Fee Rs. 322,000/-



No. ARL/ 2554 DATED: 07-04-2016

ALTAF HUSSAIN
BMI/BS # 89-7

**CERTIFIED TRUE COPY OF
MEMORANDUM OF
ASSOCIATION**

1

**THE COMPANIES ORDINANCE, 1984
(COMPANY LIMITED BY SHARES)**



Memorandum of Association

of

“HUNZA POWER (PRIVATE) LIMITED”

- I. The name of the Company is "HUNZA POWER (PRIVATE) 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 all or any of the following:-
 1. To carry on all or any of the businesses of production of electricity via independent power production mode through baggass/biomass, 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 subject to permission from NEPRA/other regulatory authorities
 2. To establish, construct, equip, operate, use, manage and maintain thermal power plants and coal fired power plants, power 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.
 3. To carry on all or any of the businesses of wholesalers, retailers, traders, importers, exporters, suppliers, distributors, designers, developers, manufacturers, installer, filters,


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testers, repairers, maintainers, contractors, constructors, operators, users, inspectors, reconditioners, improvers, alterers, protectors, removers, hirers, replacers, importers, exporters 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.

4. 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.
5. For the purposes of achieving the above objects, the company is authorized:-
 - (a) to purchase/import raw materials and allied items required in connection thereto in any manner the company may think fit;
 - (b) to do and perform all other acts and things as are incidental or conducive to the attainment of the objects of the company;
 - (c) 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;
 - (d) to make known and give publicity to the business and products of the company by such means as the company may think fit;


ALTAF HUSSAIN
BNI 135789-7



- (e) 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;
- (f) to pay all costs, charges and expenses, if any, incidental to the promotion, formation, registration and establishment of the company;
- (g) 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;
- (h) to purchase, hold and get redeemed shares, debentures, bonds of any business, company, financial institution or any Government institutions;
- (j) to guarantee the performance of contracts, agreements, obligations or discharge of any debt of the company 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.

6. 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.

ALTAF HUSSAIN
BM: IRS/694



7. Notwithstanding anything stated in any object clause, the Company shall obtain each of the following approvals or licences from the competent authority, as may be required under any law for the time being in force, to undertake a particular business.

IV. The liability of the members is limited.

V. The authorized capital of the company is Rs. 100,000,000/- (Rupees Hundred Million only) divided into 100,000 ordinary shares of Rs. 1,000/- 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 being formed into a Company in pursuance of the Memorandum of Association and we respectively agree to take the number of shares in the capital of the Company set opposite to our respective names:-

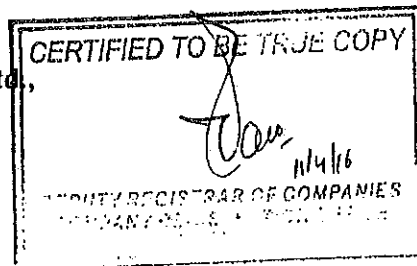
Name and surname (present & former) in full (in Block Letters)	NIC No. (in case of foreigner, Passport No)	Father's/Husband's Name in full	Nationality with any former Nationality	Occupation	Residential Address in full	Number of shares taken by each subscriber	Signatures
MUHAMMAD IDREES CHAUDHRY	35202-2788992-1	CHAUDHRY SIRAJ DIN	PAKISTANI	BUSINESS	HOUSE # 140-C BLOCK MOEL TOWN, LAHORE	1000 (ONE THOUS AND)	
MUHAMMAD SAEED CHAUDHRY	35202-2789116-1	CHAUDHRY SIRAJ UD DIN	PAKISTANI	BUSINESS	HOUSE # 66-F BLOCK MODEL TOWN, LAHORE	1000 (ONE THOUS AND)	
MUHAMMAD WAHEED CHAUDHRY	35202-2619580-9	CHAUDHRY SIRAJ UD DIN	PAKISTANI	BUSINESS	HOUSE # 39-A, AHMAD BLOCK, NEW GARDEN TOWN, LAHORE	1000 (ONE THOUS AND)	
			Total number of shares to be taken			3000 (THREE THOUSAND)	

Total number of shares taken 3000
(Three Thousand)

Dated the 24th day of March, 2016

Witness:

National Institutional Facilitation Technologies (Pvt) Ltd.,
5th Floor, AWT Plaza, I.I. Chundrigar Road, Karachi.



ALTAH HUSEAIN
BEN 1354 8947

**CERTIFIED TRUE COPY OF
ARTICLES OF ASSOCIATION**

THE COMPANIES ORDINANCE, 1984



(COMPANY LIMITED BY SHARES)

**ARTICLES OF ASSOCIATION
OF
“HUNZA POWER (PRIVATE) LIMITED”**


1. The regulations contained in Table “A” in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except in so far as those are applicable to private companies, with the exception of the Regulations which are modify, altered or added here under:

PRIVATE LIMITED COMPANY

2. The Company is “Private Company” within the meaning of sub Section 2(1) of The Ordinance and accordingly:
- a) No invitation shall be issued to the public to subscribe for any shares or the Company.
 - b) The numbers of the members of the Company (Exclusive of person in the employment of the Company) shall be limited to fifty, provided that for the purpose of this provision, Where two or more persons hold one or more shares in the Company jointly, they shall be treated as single member; and
 - c) The right to transfer shares of the Company is restricted in manner and to the extent herein appearing.

BUSINESS

- 3. The Company is entitled to commence business from the date of incorporation.
- 4. The business of the Company shall include all or any of the objects enumerated in the Memorandum of Association.
- 5. The business of the Company shall be carried out at such place or places any where in Pakistan or elsewhere as the Directors may deem proper and advisable from time to time.


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B.M. 1351, 89-7




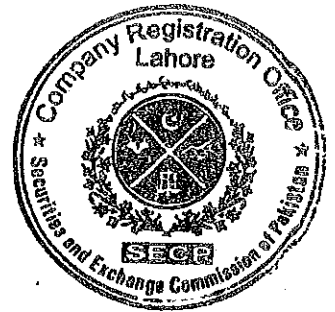
CAPITAL

6. The Authorized share capital of the Company is Rs.100,000,000/- (Rupees One Hundred Million Only) divided into 100000 ordinary shares of Rs.1000 (Rupees One Thousand Only) each with powers of the Company to increase or decrease or reduce the same and to divide the shares into several classes.
7. The shares shall be under the control of the Board of Directors who may allot or otherwise dispose off the same to such persons, on such terms and conditions and at such times, as the Board of Directors think fit.
8. The shares in the capital of the Company may be allotted or issued in payment of any property, land, machinery or goods supplied or any services rendered to the company or promotion or formation of the company or conduct of its business and any shares so allotted may be issued as fully paid shares.

TRANSFER AND TRANSMISSION OF SHARES

9. Every person whose name is entered in the Register of Members shall without payment, be entitled to a certificate under the common seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more than one certificate and delivery of a share certificate to any one of the several joint holders shall be sufficient delivery to all.
10. The Directors may decline to register any transfer of shares to transferee of whom they do not approve and shall be bound to show any reasons for exercising their discretion subject to provisions of section 77 and 78 of the Companies Ordinance 1984.
11. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to a non-member without the previous sanction of the Board of Directors.
12. The legal heirs, executors or administrators of a deceased holder shall be the only person to be recognized by the directors as having title to the shares registered in the name of two or more holders, the survivors and the executors of the deceased shall be the only persons to be recognized by the company as having any title to the shares.


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BML 1951 83-4



GENERAL MEETINGS

13. The first annual General meeting, shall be held, in accordance with the provisions 158, within eighteen months from the date of incorporation of the Company and thereafter once at least in every year within a period of four months following the

close of Financial year and not more than fifteen months after holding of its last preceding annual general meeting as may be determined by the Directors. The directors may, whenever, they think fit, call an extra ordinary general meeting, and extra general meeting shall also be called on such requisition, or in default, may be called by such requisitionists, as is provided by section 159 of the Companies Ordinance 1984.

NOTICE & PROCEEDINGS OF GENERAL MEETING


14. Twenty one days' at the least specifying the place, the day and the hours of meeting and, in case of special business, the general nature of that business shall be given in manner provided by the Ordinance for the general meeting, to such person as are, under the Ordinance or the regulation of the Company, entitled to receive such notice from the Company, but he accidental omission to give notice to, or the non-receipt or notice, by any member shall not in validate the proceedings at any general meeting.
15. The Chief Executive, with the, consent of the meeting at which quorum is present and shall if so directed by the meeting may adjourn the meeting from time to time and from place to place, but no business shall be transacted at any adjourned meeting other than the business left and finished at the meeting from which the adjournment took place.

QUORUM

16. 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, save as herein otherwise provided, members having twenty-five percent of the voting power present in person or through proxy and two members personally present will be quorum of the Company's meeting.

VOTES OF MEMBERS

17. At any General Meeting a resolution put to the vote of the General Meeting shall be decided on as show of hands, unless a poll is demanded in accordance with the provisions of Section 167 of the Companies Ordinance, 1984.


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 BME/1854/09-21



18. 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 legal guardian, and any such committee or guardian may, on a poll vote by proxy.
19. The instrument appointing a proxy and the power of attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the registered office of the company 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.

CHIEF EXECUTIVE

20. 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.

DIRECTORS

21. The number of directors shall not be less than two. The following persons shall be the first directors of the company and shall hold the office up to the date of the first annual general meeting.

1. MUHAMMAD IDREES CHAUDHRY

2. MUHAMMAD SAEED CHAUDHRY

3. MUHAMMAD WAHEED CHAUDHRY

22. The remuneration of the directors shall from time to time be determined by the company in general meeting subject to the provisions of the ordinance.
23. Save as provided in section 187 of the ordinance, no person shall be appointed as a director unless he is a member of the company.

POWERS AND DUTIES OF DIRECTORS

24. 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

ALTAF HUSEAIN
31-05-2017



to be exercised by the company in general meeting, subject nevertheless to 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 the regulation had not been made.

25. The directors shall appoint of Chief Executive in accordance with the provisions of sections 198 & 199 of the Ordinance.
26. The amount, for the time being remaining un discharged , of moneys borrowed or raised by the directors for the purposes of the company (otherwise than by the issue share capital) shall not any time without the sanction of the company in general meeting, exceed the issued share capital of the company.
27. The directors shall cause minutes to be made in books provided for the purpose:-
 - (a) Of all appointments of officers made by the directors;
 - (b) Of the names of the directors present at each meeting of the directors and of any committee of the directors;
 - (c) Of all resolutions and proceedings at all meetings of the company and of the Directors and of committees of directors.

DISQUALIFICATION OF DIRECTORS

28. No person shall become the director of a company if he suffers from any of the Disabilities or disqualifications mentioned in section 187 of the Ordinance and, if already a director, shall cease to hold such office from the date. He so becomes disqualified or disabled Provided, however, that no directors shall vacate, his office by reason only of. His being a member of any company which had entered into contracts with, or done any work for, the company of which he is director, but such director shall not vote in respect of any such contract or work, and if he does so vote, his vote shall not be counted.

PROCEEDINGS OF DIRECTORS

29. The directors may meet together for the dispatch of business, adjourn and otherwise regulate their meetings, as they think fit. Questions arising at any meeting shall be decided by a majority of vote. 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.

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B/M/185/89-91



30. The directors may elect the Chairman of their meetings and determine the period for which he is to hold office; 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, directors present may choose one of their number to be chairman of the meeting.
31. A resolution in writing signed by all the directors for the time being entitled to receive notice of a meeting of the directors shall be as valid and effectual as if it had been passed in a meeting of the directors duly convened and held.
32. As casual vacancy 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 chosen was last elected as director.
33. The company may remove a director but only in accordance with the provisions of the Ordinance.

BORROWING POWER

34. The Directors may from time to time raise, borrow or secure the payment of any sums for the purposes of the Company in such manner and upon such terms and condition as they think fit and in particular by the issue of debenture, debenture-stock or other securities charge upon all or any part of the property of the Company present or future.
35. Debenture, debenture – stock or other securities may be issued with any special privileges as to redemption, surrender, allotment of shares, attending and appointment of Directors or other privileges subject to any permission required by law.

DIVIDENDS AND RESERVE

36. The company in general meeting may declare dividends but no dividend shall exceed the amount recommended by the directors. No dividends shall be paid otherwise than out of the profits of the Company.

THE SEAL

37. The directors shall provide for the safe custody of the seal and the seal shall not be affixed to any instrument except by the authority of a resolution of the board of directors or by a committee of directors authorized in that behalf by the directors and the presence of at least two directors; and those two directors shall sign every instrument to which the seal of the company is so affixed in their presence.

ALTAH HUSAIN
BM/1351/89-90



ACCOUNTS


38. The directors shall cause to be kept proper books of account as required in section 230 of the ordinance.
39. The books of account shall be kept at 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.
40. The directors shall be required by sections 233 and 236 of the Ordinance, cause to be prepared and to be laid before the company in general meeting such profit and loss accounts or income and expenditure accounts and balance sheets duly audited and reports as are referred in those sections.

AUDIT

41. Once at least in every year the accounts of the company shall be audited and the correctness of profit and loss accounts or income and expenditure accounts and balance sheet ascertained by an auditor or auditors and the provisions of the Ordinance in regard to audit and the appointment and qualification of auditors shall be observed.
42. Auditors shall be appointed and their duties regulated in accordance with sections 252 to 255 of the ordinance.

INDEMNITY

43. Every director and other officer or servant of the company shall be indemnified by the company against, and it shall be duty of directors to pay out the funds of the company, all costs, losses and expenses which any such officer or servant may incur or become liable to by reason of any contract entered into or thing done by such officer or servant as such in any way in discharge of the duties of such officer or servant including traveling expenses.
44. No director or other officer of the company shall be liable for the acts, receipts, neglect or default of any of any other director or for joining in any receipt or other act for conformity or for any loss or expenses happening to the company through the insufficiency or deficiency of little to any property acquired by order of the directors for on behalf of the company or for the insufficiency of any security or investment in or upon which any of the money of the company shall be invested or for any loss or damage arising from bankruptcy, insolvency or tortuous act of any person with whom any money, securities or effects shall be deposited or for any loss occasioned by any error of judgment or oversight on his part or for any other loss, damage or misfortune whatever which shall happen in the execution of his office or in relation thereto unless the same happens through his dishonesty.


 ALTAF HUSSAIN
 B.M. 1354-89-7



NOTICES

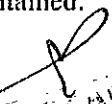
45. (1) A notice may be given by the company to any member either personally or by sending it by post to him to his registered address or (if he has no registered address in Pakistan) to the address, if any, within Pakistan supplied by him to the company for the giving of notice to him.
- (2) Where a notice is sent by post, service of the notice shall be deemed to be effected by properly addressing, prepaying and posting a letter containing the notice and, unless the contrary is proved, to have been effected at the time at which the letters would be delivered ordinary course of post.
46. A notice may given by the company to the joint-holders of the share by giving the notice to the joint-holder named first in the register in respect of the share.

ARBITRATION

47. 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 intent or construction or the incidence or consequences of the presents, or of the statute or touching any thing then or thereafter done, executed, or suffered in pursuance of these presents or of the statute or touching breach or alleged breach or otherwise relating to the premises, or to any statute the company, or to any of the affairs of the Company, including the fixing of the fair value of the shares of the company, every such difference shall be referred to the decision of an arbitrator to be appointed by the 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 any umpire to be appointed by the two arbitrators.
48. In the event that a dispute, claim or controversy arises between the company, its management and its shareholders, or between the shareholders inter-se, or the directors inter-se, all steps may be taken to settle the dispute and resolve the issue through mediation by an accredited mediator before taking recourse to formal dispute resolution such as arbitration or litigation.

SECRECY CLAUSE

49. Every directors, manager, member of the committee, officer, servant, accountant or other person employed in the business of the company shall if so require by the directors before entering upon his duties, sign a declaration pledging to observe a strict secrecy respecting all transaction of the company with the customers and the state of accounts with individuals, matters, relating thereto and shall by such declaration pledge himself not to reveal any of the matters which come to his knowledge in discharge of his duties except when required to do so by the directors or by a Court of Law and except so far as may be necessary in order to comply with any of the provisions in these presents contained.


 ALTAF HUSSAIN
 BM/BS/BS/7



WINDING UP

50. If the company is wound up, whether voluntarily or the liquidator may, with the sanction of a special resolution, divide amongst the contributories in specie or kind, the whole or any part of the assets and liabilities of the company, subject to the section 421 and other provisions of the ordinance as may be applicable.

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

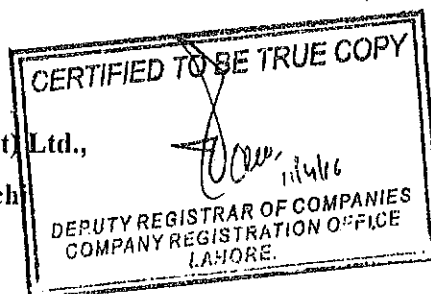
Name and surname (present & former) in full (in Block Letters)	NIC No. (in case of foreigner, Passport No)	Father's/ Husband's Name in full	Nationality with any former Nationality	Occupation	Residential Address in full	Number of shares taken by each subscriber	Signatures
MUHAMMAD IDREES CHAUDHRY	35202-2788992-1	CHAUDHRY SIRAJ DIN	PAKISTANI	BUSINESS	HOUSE # 140-C BLOCK MOEL TOWN, LAHORE	1000 (ONE THOUS AND)	
MUHAMMAD SAEED CHAUDHRY	35202-2789116-1	CHAUDHRY SIRAJ UD DIN	PAKISTANI	BUSINESS	HOUSE # 66-F BLOCK MODEL TOWN, LAHORE	1000 (ONE THOUS AND)	
MUHAMMAD WAHEED CHAUDHRY	35202-2619580-9	CHAUDHRY SIRAJ UD DIN	PAKISTANI	BUSINESS	HOUSE # 39-A, AHMAD BLOCK, NEW GARDEN TOWN, LAHORE	1000 (ONE THOUS AND)	
Total number of shares to be taken						3000 (THREE THOUSAND)	

Dated the 24th day of March, 2016

Witness:

National Institutional Facilitation Technologies (Pvt) Ltd.,

5th Floor, AWT Plaza, I.I. Chundrigar Road, Karachi



ALIA HUSSAIN
BM/BS/89-7

PLANT LOCATION AND CHARACTERISTICS

Plant Location

The proposed plant of HPPPL project will be located within the premises of the sugar mill at 8 km Layyah Road, Athara Hazari in District Jhang. GPS Coordinates of the location are 31.11 °N, 72.06 °E.

The nearest airports are at Faisalabad (120 km) and Multan (140 km), and the nearest sea port is at Karachi

at a distance of about 1,000 km. The proposed plant is well connected with Islamabad and Lahore through the National Highway



Mr. Mawla



and the M-4.

Plant Details

1. General Information

(i)	Applicant's Name	Hunza Power Private Limited
(ii)	Registered Office	1-A New Muslim Town Lahore
(iii)	Plant Location	8 km Layyah Road, Athari Hazari, District Jhang
(iv)	Type of Generation Facility	Bagasse fired Cogeneration Power Plant
(v)	Commissioning/Commercial Operation Date	19 months from Financial Close
(vi)	Expected Life of the Facility from Commercial Operation/Commissioning	30 years
(vii)	Expected Remaining Useful Life of the Facility	30 years

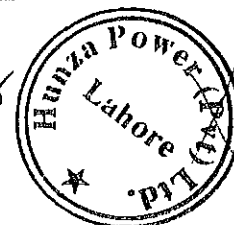
2. Plant Configuration

(i)	Plant Size Installed Capacity (Gross ISO)	49.8 MW (Gross) 2x24.9 MW
(ii)	Type of Technology	Cogeneration Power Plant with high pressure boilers and Turbo-Generators
(iii)	Number of Units	Two (2)
(iv)	Unit Make and Model	110 bar Travelling grate boiler with steam capacity of 2x135 TPH. Turbo generator - Extraction cum condensing type 49.8 MW each.
(v)	Installed Capacity	Power Generation: 49.8 MW (Season operation) 49.8 MW (Off-season operation)
(vi)	Auxiliary Consumption	10 %
(vii)	Interconnection	03 km from proposed project site 132 KV FESCO transmission system

3. Fuel / Raw Material Details

(i)	Primary Fuel	Bagasse
(ii)	Alternate Fuel	NIL
(iii)	Fuel Source (Imported/Indigenous)	Indigenous
(iv)	Fuel Supplier	Hunza Sugar Mills Limited
(v)	Supply Arrangement	Through conveyor belts/loading trucks/tractor trolleys etc.,
(vi)	Sugarcane Crushing Capacity	10,000 TCD
(vii)	Bagasse Generation Capacity	2900 Tons per day (TPD)
(viii)	Bagasse Storage Capacity	100,000 Tons

M. Hanif



(ix)	Number of Storage Tanks	Not Applicable, bagasse shall be stored in open yard
(x)	Storage Capacity of each tank	Not Applicable
(xi)	Gross Storage of bagasse	100,000 Tons

4. Emission Values

Emission values are as below

1. Particulate matter <150 mg/M³
2. SO₂ <100 mg/ M³
3. NO_x < 100 mg/M³
4. Exhaust flue gas temperature 150 to 175 Deg C
5. CO < 200 mg/M³
6. CO₂ 12.5%

5. Cooling System

(i)	Cooling Water Source / Cycle	Deep Bore well water/ Cooling Towers
-----	------------------------------	--------------------------------------

6. Plant Characteristics

(i)	Generation Voltage	11000 volts
(ii)	Frequency	50 Hz
(iii)	Power Factor	0.8 lagging, 0.9 Leading
(iv)	Automatic Generation Control (AFG)	By Turbine Governing System
(v)	Ramping Rate	600 rpm / minute
(vi)	Time Required to Synchronize to Grid and Loading the Complex to Full Load from Cold Start	<div>During cold start (i.e. when plant is started later than 72 hours after shutdown)</div> <div>During warm start (i.e. when plant is started at less than 36 hours after shutdown)</div> <div>During Hot start (i.e. when plant is started at less than 12 hours after shutdown)</div>
		<div>150 minutes</div> <div>90 minutes</div> <div>60 minutes</div>

Note:

All the above figures are indicative in nature. The Net Capacity available for dispatch will be determined through procedure(s) contained in the Energy Purchase Agreement, Grid code or any other applicable document(s).



PROSPECTUS

Prospectus

HPPL is establishing a 49.8 MW cogeneration power project with latest high pressure technology of 110 bar based on bagasse and other biomasses. The vision behind establishing HPPL is to create a strong, well-capitalized power generation company which will design, develop and operate a power project operating at highest international standards in an economic and environmental friendly manner. The project will be situated at 8 km Layyah Road, Athara Hazari, District Jhang Punjab, Pakistan within the premises of HSML.

The cogeneration will be based primarily on bagasse while ensuring that all requisite measures are in place to ensure that the project is environmentally compliant. During one hundred and ten (110) days of crushing season, bagasse being a by-product of HSML process, will be the primary fuel for the project for power generation. During the off-season, residual bagasse of HSML will be utilized for power generation.

Salient features of the facility for which license is sought

The broad parameters of the project are as under:

Project Capacity	49.8 MW (Gross)
Project Location	8 km Layyah Road, Athara Hazari, District Jhang
Land Area	35 Acres
Construction Period	19 months
Power Purchaser	CPPA
Steam Turbines	HTC China
Boilers	Wuxi China
Plant factor	45%
Upfront Levelized Tariff	US Cents 10.62 per kWh

Proposed Investment

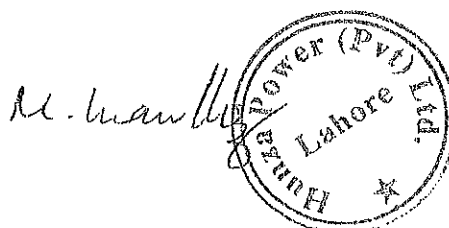
The total cost for the project is approximated PKR 6,488 Million (USD 62 million), which is expected to be financed in a debt to equity ratio of 75:25.

Social and Environmental Impact of the Proposed Facility

Bagasse is a by-product produced during the sugar manufacturing process and is an environmental friendly biomass fuel and helps reduce emission of Green House Gasses. Governments across the Globe including Pakistan and neighbouring India have incentivized biomass based generation to reduce the effects of Global Warming and to promote the use of indigenous energy sources for electricity generation.

Bagasse based power generation provides the following benefits:

- Environment friendly nature of the fuel, helps in reducing Green House Gases and carbon footprint
- The Project will use a high pressure boiler to generate electricity for sale to the national grid. The higher steam parameters shall result in more energy dispatch from the same fuel



- As the bagasse based cogeneration plants will be located invariably in the rural areas, far away from the utility plants, the transmission and distribution losses are minimal

Infrastructure

The Plant is located on Layyah Road, District Jhang. The project site well connected via the National Highway and the M-4. The closest airports are in Faisalabad (~120 km) and Multan (~140 km).

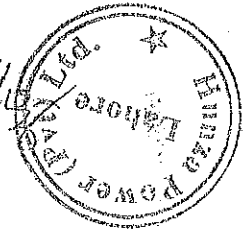
Staff Colony

The land for construction of staff colony is available adjacent to HSML's staff colony and construction shall be completed with the completion of the plant. However, enough accommodation is available with HSML which will not hinder the commencement of work.

Amenities

All amenities like water, electricity and telephone are available at the project site.

Re. Mandib



**SAFETY, EMERGENCY,
TRAINING &
DEVELOPMENT PLANS**

Safety Plan

To provide a safe working environment, the company shall follow a well devised safety plan. Key features of safety plan are given below:

Awareness

Staff working at the facility shall be given information to help them to identify the risks and take necessary measures of safety and protection during their working. To create awareness, personnel at the facility shall be briefed through handouts, in-house seminars, mock safety drills. Particular areas of interest shall be:

- Moral Obligation
- Hazard Recognition
- Importance of Personnel Protective Equipment (PPEs)
- Accident Prevention
- Importance of House Keeping
- Machine Guarding
- Fire Prevention
- Fire Protection
- Fire Fighting

Use of Safety Equipment

Use of Personal protective equipment (PPEs) will be made mandatory. PPEs like safety helmet, safety shoes, uniform, dust mask, ear plugs, ear muff, leather apron, leather sleeves, face shield, gloves for their safety shall be issued to all personnel.

Emergency Alarms

Automatic Emergency Alarms shall be installed along with fire suppression system at all fire hazardous locations of the plant site.

Emergency Numbers

Emergency call numbers shall prominently be displayed in bold at prominent places in the facility.

Emergency Shutdown

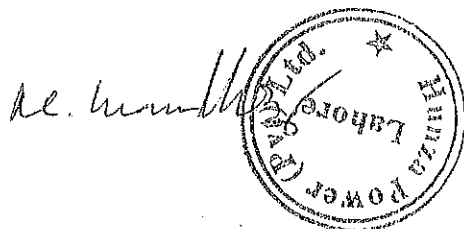
The Emergency Response Team shall be responsible to ensure immediate shutdown of the operational systems and equipment if required in the Emergency.

First Aid Facilities

The availability of first aid facilities and necessary staff to provide urgent and immediate first aid facilities will be ensured at the facility.

Ambulances

Availability of Ambulance at the facility shall be ensured for causality evacuation to the hospitals.



Mock Fire Drills

To keep fire brigade staff in good practice, mock fire drill will be executed by creating mock emergency situations.

Fire Fighting System

The fire protection system will be provided for early detection, alarm, containment and suppression of fire. A comprehensive fire protection system has been planned to meet the above objective. A multitude system shall be provided to combat various types of fire in different areas of the plant and all such systems for various areas shall form a part of a centralized protection system for the entire plant.

The system shall be designed generally as per NFPA (National Fire Protection Association) standards.



Emergency Plan

A comprehensive emergency plan would be implemented to meet unexpected situation to ensure zero injury, damage or loss of any life/property.

Key features of the emergency plan are as follows;

Emergency Escapes/Evacuation Plan

A comprehensive evacuation plan will be prepared and emergency escape procedure and route maps will be displayed at prominent places in the facility. All personnel at the facility shall be made aware of Emergency escape routes and procedures for a quick and safe escape.

Awareness of Different Types of Emergencies

All personnel at the facility shall be educated on how to react to each type of emergency. All staff working at the facility will be given detailed briefing regarding different types of emergencies and their response so that they would be able to identify emergency situations.

Training to React to an Emergency Alert Alarm

All personnel at the facility shall be trained to react to each emergency to take necessary measures of safety and protection at the earliest.

Emergency Equipment

In addition to emergency combatants training, emergency equipment like fire extinguishers and fire hydrants will be provided at the facility to tackle with different types of Emergency.

Use of Safety Gears and Equipment

The staff working at the facility will be given with proper information, guidance and training about the use the safety gears and equipment.

Emergency Alarm

Easy access to emergency alarms shall be provided to raise the alarm in case of any type of Emergency.

Emergency Numbers

Emergency call numbers shall prominently be displayed at prominent places in the facility.

Emergency Response Team

A well-equipped and specialized team will be formed which will be responsible to take all necessary measures and decisions to deal with the emergency and provide relief, support and first aid to the effected staff. The emergency response team will also be responsible for the evacuation of personnel and material from the premises.

Emergency Shutdown



The Emergency Response Team shall be responsible to ensure immediate shutdown of the operational systems and equipment if required in the Emergency.

Assembly Areas and Muster Points

Designated assembly areas / Muster points shall be identified and all personnel working at the facility will be educated to muster at the designated assembly area / muster points in the event of an evacuation for head count.



Training and Development

The major objectives of the operational training shall be to acquaint the operators of the following:

- The nature, purpose and limitations of all plant and equipment.
- The detailed operating instructions on each section and equipment of the plant.
- Normal start up and shutdown program for the unit.
- The emergency procedures.

The basis, for the training shall be the Plant's operating and Maintenance Manual Particulars Book, which shall be compiled from the manufacturers' instructions, the contract documents and the drawings. In addition, the information gathered from the visits to the other operating plants and to the manufacturers works shall also be included in the training. Supervision and co-ordination of the training program requires full time attention of a senior executive of the plant, and also the consultant's assistance may be taken. The training program shall include lectures, expositions by experienced plant operators and maintenance personnel, informal discussions and visits to operating plants and manufacturer's works and exposure to the courses conducted by Institutions like Power Plant Training Institute or any other Institution to be given to the operating & maintenance staff.

The maintenance training program shall be based on the requirements of the individual maintenance functions, like mechanical, electrical, instrumentation etc. The Engineers and the Technicians shall be sent to the manufacturers' works to witness the production and be associated with the erection of plant and equipment.

The Power Plant shall be equipped with proper measuring/testing instrument for periodic cross checking of parameters shown in the control room and power plant area local gauges. Logging of data and periodic review of the plant operation, review of failures, break downs, etc. should be done to improve the availability of the plant.

Al. Khan



A-3

**CONTROL, METERING,
INSTRUMENTATION AND
PROTECTION**

5

**INITIAL ENVIRONMENTAL
EXAMINATION REPORT
SUBMITTED TO EPA**

5



To

The Deputy Director (EIA)
 Environmental Protection Agency,
 Punjab, Lahore.

Subject: SITE INSPECTION REPORT OF 49.8 MW BAGGAS BASED
 THERMAL POWER PLANT M/S HUNZA POWER (Pvt) Ltd, 08
 KM JHANG-LAYYAH ROAD DARGAHI SHAH, TEHSIL 18-
 HAZARI DISTRICT JHANG

Reference: Assistant Director (EIA) office No. DD (EIA)/EPA/F
 572(IEE)/2016/913 Dated: 22-09-2016.

Kindly refer to the letter under reference Mr. Shafique ur-
 Rehman Inspector of this office was deputed to inspect the site. The
 inspector has conducted survey of the site selected by the management and
 submitted report.

The Site Inspection Report (SIR) states that subject project will
 be established at above mentioned site. In the Site Inspection Report it is
 also reported that the required documents for Environmental Approval
 including review fee has already been submitted to EPA, Punjab Lahore. The
 management has stated that there is no pending court case against the
 installation of project. The area is agricultural in nature and no construction
 has been started by the management.

The case is hereby forwarded to place it before the committee
 for review of Initial Environmental Examination (IEE) Report and
 recommended for issuance of Environmental Approval/ NOC for
 construction phase to the said unit at the site in question keeping in view
 above mentioned facts with the conditions that the management will comply
 with Environmental Management Plan (EMP), NEQS and all provisions of
 PEP Act, 1997 (Amended-2012).

Submitted for information and further disposal please

**District Officer Environment
 Jhang**



To

The Deputy Director (EIA)
 Environmental Protection Agency,
 Punjab, Lahore.

Subject: SITE INSPECTION REPORT OF 49.8 MW BAGGAS BASED THERMAL POWER PLANT M/S HUNZA POWER (Pvt) Ltd, 08 KM JHANG-LAYYAH ROAD DARGAHI SHAH, TEHSIL 18-HAZARI DISTRICT JHANG

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District Officer Environment
 Jhang



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**SITE INSPECTION REPORT OF 49.8 MW BAGGAS BASED THERMAL
POWER PLANT M/S HUNZA POWER (Pvt) Ltd, 08 KM JHANG-LAYYAH
ROAD DARGAHI SHAH, TEHSIL 18-HAZARI DISTRICT JHANG**

As the application was received from the office of Assistant Director (EIA) EPA Punjab, Lahore. The undersigned was deputed to visit the subject mentioned site. The visit was conducted on 29-09-2016 and findings are given below:

NAME OF UNIT WITH ADDRESS:

The project's name is M/S Hunza baggas based thermal power plant (Pvt) limited of 49.8 MW, 08 Km Layyah roads, Tehsil 18-Hazari District Jhang.

NAME AND ADDRESS OF MANAGING DIRECTOR/OWNER

Saeed Chaudhary R/o 66-F Model Town, Lahore.

LOCATION OF THE SITE

The said project is located inside the mill's premises.

CURRENT STATUS

The management has not started the construction work like foundation for installation of machinery at project site.

TOTAL AREA

35 Acres approximately as mentioned in IEE report.

Nature of Area

The Area is agricultural in nature.

FUEL

Baggas

FINISHED PRODUCTS

Electricity

NATURE OF UNIT

49.8 MW Co-generation power plant having baggas as primary fuel.

CAPACITY OF UNIT

Capacity of unit will be 49.8 MW.

PROCESS OF UNIT

The Co-Gen power plant designed to produce 49.8 MW Electric power with baggas as primary fuel. Turbine with electrical generator will be installed that will produce 49.8 MW as gross electrical output. Surplus electrical power will be sold to near WAPDA power station.



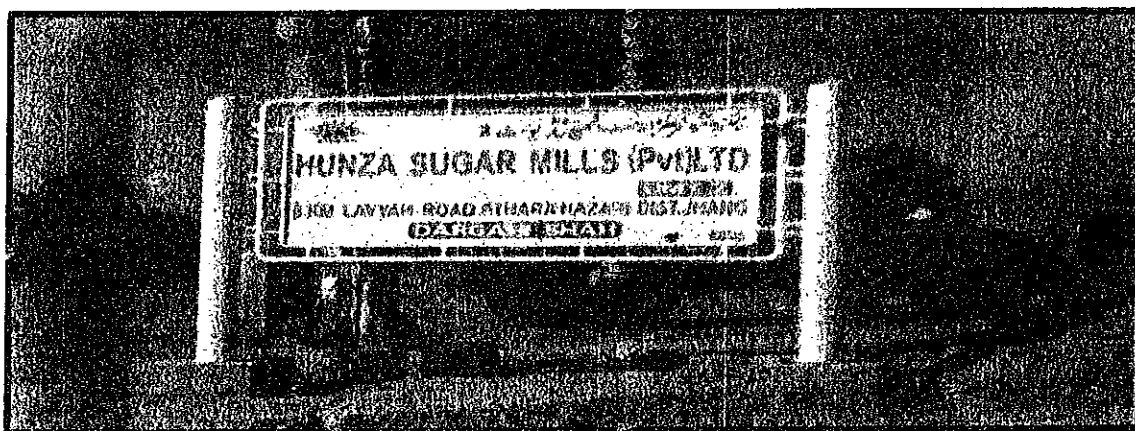
re. L. M. Khan





Environmental Consultancies & Options (ECO)

**INITIAL ENVIRONMENTAL EXAMINATION (IEE)
REPORT**



**CONSTRUCTION/INSTALLATION OF 49.8 MW
BAGASSE FIRED COGENERATION POWER PLANT**



**HUNZA POWER (PVT) LIMITED
18 HAZARI DARGAI SHAH, DISTRICT JHANG**

**SITE INSPECTION REPORT OF 49.8 MW BAGGAS BASED THERMAL
POWER PLANT M/S HUNZA POWER (Pvt) Ltd, 08 KM JHANG-LAYYAH
ROAD DARGAHI SHAH, TEHSIL 18-HAZARI DISTRICT JHANG**

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[illegible]



Environmental Consultancies & Options (ECO)

INITIAL ENVIRONMENTAL EXAMINATION (IEE) REPORT



CONSTRUCTION/INSTALLATION OF 49.8 MW BAGASSE FIRED COGENERATION POWER PLANT

**HUNZA POWER (PVT) LIMITED
18 HAZARI DARGAI SHAH, DISTRICT JHANG**

ENVIRONMENTAL CONSULTANCIES & OPTIONS



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EXECUTIVE SUMMARY

Consultant

The Hunza Power (Pvt) Limited (HPL), Jhang Pakistan is considering to install a 49.8 MW Bagasse Cogeneration Power Plant within the premises of their Sugar Mills Unit-2 located at 18 Hazari Dargahi Shah, District Jhang. In keeping with the regulatory requirement of the country, The Hunza Power (Pvt) Limited has engaged Environmental Consultancies & Options (ECO) to undertake an Initial Environmental Examination (IEE) and the purpose of the report is obtaining Environmental Approval for the construction phase of power plant from EPA Punjab.

The Proponent

Hunza Power (Pvt) Limited is a division of Hunza Group of Industries which was incorporated on 7th April 2016 as a Private Limited Company. Hunza Group of Industries is the leading sugar, edible oil, banaspati ghee, and ethanol producer in Pakistan since 2002. They have two sugar mills units located at different locations in District Jhang and District Faisalabad, Punjab. The main business of both the Sugar Mills is to manufacture White Refined Sugar, Sugarcane Molasses, Ethanol, Industrial Alcohol and other allied products. They are also planning to establish a renewable energy power plant in their Unit-2 i.e., Hunza Sugar Mills located in District Jhang.

Brief Outline of the Report

The Initial Environmental Examination (IEE) has been organized into following Chapters.

Chapter-1: Describes the purpose of report, identification of project activities proponent, details of consultant and provides a brief description of the project nature, size and location.

Chapter-2: Scope & Methodology

Chapter-3: Statutory Requirements and Standards

Chapter-4: Describes the description of the proposed project.

Chapter-5: The environmental setting of the project area

Chapter-6: Describes screening of potential Environmental impacts and mitigation measures.



Chapter-7: Is an Identification of possible impacts for preparation of Environmental Management and Monitoring Plan.

Chapter-8: Is the conclusion of Initial Environmental Examination (IEE) report.

The Proposed Project

The proposed project is installation of a 49.8 MW Bagasse Cogeneration Power Plant by Hunza Power (Pvt) Limited at Dargahi Shah, tehsil 18 Hazari 8 Km off Layyah road District Jhang. The proposed project site is located within the premises of Hunza Sugar Mills unit. The total area of the proposed Power Plant is around 35 acres out of 94 acres of total area of Sugar mills unit. The project will be completed in 20 months. The fuel to be used in the power plant will be bagasse that is the by-product of Hunza Sugar Mills and is available during 110-120 days of year during months December to March.

Environment Settings

Proposed Project of Hunza Private Limited is located at 8 Km off Layyah Road, Tehsil 18 Hazari Dargahi Shah, and District Jhang. The project scope encompasses installation of 49.8 MW Bagasse Co-generation Power Plant. The district Jhang is adjoined by Toba Tek Singh and Faislabad to the East, Hafizabad to the North-East, Khanewal on the South, Sargodha on the North, Khushab, Bhakkar and Layyah on the West. The Jhang has population growth rate of 2.41 % as per 1998 Population Census, which is quiet similar to the provincial average. The population of Town was 293,366 individuals in 1998 census, and is currently estimated at 419,320 individuals. Average temperature of the district is 31.20c minimum and maximum is 17.60c. The average rainfall in the area is 372.3 mm and average humidity is 56.6%. The nearby water-bodies include River Chenab and Rangpur Canal (500 m away). Groundwater is available in the area at a depth of 10 ft. having drinkable quality.

The residential area is about 10 km away from the project site which is Rodu Sultan and the other population is scattered near the area. Major occupation of the people near the project site is farming, workers in industries, labors and people having small businesses. Most of the people speak Jhangochi which is the oldest and pure dialect of Punjabi. Other than that, Urdu and Punjabi are also used as a language.

Flora and fauna of the area includes Trees of Jand (*Prosopis spicigera*), Karir (*Capparis aphylla*), beri (*Zizyphus jujuba*), Van (*Salvadora oleoides*), Kikar (*Acacia nilotica*), Shisham (*Dalbergia sissoo*) and Oak (*Calotropis spp*) are found within the



district. Trees of Jand, Kreer, Van, Kikar, Tahli, Bohar are spread everywhere where there is no cultivation, while herbs of Harmal, Akrey, Bathoo, etc are also found. Mammals near the project surroundings include, Buffaloes, Cows, Cats, Dogs, Wolves, Wild boar, Deer/Hog Deer, Chinkara, Jackal.

Potential Project Impacts & Mitigation

The project activities may result in localized and temporary disturbances due to construction/installation activities at the project site. This may include noise, fugitive emissions, gaseous emissions, dust, water quality deterioration because of untreated wastewater and sewage waste and solid waste management issue related to construction material. The identified impacts are not irreversible and can be mitigated through proper implementation of mitigation measures which have been identified in this IEE report. Hunza Power (Pvt) Ltd has also ensured to take all possible mitigation measures in order to protect environment. Water resources are available within the project area and the water needs shall be met through tube wells. The ambient air quality of the area can be affected by exhaust emissions from the generators at the site, vehicles and other construction equipment's. In addition, kicked up dust can also cause deterioration in the air quality of the area in the immediate vicinity of the activities. To reduce these impacts, the maximum possible distance will be kept from the settlements and vehicle speed will be reduced on roads passing through or close to them.

To mitigate the project impacts on the biological resources of the area, the following measures will be incorporated into its design:

- There will be no vegetation loss.
- Fires in the open will not be allowed.
- Waste of any kind will not be disposed off in an inappropriate way.
- Field activities and vehicle movements during the night will not be allowed.

Environmental Management Plan (EMP)

A comprehensive Environmental Management Plan is suggested with a purpose of environmental preservation. Salient features of the plan are given below:

- Effluent and Emissions Control Plan
- Trainings
- Fire Management



- Emergency Plans
- Biological Hazards
- Health & Safety Plan
- Wastewater Treatment methods

Proposed Monitoring

Environmental monitoring is one of the keys for effective management of environmental quality. Monitoring support is essential in almost all stages of pollution control and abatement programs. The decisions based upon monitoring results are far reaching, and require an accurate, reliable and comprehensive database.

The proposed monitoring will include third party audits (the projects spanning over the period of 6 months), weekly inspections by engineering and environmental personnel, and EPA officials to check compliance to the environmental standards (environmental monitoring will be carried out through a third party certified laboratory). Following environmental parameters were monitored for the proposed project:

- Drinking Water (Chemical and Physical Analysis)
- Surface Water (Chemical and Physical Analysis)
- Waste Water (Chemical and Physical Analysis)
- Soil Quality Analysis
- Ambient Air Quality and Noise Levels

Conclusion

After assessing the significance of potential impacts, the environmental consultants, ECO have concluded that:

“If the activities are undertaken as proposed and described in this report, and the recommended mitigation and environmental management measures are adopted, the project will not result in any long term or significant impacts on the local community and environment”.

Chapter - 1

INTRODUCTION



Chapter - 1

INTRODUCTION

1.1 Purpose of the Report

The Hunza Power (Pvt) Limited (HPL), Jhang Pakistan is considering to install a 49.8 MW bagasse cogeneration power plant within the premises of sugar unit-2 located at 18 Hazari Dargai Shah, District Jhang. The Hunza Power (Pvt) Limited has devised mission to achieve certain environmental objectives besides the existing local legal requirements. Consultants hereby were hired for providing Consultancy for carrying out Initial Environmental Examination (IEE) and the purpose of report is for obtaining Environmental Approval from EPA Punjab.

1.2 Background-Bagasse Based Power Plant

Bagasse is the Crushed Residue of sugar cane. It is termed as a Captive Biomass that is fibrous in nature. It has a calorific value of 2300 kcal / kg. Bagasse is an excellent Raw Material for power generation. It provides a suitable and reliable source of steam and electricity to feed the sugar industry. Pakistan sugar industry that is one of the biggest industries in the world comprises 81 sugar mills with an annual capacity of about six million tons sugar. Only a few sugar mills have surplus electricity to sell to the power utility companies. The surplus power generated by the sugar industry can be synchronized with the National Grid or local grid. As a matter of fact, power generation cost is very low for bagasse fired power generation due to the below mentioned salient factors:

- Since the fuel (bagasse) is available virtually at no cost.
- Fuel is available at site and the infrastructure for fuel transportation is not required.
- Transmission losses are very less as the bagasse co-generation power plants are decentralized.
- Net emission of carbon dioxide is zero.
- The sugar industry has decades of experience of related technology.

Bagasse is burnt to produce energy even today in low efficiency boilers. Low efficiency boilers adequately consumed bagasse for the self-requirements of the sugar mills. However, with the help of new technology, high temperature and pressure boilers with steam turbines are being used to generate more surplus power to sell out to the electric companies through national grid.



1.3 Hunza Power (Pvt) Limited-The Proponent

The Company was incorporated on 7th April 2016 as a Private Limited Company having incorporation number 0098818. Its registered address is 31/ 7-A Abu Bakar Block Garden Town Lahore and Head Office is located at 1-A, New Muslim Town, Lahore. Company's affairs are being run by the Board of Directors assisted by a team of highly qualified and experienced professionals. The background of the directors is in the industrial business and well known in the business community in Pakistan. Their experience in the business is quite deep and relevant to the business line.

Hunza Power (Pvt) Limited is a division of Hunza Group of Industries which is the leading sugar, edible oil, banaspati ghee, and ethanol producer in Pakistan since 2002. They have two sugar mills units located at different locations in District Jhang and District Faisalabad, Punjab.

They are also planning to establish a renewable energy power plant in Hunza Sugar Mills located in District Jhang. The main business of the Hunza Sugar Mills is to manufacture White Refined Sugar, Sugarcane Molasses, Ethanol, Industrial Alcohol and other allied products.

Table 1.1 Location & Production Capacity of Sugar Mills Units

Unit 1		Unit 2		
Production Capacity: 10000 TCD Location: Sirajabad 66/RB, Jhumra, Shahkot Road, Distt. Faisalabad, Pakistan.		Production Capacity: 6000 TCD Location: 8 Km Layyah Road, Atthara Hazari, Dargai Shah – Jhang, Pakistan.		
Office	Address	Phone	Fax	Email
Head Office	1-A, New Muslim Town Lahore, Pakistan.	+92.42.35882941-45, +92.42.111.161.111	+92.42.35882772	info@hunzasugar.com headoffice@hunzasugar.com
Unit 1 Site	66-RB, Sirajabad, Chak Jhumrah-Shahkot Road, District Faisalabad, Pakistan.	+92.41.4000778-79, +92.3008427705		unit1@hunzasugar.com



Unit Site	2	8 KM, Layyah Road, 18 Hazari, District Jhang, Pakistan	+92.47.7330421-7 +92.345.7999374		unit2@hunzasugar.com
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1.3.1 CSR Activities

- HPL supports the grower of sugar cane in the form of providing pesticides and fertilizer interest free loan. This year almost amount of Rs. 15,177,770 was given for pesticides of local sugar cane growers.
- A Government school located in Rodu Sultan Town near 18 Hazari Dargai Shah was renovated by HPL.
- Medical camps are provided to flood affectees whenever this calamity hits the area.

1.4 Identification of Project

Hunza Power (Pvt) Limited is planning to install a 49.8 MW bagasse cogeneration power plant within the premises of sugar unit-2 located at 18 Hazari Dargai Shah, District Jhang. The production capacity of the power plant would be 49.8 MW. The electricity generated would be used for operational purposes in the sugar mill and it will also be traded to national grid station.

1.5 Environmental Management Activities

Hunza Power (Pvt) Limited is committed to ensure that all operations are carried out with due regard for environmental protection and to meet legal requirements. This is achieved through the implementation of company environmental management plan (EMP) and Safety Health and Environment (SHE) policies.

This Plan enables environmental issues to be efficiently and systematically managed for continuous improvement. A key element within any EMP is the evaluation of the effects of operations on the environment. Emissions and discharges from the proposed project are compared to internal requirements and with industry and government standards. Potential environmental impacts on the environment are then evaluated and prioritised action plans developed to reduce environmental effects.

In addition to the evaluation of environmental effects, the EMP ensures that all personnel comply with company's SH &E standards. This includes the auditing of facilities and training of Hunza Power (Pvt) Limited personnel on the environmental sensitivities in areas of operation. Such studies add to the scientific understanding of

the environmentally sensitive areas of interest. Hunza Power (Pvt) Limited delivers solutions for sustainable production and environment. Their industrial products and solutions reduce emissions, improve air quality and support safe and efficient operations.

1.6 Details of Consultant

The ECO is a professionally run, engineering and consultancy firm with strong backup of highly qualified, experienced personnel. The company has specialized diversified fields and continuously identifying the current and future demands related to environment and engineering. The ECO has evolved into a technologically robust conglomerate with manufacturing interests in Metallurgy, Specialty Chemicals, Oil Field Chemicals and Water and Wastewater Treatment and Alternate Energy. The ECO is serving market niche with a broad range of high technology products and services to a wide spectrum of industries in Pakistan. Environmental Consultancies and Options is a member of Groups of Companies. The other members are:

- ☐ Global Waste Management (GWM)
- ☐ Global ECO Lab(GEL) [ISO 9001:2000 Certified]
- ☐ Global Technologies (GT)

1.7 Overview of Activities for the Proposed Project

The proposed activities will include the following:

- Planning & Design
- Construction Phase (Civil Work)
- Commissioning and Operation

1.8 Project Nature, Area & Location

The Hunza Power (Pvt) Limited is to install a 49.8 MW bagasse cogeneration power plant within the premises of sugar unit-2 located at 8 Km Layyah Road, Hazari Dargai Shah, Jhang District, Punjab Province, Pakistan. The Fuel used for firing in the Boiler is the Bagasse generated from Sugar Mill. It will be conveyed from Hunza Sugar Mills through belt conveyors and excess fuel will be stored in closed storage yard. The production capacity of the power plant will be 49.8 MW.

1.8.1 Project Area & Location

The proposed project area is about 35 acres of land. The proposed project will be located at 18 Hazari Dargai Shah, District Jhang within the premises of existing Hunza Sugar Mills (Pvt) Limited.



Project Title	Total Area	Project Area
Construction/Installation of 49.8 MW Bagasse Fired Cogeneration Power Plant	94 acres	35 acres

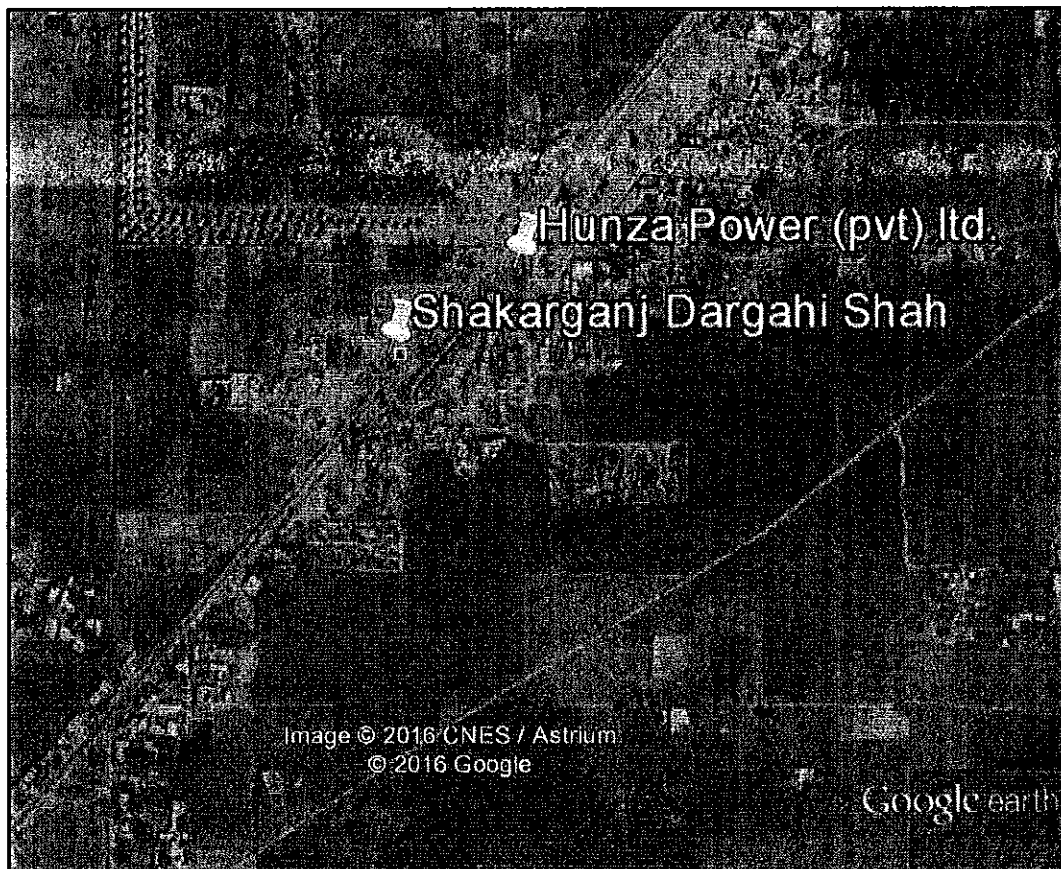


Figure 1.1: Location Map of Proposed Project Site (Google Earth)

Chapter - 2

SCOPE & METHODOLOGY



Chapter – 2

SCOPE & METHODOLOGY

2.1 Initial Environmental Examination (IEE)

Initial Environmental Examination (IEE) means a preliminary environmental review of reasonably foreseeable qualitative and quantitative impacts on the environment of the proposed project of extension to determine whether it is likely to cause adverse environmental effects for requiring preparation of Initial Environmental Examination.

2.2 Objectives of IEE

The objectives of the IEE are to:

- Assess and establish the existing environmental and socio economic conditions in the project area.
- Assess the potential environmental or socio economic impacts of project activities and identify issues of concern.
- Implement and execute environmental safe guards.
- Propose mitigation and monitoring measures that can be incorporated into the design of the project to remove or reduce any damaging effects as far as possible, and to control and monitor residual impacts.
- Facilitate the environmental decision making.
- Facilitate an appropriate follow up process with requirements for monitoring, management, audit, and evaluation.
- Assess the proposed activities to ensure that they comply with the relevant environmental and social regulations and standards.
- Prepare an IEE report as per the relevant guidelines for submittal to the concerned Environmental Protection Agency (EPA).

2.3 Approach & Methodology

Detailed methodology is described as follows:

The project activities were discussed with Hunza Power (Pvt) Limited personnel and the required information were obtained. The site was visited for collection of required information. Questionnaire was designed to collect data for social assessment of the area.



2.3.1 Step - 1: Scoping / Data Collection

In this step, information relating to the physical, technical and environmental parameters was collected from the client and other relevant agencies. Local inhabitants were interviewed in detail to understand the socio-economic, culture and customs of the area. An extensive literature review was also carried out in this step.

Following information was collected from the technical departments:

- o Details of project activities
- o Legislative obligations
- o Environmental data through physical survey (Monitoring of Effluent, Air Quality and Drinking Water Quality) was obtained.

2.3.2 Step - 2: Data Analysis

The data collected in step-1 was analyzed in the framework of Punjab Environmental Protection Act, 1997 (Amended 2012).

2.3.3 Step - 3: Initial Environmental Examination

The data collected in previous phases was used to investigate existing environmental conditions and assess the potential impacts of the proposed activities. Although the major emphasis remained on the compliance of the client's operations with the national legislation available internationally guidelines were also reviewed and mitigations measures were developed to ensure environmentally safe practices.

2.3.4 Step - 4: Initial Environmental Examination (IEE) Report

The finding of the study was communicated to the client in the form of a Draft Initial Environmental Examination (IEE) Report. The report has been prepared in accordance with the relevant guidelines of the Pakistan Environmental Protection Agency. The discussion and comments of the client regarding the recommendations by the consultants were considered and appropriate modifications were incorporated in the Draft Report to be presented as a final report.

2.4 Salient Features of the Report

The Initial Environmental Examination (IEE) Report has been organized into eight (8) chapters. **Chapter-1** describes the proponent, overview of the proposed project activities and location of the proposed project **Chapter-2** is the definition of Environmental Impact Assessment and its study, objectives and methodology. **Chapter-3** is an overview of national and international legislation and guidelines relevant to project activities and the environmental impact assessment process.



Chapter-4 describes project activities in detail. The environmental setting of the project area including the physical and socio-economic is discussed in **Chapter-5**. The project impacts, mitigation and alternatives are discussed in **Chapter-6**. An Environmental Management Plan (EMP) is detailed out in **Chapter-7** and conclusion **Chapter-8** pertains to the conclusion.

Chapter - 3

STATUTORY REQUIREMENT & STANDARDS



Chapter – 3

STATUTORY REQUIREMENT & STANDARDS

A number of laws exist in Pakistan, containing number of clauses concerning protection of the environment. However, the first legislation on environmental protection was issued in 1983. The Pakistan Environmental Protection Ordinance, 1983 was the first legislation promulgated for the protection of environment.

Pakistan Environment Protection Agency was established in 1984. No significant environmental policy, guidelines and regulations were carried out till early 1990's. The National Conservation Strategy was developed and approved by the federal cabinet in 1992. Provincial Environmental Protection Agencies were also established in 1992-1993. National Environmental Quality Standards (NEQS) were established in 1993. Detailed environmental guidelines started in 1996. The National Assembly and the Senate conferred National Environmental Protection Act in 1997.

3.1 Policy Guidelines

There are more than 100 laws regarding the environment in Pakistan. These include federal, provincial and international laws, regulations, statutes and treaties. The rules and regulations regarding the environment in Pakistan are also in a large number. Some of the important of them are National Environmental Quality Standards (self-monitoring and reporting by industry) Rules 2001, Environmental Samples Rules, 2001, Hazardous Substances Rules, 2003, Hospital Waste Management Rules, 2000.

The Pakistan Environmental Protection Act, 1997 is the key legislation empowering the government to frame regulations for the protection of the environment. Detailed rules, regulations and guidelines required to enforce the Environmental Protection Act are still in various stages of development. It provides for the protection, conservation, rehabilitation and improvement of the environment; for prevention and control of pollution and for the protection of sustainable development.

3.2 Environmental Institutions and Administration

The Constitution of Pakistan distributes the legislative powers between the federal and the provincial governments through "Federal and Concurrent Lists" attached to the Constitution as appendices. The Federal list depicts the areas and subjects on which the Federal government has exclusive powers. The second, concurrent list



contains areas and subjects on which both Federal and Provincial governments can enact laws.

The Ministry of Climate Change is responsible for environmental issues at federal level. The NCS unit within the Ministry ensures implementation of the National Conservation Strategy.

The Pakistan Environmental Protection Agency (PEPA) at the federal level is responsible for administering the provisions of the Environmental Protection Act. It is responsible to ensure compliance with the National Environmental Quality Standards (NEQS), develop monitoring and evaluation systems and initiate legislation when necessary.

The Provincial Environmental Protection Agencies (Environmental Protection Directorate in Punjab) are responsible for environmental planning and development, approval of Initial Environmental Examination (IEE) and Environmental Impact Assessments (EIA) of new projects at provincial level.

Wildlife conservation and management is also a provincial subject. Provincial Wildlife and forestry departments are responsible for implementation of provisions of provincial Wildlife Protection Ordinances, Acts and Regulations.

3.3 Laws, Regulations and Guidelines

Pakistan Environmental Protection Act, 1997 amended 2012 is the basic law that empowers the Government of Pakistan to develop policies and guidelines for the protection of natural environment. Details of the laws applicable are described below:

3.3.1 The Constitution (Eighteenth Amendment) Act 2010 gives provincial governments exclusive powers to legislate on the subject of “environmental pollution and ecology”. When the Pakistan Environmental Protection Act (PEPA) 1997 operated as a federal law, any contradictory provisions in other laws, whether federal or provincial, were nullified because PEPA 1997 had overriding effect. But this is no longer the case. Environmental Consultancies and Options (ECO) Statutory Requirement & Standards With environmental protection legislation operating at the provincial level, all federal laws now override it. Prior to the enactment of the Eighteenth Amendment, PEPA 1997 governed all operations and activities that have the potential to cause environmental damage. This included subjects such as nuclear power for which only the federal government may legislate. This too is no longer the case. The federal government retains exclusive authority over a number of subjects

that should be regulated by environmental law but the ambit of that law will now no longer extend to them.

3.3.2 National Environmental Policy 2005

Government of Pakistan has notified National Environmental Policy 2005, for different projects/aspects in which guidelines/priorities have been given to undertake/commence the projects having significant environmental impacts. The National Environmental Policy (2005) provides a framework for addressing the environmental issues (particularly pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of biodiversity, desertification etc.) confronting Pakistan. It recognizes the goals and objectives of the Pakistan National Conservation Strategy (PNCS, 1992), National Environmental Action Plans, and other existing environment related national policies, strategies, and action plans. It also provides broad guidelines to the Federal Government, Provincial Governments, federally administrated territories and local governments to address their environmental concerns and to ensure effective management of their environmental resources.

3.3.3 Pakistan Environmental Protection Ordinance (PEPO) 1983

In 1983, the Government of Pakistan issued an Environmental Protection Ordinance (EPO). It was the first legislation promulgated for the protection of environment. According to PEPO, 1983, it was necessary to carry out IEE / EIA for all development projects, but there were no IEE / EIA regulations under that ordinance.

3.3.4 Pakistan Environmental Protection Act, 1997 Amended 2012

The Act is applicable to a broad range of issues and extends to air, water, soil, marine and noise pollution, as well as the handling of hazardous waste. Some portions from the Act are reproduced below for reference purposes.

- **Section-11 (1):** "Subject to the provisions of this Act and the rules and regulations made there under no person shall discharge or emit or allow the discharge or emission of any effluent or waste or air pollution or noise in an amount, concentration or level which is in excess of the National Environmental Quality Standards."
- **Section-12 (1):** "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an Initial Environmental Examination (IEE) or, where the project is likely to cause an adverse environmental effect, an



Environmental Impact Assessment (EIA), and has obtained from the Federal Agency approval in respect thereof".

- **Section-14:** "Subject to the provisions of this Act, no person shall generate, collect, consign, transport, treat, dispose of, store, handle or import any hazardous substance except (a) under a license issued by the Federal Agency and in such manner as may be prescribed; or (b) in accordance with the provisions of any other law for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement or other instrument to which Pakistan is a party"

3.3.5 Pakistan Environmental Protection Agency Review of IEE and EIA Regulation, 2000

The Pakistan Environmental Protection Agency Review of IEE and EIA Regulations provide the necessary details on preparation, submission and review of the IEE and EIA.

Categorization of projects for IEE and EIA is one of the main components of the Regulations. Projects have been classified on the basis of expected degree of adverse environmental impacts. Project types listed in Schedule-II are designated as potentially less adverse effects. Schedule-I projects require an IEE to be conducted, rather than a full-fledged EIA, provided they are not located in environmentally sensitive areas.

Salient features of the regulations relevant to the proposed project are listed below:

- Categories of projects requiring IEE and EIA are issued through two schedules attached with the Regulations. Oil and gas extraction projects including exploration, production, gathering systems, separation, and storage are included in an IEE category.
- The IEE/ EIA must be prepared, to the extent practicable, in accordance with the Pak-EPA environmental Guidelines discussed in the sections to follow.
- A fee, depending on the cost of the project has been imposed for review of the IEE and EIA.
- The submittal is to be accompanied by an application in prescribed format included as Schedule-IV of the Regulations.
- The EPA is bound to conduct a scrutiny and reply within 10-days of submittal of report (a) confirming completeness (b) asking for additional information, or (c) requiring additional studies.



- The EPA is required to make every effort to complete the review process for the IEE within 45-days, and of the EIA within 90-days, of issue of confirmation of completeness.

When EPA accords their approval subject to certain conditions, the following procedure will be followed:

- ❖ Before commencing construction of the project, the proponent is required to submit an undertaking accepting the conditions.
- ❖ Before commencing operation of the project, the proponent is required to obtain from the EPA a written confirmation of compliance with the approval conditions and requirements of the IEE/ EIA.
- There is a requirement for an EMP to be submitted with the request for obtaining confirmation of compliance.
- The EPA is required to issue confirmation of compliance within 15-days of receipt of request and complete documentation.
- The IEE/ EIA approval will be valid for three years from date of accord.

The regulations of monitoring report are required to be submitted to the EPA after the completion of construction followed by annual monitoring reports during operations.

3.3.6 National Environmental Quality Standards (NEQS)

The National Environmental Quality Standards (NEQS) developed under the Pakistan Environmental Protection Act 1997 establishes the following discharge concentration standards:

- Maximum allowable concentration of the Pollutants, (32 parameters) in emission and liquid industrial effluents discharged to inland waters, sewerage treatment and the sea
- Maximum allowable concentration of pollutants (16 parameters) in gaseous emission
- Maximum allowable exhaust emissions and noise emission from vehicles.
- Maximum allowable noise level from vehicles
- Maximum allowable limits for Drinking Water
- Maximum allowable limits for Ambient Air Quality

The National Environmental Quality Standards (NEQS) are given in Exhibit - 3.1 to Exhibit - 3.6.

**Exhibit- 3.1: Effluent Discharge Standards (NEQS 2000) Applicable to the Work**

Sr. No.	Determinant	NEQS
1	Temperature	40 °C =≤3 deg.
2	pH	6 – 9
3	BOD5	80 mg/l
4	Chemical Oxygen Demand (COD)	150 mg/l
5	Total Suspended Solid (TSS)	200 mg/l
6	Total Dissolved Solids	3500 mg/l
7	Grease and Oil	10 mg/l
8	Phenolic compounds (as phenol)	0.1 mg/l
9	Ammonia	40 mg/l
10	Chlorine	1.0 mg/l
11	Chloride	1000.0 mg/l
12	Sulphate	600 mg/l
13	Manganese	1.5 mg/l
14	Fluoride	10 mg/l
15	Cyanide (as CN ⁻) total	1.0 mg/l
16	An-ionic detergents (as MB As)	20 mg/l
17	Sulphide (S-2)	1.0 mg/l
18	Pesticides	0.15 mg/l
19	Cadmium	0.1 mg/l
20	Chromium trivalent and hexavalent	1.0 mg/l
21	Copper	1.0 mg/l
22	Lead	0.5 mg/l
23	Mercury	0.01 mg/l
24	Selenium	0.5 mg/l
25	Nickel	1.0 mg/l
26	Silver	1.0 mg/l
27	Total Toxic metals	2.0 mg/l
28	Zinc	5.0 mg/l
29	Arsenic	1.0 mg/l
30	Barium	1.5 mg/l
31	Iron	8.0 mg/l
32	Boron	6.0 mg/l



Exhibit – 3.2: National Environmental Quality Standards (NEQS) for Gaseous Emission (mg/Nm³, Unless Otherwise Defined)

Sr. No.	Parameter	Source of Emission	Existing Standards	Revised Standards
1.	Smoke	Smoke Opacity not to exceed	40% or 2 Ringlemann Scale	40% or 2 Ringlemann Scale or equivalent smoke number
2.	Particulate Matter (I)	(a) Boilers and Furnaces (i) Oil fired (ii) Coal fired (iii) Cement Kilns (b) Grinding, crushing, clinker coolers and Related processes, Metallurgical Processes, converter, blast furnaces and cupolas.	300 500 200 500	300 500 200 500
3.	Hydrogen Chloride	Any	400	400
4.	Chlorine	Any	150	150
5.	Hydrogen Fluoride	Any	150	150
6.	Hydrogen Sulphide	Any	10	10
7.	Sulphur Oxide ⁽²⁾⁽³⁾	Sulfuric acid/ Sulphonic acid plants Other plants except power plants operating on oil and coal	 400	 1700
8.	Carbon Monoxide	Any	800	800
9.	Lead	Any	50	50
10.	Mercury	Any	10	10
11.	Cadmium	Any	20	20
12.	Arsenic	Any	20	20
13.	Copper	Any	50	50
14.	Antimony	Any	20	20
15.	Zinc	Any	200	200
16.	Oxides of Nitrogen (3)	Nitric acid manufacturing unit. Other plants except power plants operating on oil or coal: Gas fired Oil fired Coal fired	 400 - -	 400 600 1200



Explanation

1. Based on the assumption that the size of the particulate is 10 micron or more.
2. Based on 1 percent sulphur content in fuel. Higher content of Sulphur will case standards to be pro-rated.
3. In respect of emissions of sulphur dioxide Nitrogen oxides, the power plants operating on oil and coal as fuel shall in addition to National Environmental Quality Standards (NEQS) specified above, comply with the following standards.

Exhibit - 3.3: National Environmental Quality Standards (NEQS, 2009) for Vehicular Emission

Sr. No.	Parameter	Standard (Maximum permissible Limit)	Measuring Method	Applicability
1	Smoke	40% or 2 on the Ringlemann Scale during engine acceleration mode.	To be compared with Ringlemann Chart at a distance of 6 meters or more	Immediate effect
2	Carbon Monoxide (CO)	6%	Under idling condition: Non-dispersive infrared detection through gas analyzer.	--
3	Noise	85 dB(A)	Sound Meter at 7.5 meters from the source	--

Exhibit - 3.4: National Environmental Quality Standards (NEQS, 2010) for Noise

Sr. No.	Category of Area / Zone	Effective from 1 st July, 2010		Effective from 1 st July, 2013	
		Limit in dB (A) Leq*			
		Daytime	Night-time	Daytime	Night-time
1	Residential Area (A)	65	50	55	45
2	Commercial Area (B)	70	60	65	55
3	Industrial Area (C)	80	75	75	65
4	Silence Zone (D)	55	45	50	45

Note

1. Daytime hours: 6:00 a.m. to 10:00 p.m.
2. Night-time hours: 10:00 p.m. to 6:00 a.m.



3. Silence Zone: Zones which are declared as such by the competent authority.
An area comprising not less than 100 meters round hospitals, educational institutions and courts.

4. Mixed categories of areas may be decided as one of the four above mentioned categories by the competent authority.

*dB (A) Leq: Time weighted average of the level of sound in scale "A" which is relatable to human hearing.

**Exhibit – 3.5: National Environmental Quality Standards (NEQS, 2010) for
Drinking Water**

Sr. No.	Properties/Parameters	Standard Values for Pakistan	WHO Standards	Remarks
Bacterial				
1	All water is intended for drinking (E.Coli or Thermotolerant Coliform bacteria)	Must not be detectable in any 100ml sample	Must not be detectable in any 100ml sample	Most Countries follow Standards Asian also WHO
2	Treated water entering the distribution system (E.Coli or Thermotolerant Coliform and total Coliform bacteria)	Must not be detectable in any 100ml sample	Must not be detectable in any 100ml sample	Most Countries follow Standards Asian also WHO
3	Treated water entering the distribution system (E.Coli or Thermotolerant Coliform and total Coliform bacteria)	Must not be detectable in any 100ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95% of the samples taken throughout any 12-month period.	Must not be detectable in any 100ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95% of the samples taken throughout any 12-month period.	Most Countries follow Standards Asian also WHO
Physical				
4	Colour	≤15 TCU	≤15 TCU	--
5	Taste	Non Objectionable/ Acceptable	Non Objectionable/ Acceptable	--
6	Odour	Non Objectionable/ Acceptable	Non Objectionable/ Acceptable	--
7	Turbidity	<5 NTU	<5 NTU	--



8	Total hardness as CaCO ₃	<500mg/l	---	--
9	TDS	<1000	<1000	--
10	pH	6.5-8.5	6.5-8.5	--
Radioactive				
11	Alpha Emitters bq/L or pCi	0.1	0.1	--
12	Beta Emitters	01	01	--
Chemical				
Essential Inorganics		mg/litre	mg/litre	
13	Aluminum (Al) mg/l	≤0.2	0.02	--
14	Antimony (Sb)	≤0.005	0.02	--
15	Arsenic (As)	≤0.05	0.01	Standard for Pakistan similar to most Asian developing Countries
16	Barium (Ba)	0.7	0.7	--
17	Boron (B)	0.3	0.3	--
18	Cadmium (Cd)	0.01	0.003	Standard for Pakistan similar to most Asian developing Countries
19	Chloride (Cl)	<250	250	--
20	Chromium (Cr)	≤0.05	0.05	--
21	Copper (Cu)	2	2	--
Toxic Inorganics		mg/litre	mg/litre	
22	Cyanide (CN)	≤0.05	0.07	Standard for Pakistan similar to most Asian developing Countries
23	Fluoride (F)	≤1.5	1.5	
24	Lead (Pb)	≤0.05	0.01	Standard for Pakistan similar to most Asian developing Countries
25	Manganese (Mn)	≤0.5	0.5	--
26	Mercury (Hg)	≤0.001	0.001	--
27	Nickel (Ni)	≤0.02	0.02	--
28	Nitrate (NO ₃)	≤50	50	--
29	Nitrite (NO ₂)	≤3	3	--
30	Selenium (Se)	0.01	0.01	--
31	Residual Chlorine	0.2-0.5 at consumer end 0.5-	---	--



		1.5 at source		
32	Zinc (Zn)	5.0	3	Standard for Pakistan similar to most Asian developing Countries
Organics				
33	Pesticides mg/L	---	PSQCA No. 4629-2004, Page No.4, Table No. 3, Serial No. 20-58 may be consulted	Annex-II
34	Phenolic Compounds (as Phenols) mg/L	---	≤0.002	--
35	Poly nuclear aromatic hydrocarbons (as PAH) g/L		0.01 (By GC/MS method)	--
***PSQCA: Pakistan Standards Quality Control Authority				

Exhibit – 3.6: National Environmental Quality Standards (NEQS, 2010) for Ambient Air

Pollutants	Time-weighted average	Concentration in Ambient Air		Method of Measurement
		Effective from 1st July 2010	Effective from 1 st January 2013	
Sulphur Dioxide (SO ₂)	Annual Average*	80µg/m ³	80µg/m ³	Ultraviolet Fluorescence Method
	24 hours**	120µg/m ³	120µg/m ³	
Oxides of Nitrogen as (NO)	Annual Average*	40µg/m ³	40µg/m ³	Gas Phase Chemiluminescence
	24 hours**	40µg/m ³	40µg/m ³	
Oxides of Nitrogen as (NO ₂)	Annual Average*	40µg/m ³	40µg/m ³	Gas Phase Chemiluminescence
	24 hours**	80µg/m ³	80µg/m ³	
Ozone (O ₃)	1 hour	180µg/m ³	130µg/m ³	Non disperse UV absorption method
Suspended	Annual	400µg/m ³	360µg/m ³	High Volume



Particulate Matter (SPM)	Average*			Sampling, (Average flow rate not less than 1.1m ³ /minute)
	24 hours**	550µg/m ³	500µg/m ³	
Respire able Particulate Matter (PM ₁₀)	Annual Average*	200µg/m ³	120µg/m ³	β-Ray Absorption Method
	24 hours**	250µg/m ³	150µg/m ³	
Respire able Particulate Matter (PM ₂₅)	Annual Average*	25µg/m ³	15µg/m ³	β-Ray Absorption Method
	24 hours**	40µg/m ³	35µg/m ³	
	1 hour	25µg/m ³	15µg/m ³	
Lead (Pb)	Annual Average*	1.5µg/m ³	1µg/m ³	AAS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	2µg/m ³	1.5µg/m ³	
Carbon Monoxide (CO)	8 hours**	5µg/m ³	5µg/m ³	Non Dispersive Infrared (NDIR) method
	1 hour	10µg/m ³	10µg/m ³	
*Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform intervals.				
**24 hourly/8 hourly values should be met 98% in a year. 2% of the time, it may exceed but not on two consecutive days.				

3.3.7 The Punjab Local Government Ordinance, 2001

Schedules 4 and 8 of this Ordinance pertain to environmental pollution. There are not withstanding any specific provisions; every local government may perform functions conferred by or under the Punjab Local Government Ordinance, 2001, and in performance of such functions may exercise such powers as may be necessary and appropriate. Under the ordinance, the local councils are authorized to restrict projects causing pollution to air, water or land. They may also initiate schemes for improving the environment.

3.3.8 Pakistan Penal Code (Act XLV of 1860)

This defines the penalties for violations concerning pollution of air, water bodies and land. Sections 272 and 273 of this Act deal with the adulteration of food or drink. Noise pollution has been covered in section 268, which defines and recognizes noise as a public nuisance. "A person is guilty of a public nuisance who does any act or is guilty of an illegal omission which causes any common injury, danger or annoyance to the public or the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right".

3.3.9 National Policy for Power Co-Generation by Sugar Industry, 2008

The salient features of this policy are as follows:

- The incentives available to the Independent Power Plants under Policy for Power Generation Projects 2002 would be available to the Power Co-Generation units of Sugar Mills.
- The Power generated by the Sugar Industry will be purchased by NTDC or DISCO concerned at agreed/negotiated and competitive rates to be approved by NEPRA. Power Sale / Purchase Agreements, valid during the life of the Power Co-Generation units, will be signed with Sugar Mills on the lines of the Agreements signed with the IPPs.
- Bagasse and imported/local coal will be consumed as per requirement of the plant without any limitation of inter- changeability.
- The co-generation power projects will be developed on Fast Track Basis and there will be no requirement of pre-qualification, feasibility study and Letter of Interest (LOI) by PPIB. The Sugar Industry will be issued Letter of Support (LOS) by PPIB after upfront tariff has been determined by the NEPRA.
- The sugar mills selected for power Co-Generation will be required to set up the plant on fast track basis but not later than 36 months of issuance of Letter of Support (LOS) since basic infrastructure is already in place.
- It will be the responsibility of the Sugar Mills to make all other arrangement like bank financing, purchase of land, procurement of machinery etc.



3.3.10 Policy for Development of Renewable Energy for Power Generation, 2006

Local environmental and health impacts of unsustainable and inefficient traditional biomass fuels and fossil fuel-powered electricity generation can be largely circumvented through clean, renewable energy alternatives. Similarly, displaced greenhouse gas emissions carry significant global climate change benefits, towards which Pakistan has pledged action under the UN Framework Convention on Climate Change.

3.3.11 Land Acquisition Act, 1894

The Land Acquisition Act (1894) deals with the acquisition of private properties for public purposes. There are 55 sections in this Act mainly dealing with area notification, surveys, acquisition, compensation, apportionment awards, disputes resolution, penalties and exemptions. Although quite old, this act laid out the legal basis for any property affected by a project and for compensating the effected owners of the land.

3.3.12 Labour Laws

Construction and operational activities during the course of the project may affect occupational health and safety of workers. Employers are required to abide by labor laws in respect of their own employees and also to ensure that contractors follow the relevant labor laws and rules relating to safety of the workforce and creating a healthy working environment, and provide their employees at all scales and levels with their due rights. The proponents shall ensure that the labor force engaged at the project site is not exposed to any danger by monitoring the contractor's work frequently.

3.3.13 Safety Regulations

Following laws and regulations directly or indirectly govern the occupational health and safety issues during the currently studied production activities:

- Factories Act, 1934
- PEPA Laws, 2000
- Labor Laws
- Electricity Rules, 1937
- Nuclear Safety & Radiation Act, 1990



3.3.14 Other Regulations

- The Forest Act, 1927
- Rules for Prohibition and Regulation of Fishing Burboster, Labeo Rohita, Catlacatla, Cirrhina, and Mirgala less than 10 inches in length. (No. 2989/54-6541-D (f), 1954.
- West Pakistan Land Reform Rules, 1959
- West Pakistan Land Reforms Regulation, 1959, MLR No. 64.
- West Pakistan Wildlife Protection Ordinance, 1959
- Wildlife Protection Rules, 1960
- The Land Acquisition Act, 1984
- Wild Birds and Animals Protection Act, 1992

3.4 Environmental Guidelines of the Pakistan EPA

Sets of environmental guidelines to facilitate environmental assessment studies have been developed under the statutory cover of the Pakistan Environmental Protection Act, 1997. The following guidelines have been developed through a consultative process:

- Guidelines for the preparation and review of environmental reports
- Guidelines for Public Consultations
- Guidelines for sensitive and critical areas
- Sectoral Guidelines

3.5 Environmental Guidelines of UNEP and the World Bank

Some of the environmental guidelines of UNEP and the World Bank are as follows:

- Environmental Impact Assessment Training Resource Manual, Draft 1996, UNEP
- Pollution Prevention and Abatement Handbook 1998: Towards Cleaner Production (WB/UNIDO/UNEP, 1999)
- Environmental Assessment Sourcebook, Volume-I: Policies, Procedures and Cross-Sectoral Issues (WB, 1991a)
- Environmental Assessment of Energy and Industry Projects (WB, 1991a)

Exhibit - 3.7 and 3.8 depicts the maximum discharge limits of pollutants proposed by the World Bank for liquid effluents and gaseous emissions. Ambient air quality standards are provided as Exhibit - 3.9.



3.6 International Treaties and Obligations

Pakistan is a signatory to various international treaties and conventions on the conservation of the environment and wildlife protection. Some of these treaties and conventions are as follows:

- UN Convention on Biological Diversity, Rio-de-Janeiro (1992)
- Convention of the Conservation of Migratory Species of Wildlife Animals (1979)
- International Plant Protection Convention (1952)

3.7 Environmental Assessment Process

The environmental assessment process is governed by the following documents:

- The Pakistan Environmental Protection Act, 1997
- Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000
- Pakistan Environmental Protection Agency Guidelines for the preparation and review of environmental reports.

Submission of environmental assessment study report to obtain No-Objection-Certificate (NOC) was made mandatory by the Pakistan Environmental Protection ordinance (1983) and the Pakistan Environmental Protection Act (1997). Section 12(1) of the Pakistan Environmental Protection Act (1997) stipulates that no project involving construction or any change in the physical environment can be undertaken unless an IEE or an EIA is conducted, and approval (NOC) is received from the relevant provincial Environmental Protection Agency.

The Pakistan Environmental Protection Agency Review of IEE and EIA Regulation (2000) categorize projects into various schedules based on the anticipated environmental hazards. Projects with fewer environmental hazards are listed in Schedule-I and are required to carry out an Initial Environmental Examination (IEE). Projects with significant environmental hazards are grouped as Schedule-II. Projects listed in Schedule-II require that a detailed Environmental Impact Assessment (EIA) is carried out. Projects listed under Schedule-I will require a detailed EIA if the project is to be located in a sensitive area.

Exhibit - 3.7: World Bank Liquid Effluent Discharge Limits

Parameter	Oil and Gas Production (Onshore)	Other Industry
PH	6-9	6-9
BOD5	50 mg/l	30 mg/l
COD	-	150 mg/l
Total Suspended Solids	50 mg/l	30 mg/l
Oil and Grease	20 mg/l	10 mg/l
Chromium (Hexavalent)	-	0.1 mg/l
Chromium (total)	-	0.5 mg/l
Lead	-	0.1 mg/l
Phenol	1 mg/l	0.5 mg/l
Benzene	-	0.05 mg/l
Benzo(a)pyrene	-	0.05 mg/l
Sulfide	1 mg/l	1 mg/l
Nitrogen (total)	-	10 mg/l
Cyanide (total)	0.2 mg/l	-
Total Toxic Metals	5 mg/l	-
Temperature Increase	<3°C	<3°C

Exhibit - 3.8: World Bank Emissions Discharge Limits

Parameter	Oil and Gas Production (Onshore)	Other Industry
Volatile Organic Compounds (including benzene)	20 mg/Nm ³	-
Hydrogen Sulfide	30 mg/Nm ³	152 mg/Nm ³
Sulfur Oxides (for oil production)	1,000 mg/Nm ³	-
Sulfur Oxides (for sulfur recovery units)	-	150 mg/Nm ³
Sulfur Oxides (for combustion units)	-	500 mg/Nm ³
Nitrogen oxides (gas fired)	320 mg/Nm ³	-
Nitrogen oxides (oil fired)	460 mg/Nm ³	-
Nitrogen oxides (excluding catalytic units)	-	460 mg/Nm ³
Particulate matter	-	50 mg/Nm ³
Odor at the receptor end	Not offensive	-
Nickel And vanadium (combined)	-	2 mg/Nm ³



Exhibit - 3.9: Standards and Guidelines for Ambient Levels of Nitrogen Oxides, Sulfur Dioxide and Particulate Matter ($\mu\text{g}/\text{Nm}^3$, unless otherwise defined)

Pollutant	Agency	Annual Average	24-hr Average	1-hr Average
Nitrogen Oxides	EU (1985)	200	-	-
	USEPA (1992)	100	-	-
	WHO (1977)	-	-	190-230
	WHO for Europe (1987)	-	150	400
Sulfur Oxides	EU (1985)	80-120	250-350	-
	USEPA (1992)	80	365	-
	WHO (1977)	40-60	100-150	-
	WHO for Europe (1987)	50	125	350
Particulates	EU (1985)	80 (BS) 150 (TSP)	250 (BS) 300 (TSP)	-
	USEPA (1992)	50 (PM_{10})	150 (PM_{10})	-
	WHO (1977)	40-60 (BS) 60-90 (TSP)	100-150 (BS) 150-230 (TSP)	-
	WHO for Europe (1987)	50 (BS)	70 (PM_{10}) 125 (BS) 120 (TSP)	-

Legal Requirement

Pakistan Environment Protection Agency (Review of IEE & EIA) Regulation 2000, Schedule -I clearly states the list of projects requiring IEE. The proposed project of Construction/Installation of 49.8 MW Bagasse Fired Cogeneration Power Plant at Hunza Power (Pvt) Limited falls under Schedule-I (IEE) in Category B.

Chapter - 4

PROJECT DESCRIPTION



Chapter – 4

PROJECT DESCRIPTION

The proposed project is described below, with particular emphasis on aspects related to the environment.

4.1 Type and Category of Proposed Project

Pakistan Environment Protection Agency (Review of IEE & EIA) Regulation 2000, Schedule-I clearly states the list of project requiring IEE. The proposed project of Construction/Installation of 49.8 MW Bagasse Fired Cogeneration Power Plant utilizing bagasse produced in the sugar production at Dargahi Shah, tehsil 18 Hazari 8 Km off Layyah road District Jhang falls under Schedule-I (IEE) in Category B.

4.2 Project Objectives

The objectives of the proposed project are to:

- Generate cheaper, easy available and environmental favorable electricity.
- Become fully self-sufficient in electricity production and utilized the power for the operation of the factory.
- Sell surplus electricity to WAPDA.
- Reduce GHG emission by bagasse power generation.
- Contribution of local economy by generation of job opportunity.

4.3 Need of the Project

The proposed project shall be an installation of new plant for bagasse-based power generation. This project is a part of an existing sugar mill and shall not only replace consumption of grid electricity and/or fossil fuel but also supply electricity to the grid.

4.4 Scope of Power Cogeneration by Sugar Industries in Pakistan

Pakistan is the 15th largest producer of sugar in the world, 5th largest in terms of area under sugar cultivation and 60th in yield. The sugar industry is the 2nd largest agro based industry which comprises of 89 sugar mills with crushing capacity of 6 million tons per year. In a sugar industry, the sugar is produced predominantly from sugarcane. The acreage under cane was reported as 1080,000 hectares in 2009-10 produced about 55



million tons of sugarcane. Punjab province accounted for over half of the total cane produced followed by Sindh Province. Sugar industry supply bagasse as a by-product and until recently, bagasse was used as a feed stock for both paper and chipboard manufacture.

Besides it, bagasse is also a source for energy for grid electricity. Generation of electricity through bagasse in Pakistan is need of the hours in the scenario of prevailing energy crisis. It becomes more significant as this generated power is available in winter season when our country has to face a flagrant situation of less power generation due to water and gas shortages. The bagasse based power generation offers a number of advantages apart from helping in bridging the gap between the demand and the supply in the power sector. According to Alternative Energy Development Board (AEDB), Pakistan sugar industry can provide cheap and easy electricity to the common consumers on local level as well as to the industry to some extent. It not only offers an environmentally friendly solution for additional power generation but also helps in reducing the dependence on the fossil fuels, saves on the foreign currency outflow from the country and improves the financial position of the sugar industry.

Using a conservative factor that crushing 90,000 tons of cane will provide enough bagasse to produce 1 net MW of excess power per season (net means that the sugar factory power needs have already been met) for sale to the grid. The total of 200 MW is significant in the sugar industry, when treated as an indigenous energy resource and potential supplier, can make a significant contribution in the power sector, mainly in the more rural areas.

4.5 The Proposed Project

The proposed project is the Construction/Installation of 49.8 MW Bagasse Fired Cogeneration Power Plant within the premises of Hunza Sugar Mill Unit located at Jhang. The fuel that will be used for power generation in the plant will be Bagasse which is a by-product of Hunza Sugar Mill.

4.5.1 The Fuel for Proposed Power Plant

The Fuel used for firing in the Boiler is the Bagasse generated from Sugar Mill. The Bagasse is the fibrous residue of cane stalk obtained after crushing and the extraction of juice. Each ton of sugarcane can yield 300 kg of bagasse. Considering 110-120 days of



crushing operation and over all capacity utilization of 90% the sugar plant, it will generate around 335500 MT of bagasse. It will convey from Hunza Sugar Mills through belt conveyors and excess fuel will be stored in closed storage yard.

4.5.2 Location of the Project

The proposed project site is located within the existing premises of Hunza Sugar Mill which is situated 8 Km off Layyah Road, Hazari Dargahi shah, Jhang District, Punjab Province, Pakistan. This proposed Power Plant will not only fulfill Factory energy requirements but also will enable the Hunza Sugar Mill to sell surplus energy to Grid.

4.5.3 Nearby Locations

East: Faisalabad

West: Layyah

North: Jhang

South: Multan

4.5.4 The proposed project area of land

Proposed project area is 35 acres out of 94 acres of factory area (Engineering Layout/Map with clearly marked proposed area is attached as Annex G.

Proposed Project area	Total Area
35 Acres	94 acres

4.5.5 Project Duration

The proposed project duration will be twenty (20) months from finalization of EPC Contractor.

4.5.5 Project Cost

The cost of the proposed project would be approximate USD 64 Million.

4.5.6 Man Power Requirement

Estimated Labour required for Proposed Project is as follows:

- Construction Phase: 600-700 workers
- Operational Phase: 60-70 workers



4.5.7 Water Requirement

Groundwater in the proposed project area is available at the depth of 10 ft. Raw Water requirements for the power plant will be met by installing 3 tube wells in the proposed plant by using the available groundwater sources. The raw water requirement for the co-generation plant will be 4200 m³/Day during Season and 6900 m³/Day during Off-Season.

4.5.8 Water Consumption

Estimated water consumption during the proposed project will be as follows;

- Construction Phase: 100-150 Cu.M/day
- Operational Phase: 4200 Cu.M/day (Season) and 6900 Cu.M /day (Off-Season)

4.5.9 Energy Requirements

The energy requirements during construction period of the proposed project will be 300Kw-400Kw and fulfilled through self-generation. Whereas during operational phase, the proposed power plant will provide energy for all remaining requirements.

4.5.10 Energy Consumption

Estimated energy consumption during the proposed project will be as follows:

- Construction Phase: 800-900 Units
- Operational Phase: The estimated power consumption during operational phase can be indicated as 4500 units during Season and 4250 units during Off-Season.

4.5.11 Process Description (Power Generation Process)

Conventionally, the sugar mills use low pressure boilers for generating power and process steam. The steam passes through turbine and generates required power for the sugar plant. The exhaust steam from the turbine is used in the processing of sugar. This process of utilization of steam for generating power and for processing of sugar is called cogeneration. The proposed project will install High Pressure Boilers and steam Turbines. Using the same quantity of bagasse, the proposed power plant will be able to generate additional power for export besides meeting the power and steam requirement of the sugar mill. The additional power will be fed to the National Grid system. The process of bagasse cogeneration is sketched out in Figure 4.1.

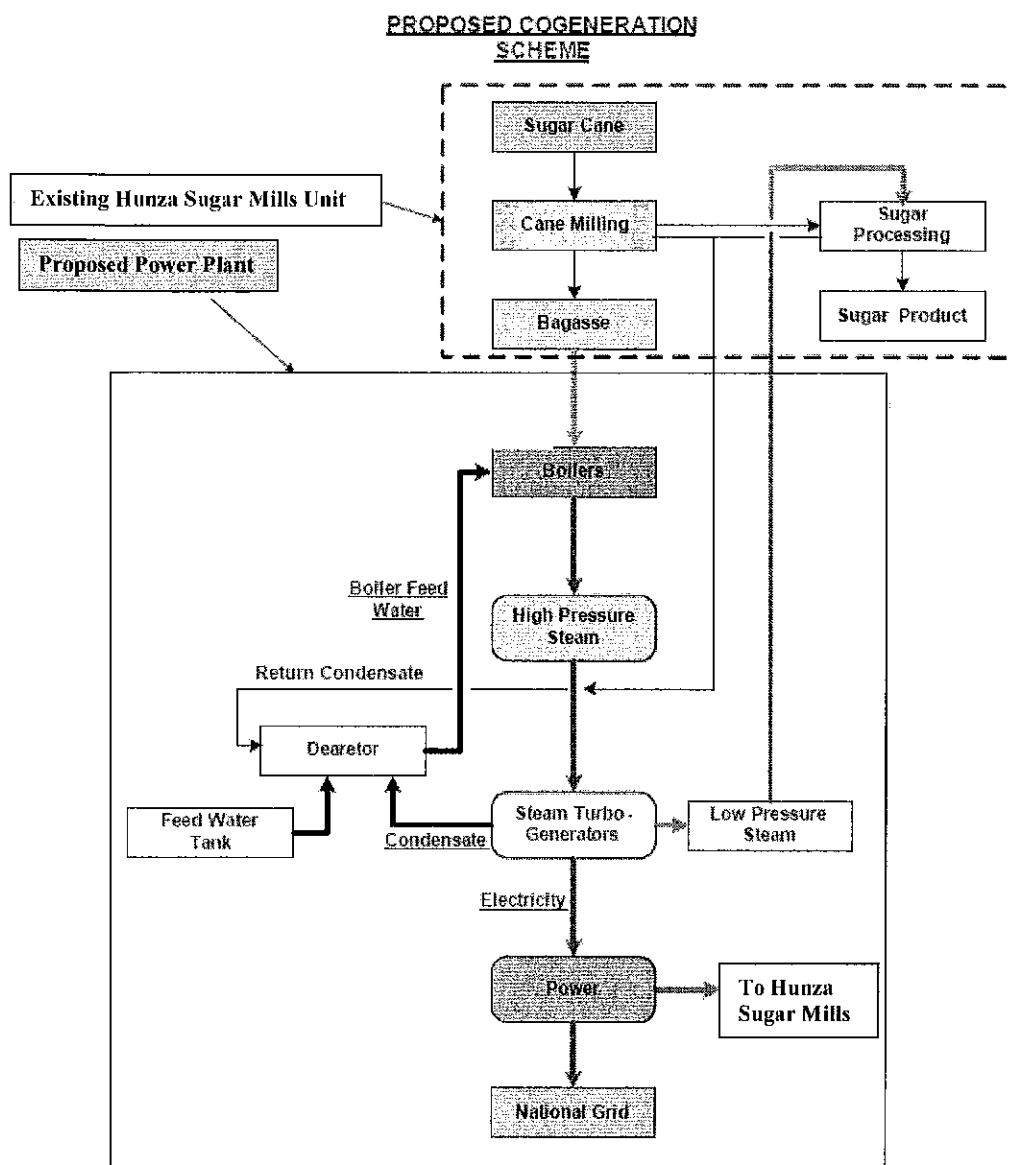


Figure 4.1 Overview of Bagasse Cogeneration

4.5.12 Equipment/Machinery Details and Specifications

Detailed specifications of Equipment/Machinery are given below;

- i. Turbo generator and Auxiliaries.
- ii. Fuel & grate bottom ash Handling system.
- iii. Cooling Tower
- iv. Water treatment plant and other associated systems
- v. Air compressor and dryer
- vi. Air conditioning & ventilation system
- vii. Centrifugal Pumps and Drives.
- viii. Dense Phase ash handling system
- ix. EOT crane
- x. Piping and appurtenances.
- xi. Electrical distribution (MCC, PCC, cables, lighting, Transformers, switchyard)
- xii. DCS and Balance of Plant (BOP) Instrumentation
- xiii. Steam generator & Auxiliaries

Chapter - 5

DESCRIPTION OF ENVIRONMENT

**Chapter - 5****DESCRIPTION OF ENVIRONMENT**

Data used to compile this section was obtained from two main sources: published literature and field survey. Published literature was reviewed to collect available environmental information about Jhang including climate, ecological, biological, socioeconomic, cultural conditions and land use. Field survey was also conducted to collect primary data for this study. A team consisting of an environmentalist, a sociologist and a biologist visited the project area.

In order to evaluate the current status of the area, the team studied ecological, biological, economic and cultural characteristics.

5.1 Physiography of Pakistan

Pakistan can be divided into five broad physiographical regions. These are the mountainous regions of the north, the western highlands and plateaus, the sub-mountainous Indus region, the Potwar Plateau, Salt Range, and the Indus Plain.

Brief descriptions of these regions are presented in Exhibit 5.1.

Exhibit 5.1: Physiographical Regions of Pakistan

Region	Characteristics	Location	Height
Northern Mountainous	Hindu Kush, Karakoram and Himalayan Mountain Ranges	Northern Part of KPK, Gilgit Agency, Northern Areas and Kashmir	Rises above 8,000-m
Western Highlands and Plateaus	Toba Kakar, Sulaiman, Central Baruhi, Saihan, Central Makran, Makran Coastal and Kirthar Ranges	Mainly in Baluchistan, also parts of Sindh and KPK	Between 1,200 to 3,000 m
Sub-Montane Indus	Alluvium filled Basins	Plains of Peshawar, Kohat and Bannu	Less than 1,000 m
Potwar Plateau and Salt Range	Flat to gently undulating surface, broken by gullies, accelerated erosion, "bad land" topography	Mainly northern parts of Punjab, some parts of KPK	Less than 1,000 m
Indus Plain	Flood plains of the Indus, Jhelum, Chenab, Ravi and Sutlej Rivers	Punjab and Sindh	Less than 1,000 m

5.2 Profile of Jhang

Jhang District is situated in the central Punjab and lies between 30.37 to 31.59 degree North latitudes and 71.37 to 73.13 degree East longitudes. The district Jhang is adjoined by Toba Tek Singh and Faisalabad to the East, Hafizabad to the North-East, Khanewal on the South, Sargodha on the North, Khushab, Bhakkar and Layyah on the West. District Jhang spreads over an area of 8809 square kilometers and comprises of following four tehsils:

Ahmed pur Sial

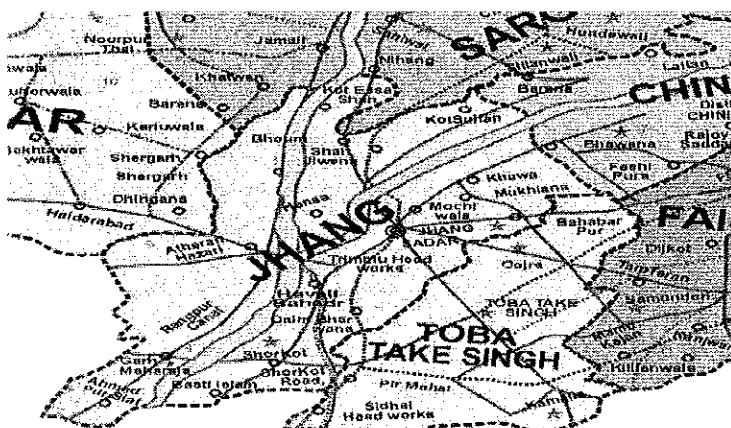
Chiniot

Jhang

Shorkot

Most of the land is plain cultivable, except the area near the bank of River Chenab where there is a series of Kirana Hills. In the Western part, a desert area called Thal extends from the banks of the Jehlum River to the far West in the districts of Khushab and Bhakkar, while the Sandal Bar area arises from the Pabbarwala area near the Gujranwala boundary. No cultivation was possible in this wild area in past. Later, the British Colonial Government established a canal system and the town of Lyallpur (now Faisalabad) on 975 acres of land, which is now the textile industry hub of Pakistan.

Between the Jehlum and Chenab rivers, a small area of kirana bar is also located in this district, which ends at the Ghoriwala village. The area alongside the banks of rivers Ravi, Chenab and Jehlum is called Hitthar (area in which flood water reaches), while the upland area between bars and hitthar is called Utar.



The map of Jhang District

5.3 Physical Environment of Jhang

Following sections will describe salient aspects of study area such as demographic, socio-economic and physical characteristics.

5.3.1 Location

It is located at 32°16'0N 74°40'0E with an altitude of 238 meters. The nearest big cities are Sialkot, Narowal and Gujranwal. It is situated on the east bank of the Chenab River, about 210 km (130 mi) from Lahore, about 70 km (43 mi) from Faisalabad, about 160 mi (257 km) from Multan, and about 35 km (22 mi) from Gojra.

5.3.2 Area

The Jhang District has an area of 8809 square kilometers and comprises of four tehsils: Ahmed pur Sial, Chiniot, Jhang, Shorkot.

5.3.3 Topography

Almost all the area is plain cultivable land except to the North are some rocks near Rabwah at the banks of the River Chenab which belong to the series of Kirana Hills which in nature are like the mountains of Aravalli series. In the western part, a desert area called Thal extends from the banks of the Jehlum River to the far west in the districts of Khushab and Bhakkar, while the Sandal Bar area arises from the Pabbarwala area near the Gujranwala boundary as the land abruptly arises from the land level almost at ten feet (3 m) height and almost gains 30 feet (9 m) height and this tract runs up till 87 km in the south and has a breadth of almost 30 to 40 km. This while area comprised forest in past and no kind of cultivation was possible for almost 100 years before the British colonial government established a canal system and the town of Lyallpur (now Faisalabad) on 975 acres (395 ha) of land, which is now the textile industry hub of Pakistan. Between the rivers Jehlum and Chenab a small area of kirana bar is also located in this district, which ends at the Ghoriwala village.

5.3.4 Geography

The district is spread over an area of 1.525 million acres and bordered by nine districts. Much of the area is plain and cultivated except some rocks near in the north Rabwah and Chenab Nagar at the bank of Chenab River which belongs to the series of Kirana Hills which in nature are like the mountains of Aravalli series.



5.3.5 Demography

Jhang Tehsil is a subdivision (Tehsil) of Jhang District in the Punjab province of Pakistan. It is subdivided into 55 Union Councils. The city of Jhang is the headquarters of the tehsil.

5.3.6 Soil

The surface of the district presents three distinct levels i.e. Sand Dunes of Thal on the extreme West, low lying river valley in the center and old Sandal Bar on the extreme East. The rivers of Jhelum and Chenab make their way through the district and Trimmu Head-works is the point of their confluence.

5.3.7 Water Sources

Ground water in the Municipal area is generally adequate. The depth of water table varies from 5 to 10 meters. According to District Environment Officer Jhang Consumers are reported that quality of drinking water supply is satisfactory. The water supply pipe network coverage in city Jhang is about 35% and which benefits 25% population. Out of 7 Tube wells five are functional.

5.3.8 Drainage Feature

Sewerage and drainage Services in Jhang are provided by the Tehsil Municipal Administration (TMA). The major problem of the town is the inadequate network of sewers, open drains and lack of facilities for disposal of effluent. The existing Sewerage System covers only 65% of the built area. The existing open drainage system covers about 95% of area.

At present there is no facility for treatment of the waste water. The wastewater pumped from disposal stations is utilized without any treatment by farmers for irrigation, presenting a potential health hazard. The excess wastewater from the disposal stations is pumped into the Agricultural lands.

5.3.9 Climate

The climate of the city is hot and dry in summer and cold in winter. The summer season is lengthy which begins in April and continues till October for about seven months. The hottest months are May, June and July. Maximum mean temperature during summer is 46 degree centigrade. Whereas it is 26 degree centigrade in winter. Mean temperature during summer and winter seasons are 41 degree centigrade and 21.9 degree centigrade respectively. Whereas the minimum mean temperature is

23degree centigrade and 2 degree centigrade during summer and winter seasons respectively.

Table 5.2: Mean Values over the 30 years

Month	Mean Temperature (°C)		Precipitation (millimeters)	Relative Humidity (%)
	Maximum	Minimum		
January	19.4	4.1	11.5	66.0
February	21.9	7.1	20.1	61.2
March	26.7	12.3	25.7	58.2
April	33.5	18.0	16.9	46.5
May	38.4	22.7	16.1	37.5
June	41.5	31.8	27.9	41.7
July	40.1	32.4	115.0	61.5
August	38.1	26.6	89.8	65.9
September	35.7	23.7	28.6	59.9
October	33.0	17.1	3.8	54.7
November	27.2	10.3	3.0	62.7
December	21.4	5.1	8.6	66.5
Annual (Average)	31.2	17.6	372.3	56.6

Source: Data Processing Centre, Pakistan Meteorological Department.

5.3.10 Rainfall

Precipitation is in the form of rainfall. Towards the end of June, monsoon conditions appear and during July- August and part of September, rainy season alternates with intervals of Sultry weather. Most of the rainfall falls during July-September. Some winter cyclonic rains are received during February and March. This pattern of rainfall will support xerophytic vegetation and all introduced flora shall largely depends upon year round irrigation. The precipitation of Jhang district is shown in the above table.

5.3.11 Humidity

Relative humidity in the project area is 59% on average and the detailed analysis of 30 years is shown in the above table.

5.3.12 Water Quality Analysis

The samples of drinking and wastewater were collected from different water resources of the project area. Samples were also collected from RO inlet and outlet. The results of quality of drinking and wastewater are given in Table 5.3 and 5.4 respectively. The results showing quality of RO inlet and outlet water are given in Table 5.5 and 5.6.

**Table 5.3: Summary of Parameters for Drinking Water Quality**

Sr No.	Parameters	Units	Results
1.	Appearance when analyzed	---	Clear
2.	Appearance when filtered	---	Clear
3.	Turbidity	NTU	7.0
4.	Total Suspended Solids	mg/L	10.0
5.	Smell	---	N.D
6.	Color	---	Colorless
7.	pH at 25°C	---	7.0
8.	Conductivity	μ s/cm	626.0
9.	Non Colloidal (Non-Reactive) Silica	---	N.D
10.	Calcium	mg/L	72.0
11.	Magnesium	mg/L	16.0
12.	Sodium	mg/L	70.0
13.	Potassium	mg/L	2.0
14.	Ammonium	---	N.D
15.	Barium	mg/L	0.03
16.	Copper	---	N.D
17.	Iron	mg/L	0.02
18.	Manganese	---	N.D
19.	Zinc	mg/L	0.04
20.	Strontium	---	N.D
21.	Chlorides	mg/L	22.0
22.	Fluorides	---	N.D
23.	Nitrates	---	N.D
24.	Nitrate Nitrogen	---	N.D
25.	Nitrites as NO ₂ ⁻	mg/L	2.3
26.	Phosphate As H ₂ PO ₄	mg/L	146.0



27.	Sulphate	---	N.D
28.	SulphideS	---	N.D
29.	Lime as CAO	mg/L	1.20
30.	Reactive Silica as SiO ₂	mg/L	5.91
31.	Total Volatile Solids	mg/L	53.0
32.	Total fixed Solids	mg/L	339.0
33.	Total Dissolved Solids	mg/L	392.0
34.	Total Hardness	mg/L	248.0
35.	Methyl Orange Alkalinity as CaCO ₃	mg/L	106.0
36.	Phenolphthalein Alkalinity as CaCO ₃	---	N.D
37.	BOD ₅ at 20°C	mg/L	<2.0
38.	COD	mg/L	<2.0
39.	Total Organic Carbon	mg/L	0.1
40.	Ammonical Nitrogen as N	---	N.D
41.	Albominoid Nitrogen as N	---	N.D
42.	Lead	---	N.D
43.	Cyanide	---	N.D
44.	Mercury	---	N.D
45.	Chromium	---	N.D
46.	Nickel	---	N.D
47.	Cadmium	---	N.D
48.	Arsenic	mg/L	0.02
49.	Sulphide as H ₂ S	---	N.D
50.	Free Carbon dioxide as CO ₂	mg/L	8.2
51.	NH ₃	---	N.D
52.	Total Bacterial Count	cfu/ml	28.0
53.	HCO ₃	mg/L	129.0
54.	CO ₃	---	N.D



According to above Table 5.3 all the parameters analyzed for drinking water were under compliance with NEQS.

Table 5.4: Summary of Parameters for Wastewater Quality

Sr. No.	Parameters	Units	National Standard	Concentration
1.	pH Value	....	6-9	7.04
2.	BOD ₅	mg/l	80.0	7
3.	COD	mg/l	150.0	16.0
4.	TSS	mg/l	200.0	34.0
5.	TDS	mg/l	3500.0	340.0
6.	Chloride	mg/l	1000	60.0
7.	Sulphate	mg/l	600	20.0
8.	Flouride	mg/l	10.0	BDL

According to above Table 5.4 all the parameters analyzed for waste water were under compliance with NEQS.

Table 5.5: Summary of Parameters for RO Inlet Water Quality

Sr. No.	Parameters	Units	National Standard	Concentration
1.	pH Value	....	6.5-8.5	7.12
2.	Chloride	mg/l	<250	44.0
3.	Turbidity	NTU	<5	2.75
4.	Sodium	mg/l	....	58.9
5.	Potassium	mg/l	....	4.0
6.	Total Dissolved Solids	mg/l	<1000	344.0
7.	Flouride	mg/l	1.5	0.18

Table 5.6: Summary of Parameters for RO Outlet Water Quality

Sr. No.	Parameters	Units	National Standard	Concentration
1.	pH Value	....	6.5-8.5	6.80
2.	Chloride	mg/l	<250	28.0
3.	Turbidity	NTU	<5	0.68
4.	Sodium	mg/l	....	27.9
5.	Potassium	mg/l	....	BDL
6.	Total Dissolved Solids	mg/l	<1000	190.0
7.	Flouride	mg/l	1.5	0.17

According to above Table 5.5 and 5.6 all the parameters analyzed for RO inlet and outlet water quality were under compliance with NEQS.

5.3.13 Ambient Air Quality

Monitoring Analysis

Ambient air quality of the proposed project areas was also monitored. Table 5.7 shows monitoring results of ambient air quality.

Table 5.7: Summary of Ambient Air Quality Analysis

Sr. No.	Sources	CO	SO ₂	NO ₂	PM ₁₀
	Units	ppm	µg/m ³	µg/m ³	µg/m ³
	NEQS	9	120	80	150
1.	Project Site (Near Officer Hostel)	BDL	2.6	56	48
2.	Mid of Site	BDL	BDL	45	36

The above Table 5.7 shows that all parameters monitored for ambient air quality were under compliance with NEQS.

5.3.14 Noise

Noise poses quite different problem. Unwanted sound becomes more pervasive and more intense in urban settings, where transport and industrial sources have particularly high nuisance values. Acute exposure to intense noise may temporarily impair hearing, while repeated occupational exposures to high levels can cause

permanent deafness. Increased noise levels are also associated with cardio-vascular, endocrine, respiratory, neurological and psychological changes, some of which are indicative of increased stress.

The maximum noise level for Fans, safety valves etc., in the co-generation plant shall be 85 dB(a) at a distance of 2 meters from the equipment. The noise levels recorded at the selected spots of the proposed areas were within the acceptable range as shown in Table 5.8.

Table 5.8: Results Analysis of Noise Monitoring

Sources	Noise Level <i>dB (A)</i>	NEQS
Project Site (Near Officer Hostel)	48.9	75dB
Mid of Site	51.6	

5.4 Biological Environment of the City

A survey of the local biological environment was conducted which includes the study of flora and fauna of the project area. Preservation of biodiversity is of global concern, but the causes of loss and their solutions are very often local in scale. The detail flora fauna study contains the discourse of Flora and Fauna of project site and the surroundings as part of the requirement of the Initial Environment Examination study.

5.4.1 General Ecology

Ecological data is necessary to identify and assess the main effects, which that development is likely to have on the environment. A description of the likely significant effects, direct and indirect, on the environment of the development, explained by reference to its possible impact on the following:

- Flora & fauna;
- Soil;
- Water & air;
- Climate;
- The landscape;
- Material assets;
- Human beings, cultural heritage, social cohesion;
- The interaction between any of the foregoing.

The detail flora fauna study contains the discourse of Flora and Fauna as part of the requirement of the Environmental Impact Assessment study. The number of plant and animal species and numbers of plants and animals seen in each species were inventoried in order to obtain an estimate of frequency and relative abundance of each species.

5.4.2 Flora and Fauna

Trees of jand (*Prosopis spicigera*), karir (*Capparis aphylla*), beri (*Zizyphus jujuba*), van (*Salvadora oleoides*), kicar (*Acacia nilotica*), shisham (*Dalbergia sissoo*) and aak (*Calotropis spp*) are found within the district. Trees of jand, kreer, van, kicar, tahli, bohar are spread everywhere where there is no cultivation, while herbs of harmal, akrey, bathoo, etc are also found.

Birds

1. Sparrow
2. Crows
3. Dove
4. Pigeons
5. Quails
6. Parrots
7. Little green bee eater

Reptiles

1. Snakes
2. Lizards

Amphibians

1. Frogs

Insects

1. Black ants
2. Dragon fly
3. Butter flies
4. Honey Bees

5.5 Socio-economic Environment (Quality of Life Values)

5.5.1 General

This section provides an overview of the socioeconomic conditions and cultural mores in the project area. Socio economic conditions of the area depend upon the



population, employment level, trade and businesses, customs, religion, social activities, occasions, and their social cohesion.

It is to notify that people living in the vicinity mostly belong to a middle class. It was observed that mostly people live in independent family systems, among these families, few like to live in joint family system as the load is distributed among the different earning members of the family. Similarly families who are living in joint family system are of the view that joint family system can create misunderstandings among families and limit the opportunities for progress.

Most of the inhabitants have their own houses and very few of them were living on rent. It was observed through interviews that most of the people have that diseases are more common in rainy season or they are seen more often with the seasonal variations.

5.5.1.1 Population

The Jhang has population growth rate of 2.41 % as per 1998 Population Census, which is quiet similar to the provincial average. The population of Town was 293,366 individuals in 1998, and is currently estimated at 419,320 individuals. Given the population growth rate and using 1998 as the base year for arithmetic growth method estimation, the population of town is likely to increase to 659,250 individuals in 20 years from now (year 2033).

Town's Population Projection

YEAR	1998	2013	2018	2023	2028	2033
POPULATION	293,366	419,320	472,343	532,070	599,350	659,250

5.5.1.2 Ethnic Group and Religion

Major tribes of the district are sials, syeds, awans, shikhs, sipras, balouch, nauls, lalis, bhattis, harrals etc. Jhang is predominantly Sunni Muslim with a significant Shia population. There is a sizable Christian minority also. Among the majority Sunnis, Barelvi school of thought has a major influence. Dr. Tahir-ul-Qadri is a prominent religious scholar and politician representing this Sunny Barelvi influence. Maulana Haq Nawaz Jhangvi was another prominent and disputed leader from Jhang who created Anjuman-e-Spahe-e-Sohaba a deobandi, now a banned organization by the United Nations. Jhang has been the center of the greater chess board of centuries old dispute between Sunnis and Shias for over two decades.

5.5.1.3 Languages

Most of the people speak Jhangochi which is the oldest and pure dialect of Punjabi. Other than that urdu and Punjabi is also used as a language.

5.5.1.4 Dress

The men wear turbans and dhotis (like a kilt) though in recent years people have started wearing the national dress which is shalwar kameez. The old women still wear dhotis (skirts) but the younger women wear shalwar kameez.

5.5.1.5 Employment

Major economic activity in the area is working for different industries, trade, agriculture and cultivation. A few numbers of people also work in the nearby cities.

5.5.1.6 Education

There are 3318 Public schools in District Jhang. Out of which, 2,824 are Primary schools, 279 middle Schools, 171 are High schools and 44 are Higher. Sec/ Inter Colleges/ Degree Colleges /Technical & Vocational Institutions/Deeni Madaris. Jhang is a fast developing area of Punjab Province. The literacy rate of the Jhang District is about 60%. Some of the educational institutions are listed below:

- Chenab College Jhang
- Faran Model School Jhang
- Faran Model College Jhang
- Govt. higher Secondary School Mari Shah Sakhira
- Lahore College for Women University
- Ali Informatics Computer College Jhang
- Quaid-e-Azam Model School, Ahmad Pur Sial, Distt. Jhang
- Ghazali Pilot Schools Jhang
- Rachna College of Commerce, Jhang.
- Sacred Heart High School
- St. Martin's School (Christian Colony, Jhang)

There is only one Government school near the project site and this is due to the lack of residential areas near the project area.

5.5.1.7 Health Facilities

Medical facilities are present in the district Jhang District. JHANG has one district, two tehsil headquarters hospitals, 15 rural health centres (RHCs) and 94 basic health units (BHUs) for its population of over three million.



The DHQ hospital is in Jhang while Shorkot and Chiniot each have a THQ hospital. The RHCs are in Garh Maharaja, Ahmadpur Sial, Roda Sultan, Kot Shakir, Bagh, Mochiwala, Bhowana, Ahmadnagar, Lalian, Barana, Shah Jewna, Haveli Sheikh Raju, Chak 14, Mukhiana and Haveli Bahadur Shah.

5.5.1.8 Crop and fruits:

The major crops of this district are Wheat, Cotton, Rice, Sugar Cane, Maize and Grams. The main fruits are Mango, Orange and Lemon.

5.5.1.9 Roads and transport in Jhang:

There are five major roads in Jhang city namely Faisalabad Road, Gojra Road, Toba Tek Singh Road, Bhakkar Road and Sargodha Road. These roads have wide right of ways ranging between 75-110 feet. Even though a lot of problems are being faced in the smooth flow of traffic.

There is no Signal on any Chowk and no urban bus or van services are available. On all roads mostly motorcycle rickshaws, auto rickshaws are being used as urban transport services. The effective capacity of the most road share reduced by poor traffic management, compounded by a lack of discipline and poor compliance with traffic regulations on the part of drivers, and the mix of motorized and non-motorized traffic on all roads in the city. The resulting traffic congestion, together with a large number of vehicles producing high levels of exhaust emission, has serious environmental implications.

5.5.1.10 Sites of Archaeological Significance

The site having archeological significance includes:

The heroine of the famous love story, Heer Ranjha, Heer's tomb lies just north of Jhang on the way to Faisalabad. An annual fair is held at her tomb. A comprehensive account of her story is told by Waris Shah in his book. And after this Waris Shah admit that it was a fantasy and nothing more. Other than that there are many shrines of popular personalities.

5.6 Stake holder Consultation

5.6.1 General

Social Impact Assessment (SIA) mainly involves the processes of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions. These assessments



can enable the project implementing authorities to not only identify social and environmental impacts, but also to put in place suitable institutional, organizational and project-specific mechanisms to mitigate the adverse effects. They can also aid in bringing about greater social inclusion and participation in the design and implementation stages of the project. The main types of social impacts that occur as a result of the project related changes can be grouped into five overlapping categories:

Lifestyle impacts – on the way people behave and relate to family, friends and cohorts on a day-to-day basis

Cultural impacts – on shared customs, obligations, values, language, religious belief and other elements which make a social or ethnic group distinct

Community impacts – on infrastructure, services, voluntary organizations, activity networks and cohesion

Quality of life impacts – on sense of place, aesthetics and heritage, perception of belonging, security and livability, and aspirations for the future

Health impacts – on mental, physical and social wellbeing, although these aspects are also the subject of health impact assessment.

5.6.2 Objectives

Identify all potential significant adverse environmental and social impacts of the project and recommend measures for mitigation;

Verify compliance with the environmental regulations and relevant standards;

Identify problems (non-conformity) and recommend measures to improve the environmental management system;

Generate baseline data that will be used to monitor and evaluate the mitigation measures implemented during the project cycle.

Identify and quantify different categories of project affected people (PAPs) who would require some form of assistance, compensation, rehabilitation or relocation.

Provide guidelines to stakeholders participating in the mitigation of adverse social impacts of the project.

5.6.3 Stakeholder Consultation

Stakeholder's consultancy refers to a process through which the public/stakeholders can influence decisions and share control over development proposals which may affect them. In a participation exercise, the shared analysis, agenda setting and



decision making are normally reached through consensus on the main issues between the public and the proponent.

The Environment Protection Act 1997 makes the participation of the local communities mandatory in the planning and design of a development project. United Nations Conference on Environment and Development (UNCED) in 1992 endorsed the process of stakeholders' participation and consultation as one of the key documents of the Conference-Agenda 21. It is obligatory not only to satisfy the legal requirements of the IEE process in Pakistan but also to improve and enhance the social and environmental design of the Project.

5.6.4 Specific objectives of Stakeholder Consultation

The aims and objectives of public involvement and consultation of this project include:

- To provide information related to proposed Project activities to stakeholders.
- Allowing the public to express their views on the scope and content of an IEE (and the proposed development action).
- Obtaining local and traditional knowledge (corrective and creative) before decision-making.
- To seek for the participation of all interested parties and to identify stakeholders' interests and issues.
- Ensuring that important impacts are not overlooked.
- Reducing conflict through the early identification of contentious issues.
- Influencing project design in a positive manner (thereby creating a sense of ownership of the proposal).

5.6.5 Methodology

The methodology adopted for the purpose of socio-economic and health assessment was based on general observation, interviews, questionnaires and recording of various parameters for the baseline information. Stakeholders were selected randomly for this process. Secondary data includes mode of transportation, education level and facilities, health facilities, water and sanitation facilities etc. Views of the people about the proposed project were collected by interviewing them using a semi structured questionnaire.

5.6.6 Classification of Stakeholders

One of the most common divisions is between primary and secondary stakeholders. The former consists of those whose interests can be affected directly by a decision on a proposed initiative (examples are local communities living in the Project Area). Secondary stakeholders consist of those who are not directly affected but may be indirectly affected and/or have an ability to influence the decision (examples might be international conservation NGOs or local/national media). Another classification divides stakeholders into internal and external groups. The former are those who are involved in the decision-making and the latter are those having interests that may be directly or indirectly affected.

5.6.7 Analysis

This section provides an overview of the socioeconomic conditions and cultural habits in the project area. Socio economic conditions of the area depend upon the population, employment level, trade and businesses, customs, religion, social activities, occasions, and their social cohesion.

5.6.7.1 Education

The residents living near the project site are not very educated. The literacy rate is very low particularly in women. According to the data collected with the help of a questionnaire, education level of the people living there was as follows:

Some of the population (30%) was illiterate, while percentages of the people having education of primary, middle and matric levels were 30%, 2% and 3% respectively.

At the same time, a good number of people with education above matriculation was also found such as 5% people were intermediate and 30% were graduate.

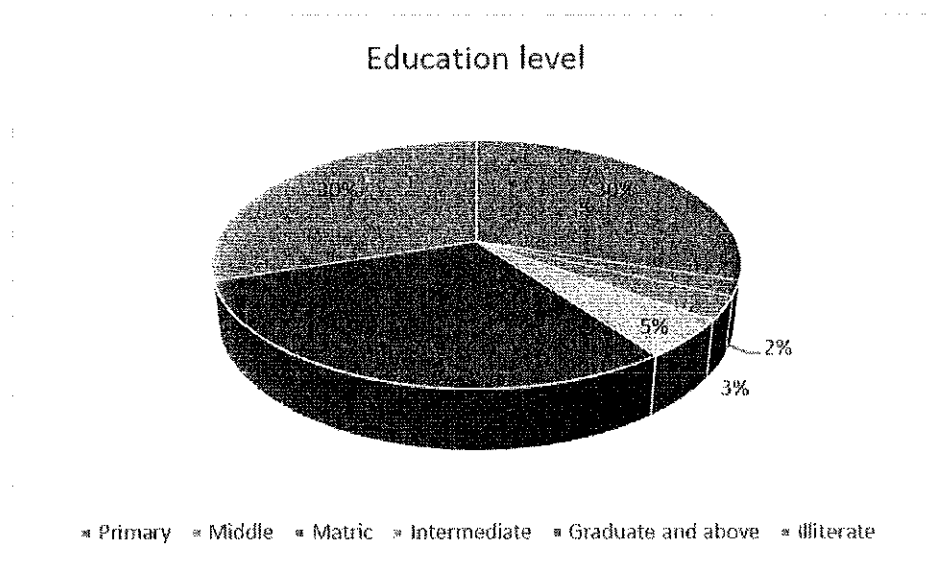


Figure 5.1: Graph shows the percentage of educated and illiterate people

5.6.7.2 Occupation

Mostly people there are working for different industries, departments, agriculture and cultivation. Many of them have their own shops and small scale business. Majority of the people are labors, drivers, shop keepers, contractors. The percentages of stakeholders are displayed in the following graph:

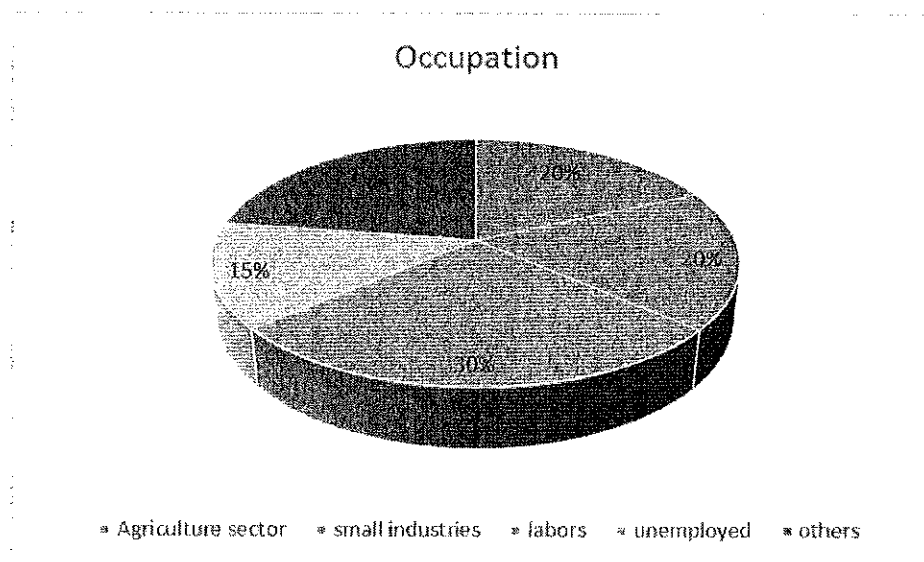


Figure 5.2: Graph showing percentage of occupations

5.6.7.3 Health Facilities

No major health facility exists in the premises of the project site. But there is a hospital after 7Km (District Head Quarter Hospital).

5.6.7.4 NGOs

No NGO was found in the vicinity of the project site.

5.6.7.5 Age

Age of the stakeholders was also recorded. The people interviewed for the socioeconomic assessment belongs to different age groups of which 20% belongs to the age group of 56 and above, 40% belongs to 46-55 years, 30% belongs to 36-45 years and 10% belongs to 20-35 years.

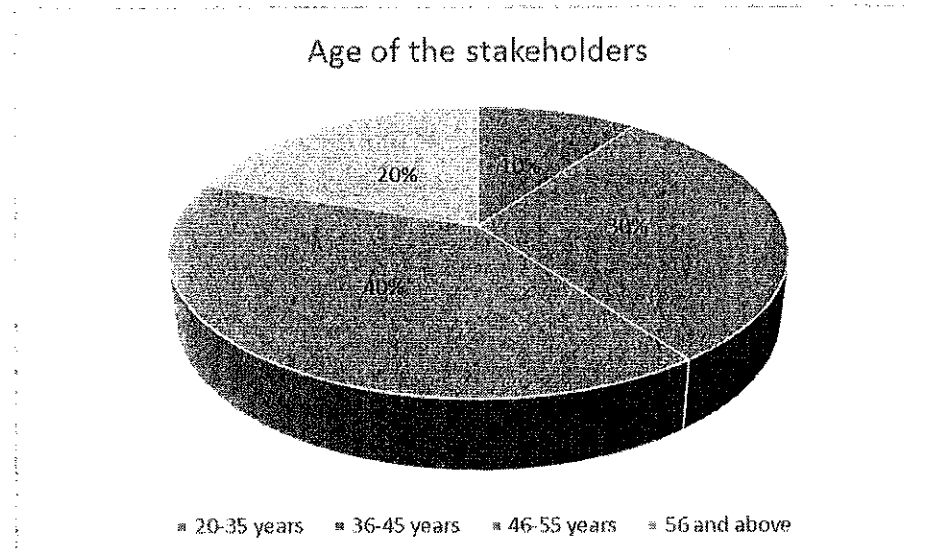


Figure 5.3: Graph showing the percentage of ages

5.6.7.6 Income

It is to notify that people living in the vicinity mostly belong to middle class. 20% of the people have income 31,000 and above, 50% have monthly income ranges from 21,000-30,000 and 30% have the income ranges from 10,000 to 20,000 PKR.

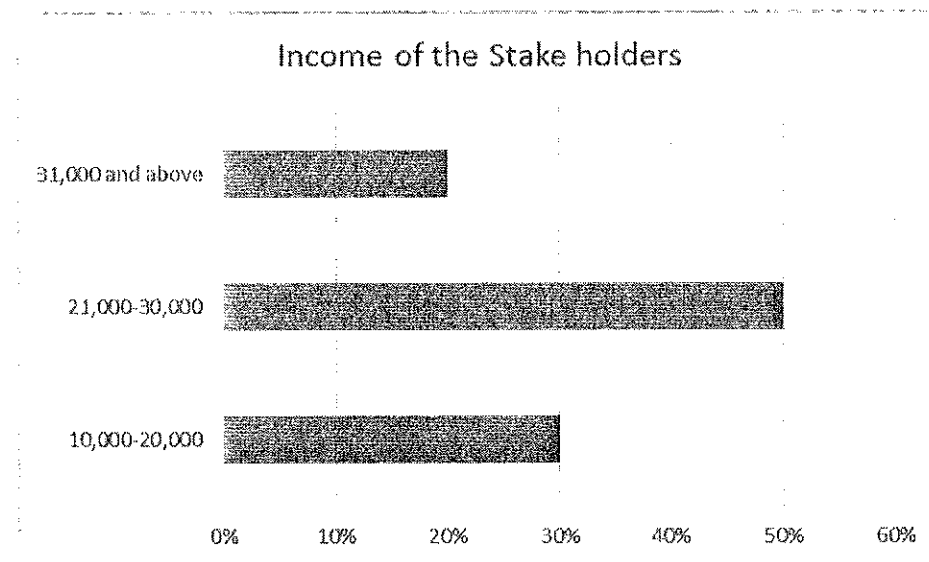


Figure 5.4: Graph showing the percentages of income

5.6.7.7 House Structure

It was observed that mostly people live in independent family systems, among these families, few like to live in joint family system as the load is distributed among the different earning members of the family. Most of the inhabitants have their own houses and very few of them were living on rent. Lower middle class residents mostly have semi-pecca houses with no water access.

5.6.7.8 Project Response

The majority people of the nearby communities are strongly in favor of the proposed project. They have the perspective of healthy future which will bring prosperity to their young ones. They also gave comments that the proposed project will pave the path of development. On the other hand, 2% of people seemed not satisfied with the project. As they said that these project will bring disturbance to them. They were afraid that these tasks will never be done hence will create a lot of pollution and waste water. They said, if mitigation measures would be provided and monitored then they would have no objection.

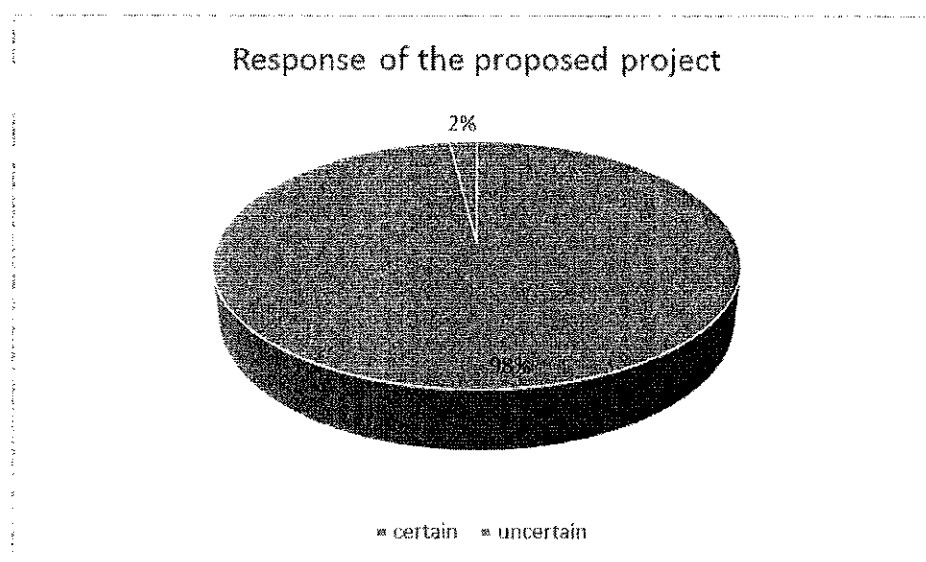


Figure 5.5: Graph showing the percentage of people against and in favor of the proposed project

So we can conclude that if proposed project is not harming the natural and green environment, then proposed project is environment friendly and without any hesitation and deterioration under risk we can commence the project. This will enhance the development of the people and will get desirable results.

PICTORIAL REPRESENTATION OF THE SOCIAL SURVEY



Consultation with the labor outside
sugar mill



Consultation with local labors of the
area



Consultation with the workers of
Hunza sugar Mill



Consultation with local labors of the
area



Consultation with the workers
working in the mill



Consultation with the local residents
of the project area



Consultation with the residents near
the project site



Consultation with the labor working
in nearby areas



Consultation with the labors of mill



Consultation with the local labors
near the sugar mill



Consultation with the workers of the
nearby area



Consultation with the workers of
sugar mill



Consultation with the local residents



Consultation with the people who have residence near the project site



Consultation with a local worker



Consultation with the labor working in the sugar mill.



Consultation with the workers of nearby areas.



Consultation with the local resident of the area.

Chapter - 6

IMPACTS & MITIGATION

Chapter - 6

IMPACTS & MITIGATION

The potential impacts of the proposed project on the area's geomorphology, surface and groundwater resources, air quality, biological resources, and socio-cultural environment have been discussed in the following sections. Where appropriate, mitigation measures have also been included to reduce the unacceptable impacts.

The proposed project of IEE is not only to address and analyze the expected environmental impacts of a project, but also to enhance project benefits, and to introduce standards of good practice to be adopted for all project works. The primary objectives are to:

- Facilitate the implementation of the mitigation measures required by EPA.
- Define the responsibilities of the project proponent and contractor and provide a means of effective communication of environmental issues between them.
- Identify monitoring parameters in order to ensure the effectiveness of the mitigation measures.
- Provide a mechanism for taking timely action in the face of unanticipated environmental situations.
- Identify training requirements at various levels

6.1 Project Location

The proposed project site is located at 8 Km Layyah Road, Hazari Dargai shah, Jhang District, Punjab Province, Pakistan.

6.2 Key Environmental Concerns

The proposed project will be accomplished in two main phases; Construction/Installation and Operation. Environmental concerns associated with such activities are as follows:

- Physical Environment
- Biological Environment
- Socioeconomic Environment

6.2.1 Physical Environment

- Water Resources
- Effluent/Wastewater Disposal
- Dust



- Air Quality
- Gaseous Emissions
- Soil Erosion
- Soil Contamination
- Noise Level
- Solid Waste

Impacts during Construction Phase

Water Resources

The water is available from following sources:

- Rain water for agriculture and surface storage.
- Surface water i.e. ponds and canals and
- Ground water i.e. wells and tube wells

Surface and aquifer quality may deteriorate if pollutants are mixed with surface runoff during rain and carried to water resources in the vicinity, or if pollutants leach into the ground.

Mitigation Measures

To avoid any undesirable impact on the water resources in the area following mitigation measures are recommended.

- Adopt a general strategy to avoid contamination of ground water from construction activities. The strategy may comprise of the following:
 - Minimized and controlled discharge of effluent.
 - Best effort/measures to be placed against accidental discharge.
 - Regular and scheduled monitoring to ensure that no contamination of water has taken place.
- Reverse Osmosis (RO) Plant is already installed near the proposed project site.

Wastewater

Wastewater would be generated from construction activities (work with cement and masonry). However their quantity is insignificant, and poses just minor impacts on the environment.

Mitigation Measures

- A simplified sedimentation tank shall be built on the construction site, through which, the wastewater may be collected and settled, and then be used for site



sprinkling to reduce fugitive dust. If necessary, pH adjustment should be undertaken to neutralize the wastewater;

- Sanitary wastewater will be treated as per waste management plan.
- No hazardous untreated effluents should be released to the environment
- Wastewater sampling should be conducted on monthly basis by 3rd party.

Dust

The emissions of dust and particulate matter can be significant depending upon the nature of activity taking place i.e. civil work etc.

Mitigation Measures

- Train workers to handle construction materials and debris during construction to reduce fugitive emissions.
- Keep soil moist while loading into dump trucks.
- Minimize drop heights when loaders dump soil into trucks.
- Cover dump trucks before traveling on public roads.
- Raw materials loading and unloading should be done in the covered area.
- Raw materials should be stored in a covered structure.
- Prevent the generation of dust in preference to applying dust suppression measures such as promptly watering exposed areas when visible dust is observed.

Air Quality

The potential sources of air pollution on construction site are exhaust gases from vehicles and machinery.

Mitigation Measures

- The machinery and vehicles to be used should be properly tuned and maintained
- Monitoring of the emission sources should be regularly monitored by 3rd party.

Gaseous Emissions

Exhaust gases would be mainly produced from the vehicles and the generators which produce NO_x and SO_x.

Mitigation Measures

- Pollution control equipment should be installed to control emissions.
- Generators and vehicles should be properly maintained



- Monitoring of gaseous emissions should be carried out regularly by 3rd party to ensure compliance with the NEQS

Soil Erosion

Soil erosion may occur in the workshop areas as a result of improper runoff drawn from the equipment washing-yards and improper management of construction activities.

Mitigation Measures

- Good engineering practices will help to control soil erosion both at the construction sites and in peripheral areas
- Controlled and well managed vehicular movement, excavation, vegetation and regular water sprinkling will reduce the chances of soil erosion.

Soil Contamination

Lands may get contaminated from the spillage of chemicals like fuels, solvents, oils, paints and other construction chemicals and concrete. This normally happens when these materials are transported in open or loosely capped containers. Unmanaged sewage can also contribute to contamination of soil. The possible contamination of soil by oils and chemicals at camp sites, workshop areas, and equipment washing-yards may limit the future use of land for vegetation purposes.

Mitigation Measures

To ensure that fuels and chemicals, raw sewage and wastewater effluent are disposed off in a controlled manner to reduce the risk of contamination.

- Control measures will be needed for oily residues such as lubricants in the case of accidental or unexpected release.
- Good housekeeping techniques should be used to control oil spillage.

Noise

Noise mainly results from the work of equipment and traffic movement as well.

Mitigation Measures

- Noise level from construction activity can be reduced by regular maintenance of machinery.
- Equipment should be regularly serviced.
- Ensure that the workers are wearing PPE's (ear plugs, ear muffs etc.) where engineering control is not applicable to reduce the impact of noise



- Schedule different noisy activities to occur at the same time as less frequent noise activities would be less annoying.

Solid Waste

Solid waste is generated during civil work. Solid inert waste found on construction site usually consists of building rubble, but may also include as demolition material, concrete, bricks, timber, plastic, glass and metals .

Mitigation Measures

The solid waste produced will be properly disposed off through available means such as wastes will be reused, recycled, or may be sold to the vendor.

Litter

On construction site, there are two main sources of litter, building material washed away during a storm and deposited into waterways, and rubbish thrown away by construction workers.

Mitigation Measures

- Maintain a high quality of housekeeping and ensure that materials are not left where they can be washed or blown away to become litter.
- Provide bins for construction workers and staff at locations where they consume food.

6.2.2 Biological Environment

Biological resources include flora and fauna. No such endemic species are reported at the proposed project site.

Mitigation measures

- No endangered species are reported to exist within the study area. All the necessary precautions will be taken to ensure the minimum disturbance to the local flora and fauna.
- Strict instructions given to all personnel working in project area to refrain from killing, capturing or disturbing any species of bird, reptile or mammal encountered during project activities, except in self-defense.
- No removal of vegetation will be done at the project site.
- Appropriate mitigation measures will be introduced to minimize contamination of soil and ground water.



6.2.3 Socio-Economic Impacts

- Displacement: No displacement of population is envisaged.
- Employment: Employment opportunities generated by the project include construction labor at the site in the initial stages of setting up of the proposed facility, skilled and unskilled labor. Reliance on local markets for provision of construction materials and other supplies will be a significant effect. Thus good amount of employment opportunities will be generated.
- Traffic and Transportation: Vehicle movement shall not result in significant increase in traffic density. The roads are already frequently used. The traffic management however is done according to the requirements.
- Noise: Extra measures should be taken into consideration so that the noise from the construction and operational activities shall not exert any adverse impact on the community.

Mitigation Measures

Following mitigations are recommended for the anticipated social impacts:

- The civil work will be undertaken as such that negligible noise will be induced.
- Employment opportunities will preferably be provided to the locals in case of new requirement, if any.

Impacts during Operation Phase

Water Resources

Proposed activities could affect the area's water resources in two ways by overuse and contamination. Water will be required during operational activities. Water will be exploited from groundwater aquifer through deep bore wells.

Mitigation Measures

- Water conservation practices should be utilized to reduce the water consumption.
- Good housekeeping practices should be followed to protect water resources

Wastewater

- Water pollution is caused by run-off from bagasse piles.
- During operational phase wastewater would also be generated from boiler and cooling tower blow down (blow down is required to maintain air quality).

Mitigation Measures

- Impervious base with channels leading to a collection pond should be made from which the polluted water can be passed to effluent treatment if necessary. The pond provides a convenient source of water for fire-fighting.
- Wastewater will be treated before discharging into nearby drain canal. Monitoring of effluents should be carried out as per requirement of SMART to ensure compliance with the NEQS.
- Sanitary wastewater will be treated as per waste management plan.
- Boiler blow down can be reused as make up water for cooling tower.
- Cooling tower blow down can be recycled after treatment and used as makeup water to the same cooling tower.
- No hazardous untreated effluents should be released to the environment
- Wastewater sampling should be conducted on monthly basis by 3rd party.

Dust

Possibility of generation of bagasse dust occurs during handling, conveying and storage.

Mitigation Measures

- Adequate measures, as practiced internationally, should be adopted to eliminate the possibility of generation of bagasse dust during handling, conveying and storage.

GHG Emissions

Greenhouse gases are released as a result of combustion process. The increase in greenhouse gas emissions in the atmosphere would be due to human activities such as combustion and land use change contributes to the global warming.

Mitigation Measures

There are no generally accepted methods for the mitigation of CO₂ emissions. However, one possible mitigation strategy should be given consideration. This includes carbon sequestration by planting trees. As the plant site is in the area with an average rainfall of 372.3 mm on the basis of last 10 years data, carbon sequestration by planting indigenous trees near the plant site could be viable remedial measure.

Stack Emissions

- Flue gas and smoke emissions from boiler.



Mitigation Measures

- Pollution Control Technology should be installed to mitigate flue gases and smoke from boiler.
- Monitoring should be carried out by 3rd party on regular basis.

Ash

Both Fly and bottom ash contain traces of heavy metals that may contaminate the soil and water.

Mitigation Measures

- Fly ash can be used as an adsorbent for the removal of copper and zinc from wastewater.
- Ash can be disposed off in variety of methods like: In cement as aggregate, in manufacturing of tiles for face lifting of buildings and for flooring of paths etc.
- Personal protective equipments must be used to avoid the inhalation of dust

Soil Pollution

Ash may deposit on the soil and alter its conditions.

Mitigation Measures

- Power plant needs to be operated under strict environmental control, failing which there could be loss to the soil quality leading to drastic cut in the productivity of the soils.
- Soil testing should be carried by 3rd party on monthly basis

Hazardous Materials

The operations of power plant will require use of process chemicals for water treatment, lubrications and corrosion control etc. Some of these chemicals may be of hazardous nature. These chemicals may have a potential to harm human health and contaminate soil, surface and groundwater if not handled correctly.

Mitigation Measures

- A chemical and hazardous material handling procedure should be prepared in accordance with international standards.
- Storage areas for fuels and liquid chemicals should be designed with secondary containment to prevent spills and contamination of soil and groundwater.



- Labeling should be placed on all storage vessels/containers as appropriate to national and international standards. The labeling should clearly identify the stored materials.
- Supporting information such as material safety data sheets (MSDS) should be available for all hazardous materials.
- Hazardous materials such as used oil filters, batteries, chemical containers, grease traps etc. should be hauled away by contractor for recycling.

Solid Waste

Spoil waste may pose health hazards if not properly managed

Mitigation Measures

- All solid wastes should be disposed off according to a set procedure and record of sales should be kept to track at any time when it is required.
- The contractors to whom any waste is to be sold should be fully made aware of the environmental impacts and health effects of the waste to be sold.
- Training should be provided to personnel for identification, segregation, and management of waste.
- Separate waste bins should be placed for different type of wastes -plastic, paper, metal, glass etc.
- Recyclable material should be separated at source and hauled away by contractor for recycling,
- Non-hazardous non-recyclable wastes should be properly disposed off.

6.3 Project's Intended and Likely Benefits

The proposed project of Hunza Power (Pvt) Ltd is intended to bring forth qualitative as well as quantitative benefits. The majority of the qualitative benefits are those that will be realized as a result of accomplishment of the project and would continue throughout the lifespan of the project. Some of the significant benefits likely to accrue from the project can, however be enumerated as under:

- The project indicators depict a positive cost to benefit ratio (CBR) showing that the project is feasible and is likely to bring forth economical and socio-economic benefits in its wake.
- The economic analysis of the project reveals an encouraging Expected Internal Rate of Return (EIRR).
- There will be an impetus to production and business.



- The project is likely to create job opportunities in various categories during operational phase.

Table - 6.1: Checklist of Potential Impacts for Construction Phase

Environmental Aspects (Construction Phase)		Impact Categorization								
		Mild			Moderate			Severe		
		*	**	***	*	**	***	*	**	***
1. Land Resources										
1.1	Site for disposal of waste generation and disposal of waste material	✓								
1.2	Waste disposal Management				✓					
1.3	Location of labor camps, material camps, equipment yards and approach roads		✓							
1.4	Access tracks	✓								
1.5	Contamination from diesel and other spills from construction machinery	✓								
1.6	Drainages paths roads crossed. Damages by moving machinery	✓								
1.7	Agriculture land and crop Damage	✓								
1.8	Any discharge or diversion of water to a graveyard or archaeological site	✓								
1.9	Electrical and mechanical works	✓								
2. Hydrology and Water Resources										
2.1	Impact on source of construction water	✓								
2.2	Contamination of surface water due to diesel and other fluids		✓							
2.3	Protection of construction work from floods	✓								
3. Air Quality and Noise Pollution										
3.1	Dust and smoke and other pollutants		✓							
3.2	Dust or other pollutant from stored materials and spoil heaps		✓							
3.3	Smoke from burning of waste materials or burning fire wood	✓								
3.4	Noise control from use of old or outdated machinery				✓					
4. Biological Resource										



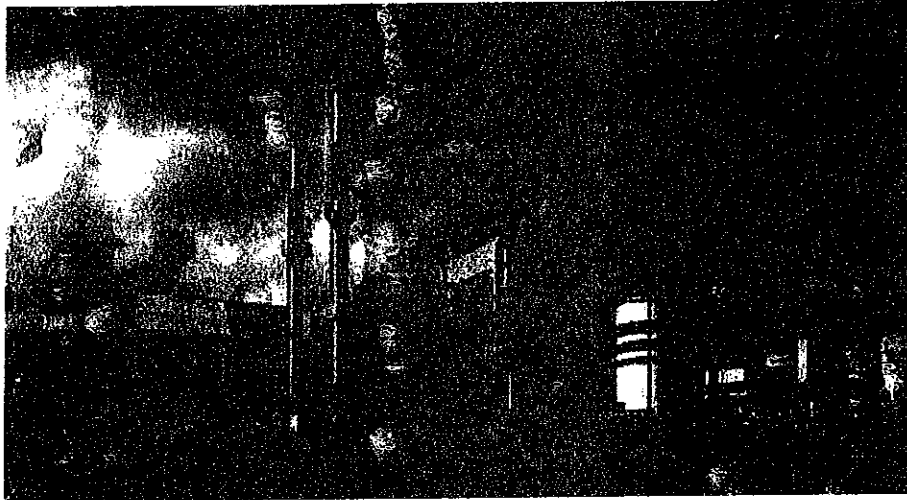
Environmental Aspects (Construction Phase)		Impact Categorization								
		Mild			Moderate			Severe		
		*	**	***	*	**	***	*	**	***
4.1	Damage to biological resource flora, fauna, biota	✓								
4.2	Impact of construction on aquatic life	✓								
5. Socioeconomic and Cultural Issues										
5.1	Existing services; education health, electricity, and water supply	✓								
5.2	Tribal tensions and local rivalries on canals and aquatic life	✓								
5.3	Land ownership and land acquisition	✓								
5.4	Access to other construction materials		✓							
5.5	Effects on sites of archeological, historical, cultural or religious significance	✓								
5.6	Public safety at construction sites	✓								
5.7	Health and safety of labor and employees on construction site	✓								
5.8	Employment	✓								
5.9	HIV/AIDS and other communicable diseases.		✓							
5.10	Aesthetic / scenic value	✓								
<p>Key:</p> <p>*Avoidable through design (Preventive)</p> <p>**Mitigation through contractor's obligation</p> <p>***Non-reversible permanent change.</p>										



INTERCONNECTION STUDY

For

49.8 MW CO-GENERATION POWER PROJECT BY HUNZA POWER PRIVATE LIMITED



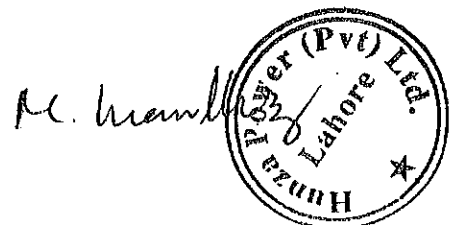
*Draft Report
(September 2016)*

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Executive Summary

- ❖ The Draft Report of 49.8 MW Hunza Power Private Limited, referred to as Hunza PP, is submitted herewith. The installed capacity of the plant would comprise of two unit of 25 MW which would deliver maximum net power of 44.8 MW to the grid.
- ❖ It would like to go for high pressure cogeneration in the sugar mill with the aim of exporting power nearly 34.8 MW to the national grid during the crushing season, from November to March. During the Non-crushing season Hunza PP will supply 44.8 MW power to the national grid, the operational period will depend on the availability of bagasse.
- ❖ The latest generation, transmission plan and load forecast provided by NTDC has been used for the study, attached in Appendix – A, vide data permission letter no. GMPP/CEMP/TRP-333/3671-73 dated 31-08-2016.
- ❖ The study objective, approach and methodology have been described and the plant's data received from the Client is validated.
- ❖ The nearest grid facility is the 132 kV substations of 18-Hazari. It lies at about 10 km from the site of Hunza PP.
- ❖ Due to the location of Hunza PP, the most feasible interconnection scheme would be looping in-out one of the 132 kV double circuit between 18-Hazari to Garh Maharaja passes about 3 km from the proposed Hunza PP on rail conductor. The up-coming chapters discuss in detail the location and interconnection of the Hunza PP. A few approximate sketches are shown in Appendix-B.
- ❖ The proposed scheme will require two breaker bays of 132 kV at Hunza PP to connect with the 132 kV circuits each from 18-Hazari and Garh Maharaja respectively.
- ❖ In view of planned COD, of the Hunza PP in December 2018, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for January 2019 for maximum thermal power dispatches in the grid during winter which is the crushing season.



- ❖ Steady state analysis by load flows, short circuit and stability criterion reveals that proposed scheme is adequate to export 44.8 MW output of the plant under normal and contingency conditions.
- ❖ Since the plant operates during summer as well, the high-water season, its detail analysis has also been carried out for September 2019.
- ❖ In an extended term scenario, September 2021 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. Along with it, short circuit and dynamic stability analysis have been carried out for a complete check of the system.
- ❖ The short circuit level of the Hunza Power Project 132 kV is 5.88 kA and 6.13 kA for 3-phase and 1-phase faults respectively for the year 2021. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 132 kV switchyard of Hunza Power Project taking care of any future generation additions and system reinforcements in its electrical vicinity and also fulfill the NEPRA Grid Code requirements specified for 132 kV switchgears. There are no violations of exceeding the rating of the equipment in the vicinity of Hunza PP due to contribution of fault current from it.
- ❖ The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 132 kV bus bar of Hunza PP substation followed by the final trip of 132 kV circuits emanating from this substation has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 132 kV protection system. Also the extreme worst case of stuck breaker (breaker failure) has been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms for single phase fault. The stability of system for far end faults of 3-phase occurring at 18-Hazari 132 kV and Garh Maharaja 132 kV bus bar has also been checked.

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Appendices

Appendix –A: Generation, Transmission Plan and Load Forecast for Chapter – 4

Appendix –B: Map & Sketches for Chapter – 4

Appendix –C: Plotted Results of Load Flow for Chapter – 5

Appendix –D: Plotted Results of Short Circuit for Chapter – 6

Appendix –E: Plotted Results of Stability Analysis for Chapter – 7

Appendix –F: Generator, Transformer and Dynamic Data



1. INTRODUCTION

1.1 Background

Hunza Power Plant is a Cogeneration plant near 18-Hazari in District Jhang embedded in the distribution network of FESCO. The electricity generated from this project would be supplied to the grid system of FESCO through 132 kV grids available in the vicinity of this project. A general idea of the location of plant and grid stations in its vicinity can be viewed in sketch-1 attached in Appendix - B.

Hunza PP aims to install 49.8 MW units and go for high pressure cogeneration in the sugar mill with the aim of exporting 34.8 MW power to the grid during the crushing season and 44.8 MW after it, depending on the availability of bagasse. The project is expected to start commercial operation by December 2018. The electricity generated from this project would be supplied to the grid system of FESCO through 132 kV grids, as that of 18-Hazari and Garh Maharaja, available in the vicinity of this project. The location of Hunza PP can be seen in sketch-2 attached in Appendix - B.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection scheme between Hunza Power Project and FESCO network, for stable and reliable evacuation of 49.8 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives of this report are:

- To develop scheme of interconnections at 132 kV for which right of way (ROW) and space at the terminal substations would be available.
- To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
- To check if the contribution of fault current from the plant unit increases the fault levels at the adjoining substations at 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at Hunza PP.



- To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping.

1.3 Planning Criteria

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

Steady State:

Voltage	$\pm 5 \%$, Normal Operating Condition
	$\pm 10 \%$, Contingency Conditions
Frequency	50 Hz Nominal
	49.8 Hz to 50.2 Hz variation in steady state
	49.4 - 50.5Hz, Min/Max Contingency Freq. Band
Power Factor	0.8 Lagging; 0.9 Leading

Short Circuit:

132 kV Substation Equipment Rating 31.5 kA or 40 kA

Dynamic/Transient:

The system should revert back to normal condition after dying out of transients without losing synchronism with good damping

- Permanent three-phase fault on any primary transmission element; including: transmission circuit, substation bus section, transformer, or circuit breaker. It is assumed that such a fault shall be cleared by the associated circuit breaker action in 5 cycles.
- Failure of a circuit breaker to clear a fault ("Stuck Breaker" condition) in 9 cycles after fault initiation.



2. ASSUMPTIONS OF DATA

The number of new generating units at Hunza PP will be two. As per the data provided by the client following data has been modeled:

2.1 Hunza-PP Data

Installed capacity of power plant	= 2 x 25 = 50 MW
Net Capacity of power plant	= 49.8 MW
Power factor	= 0.80 lagging, 0.85 leading
Lump sum MVA capacity	= 2 x 31.25 MVA = 62.5 MVA
Inertia Constant	= 1.1462 MW-sec/MVA
Generating Voltage	= 11 kV
Transformer Rating	= 35 MVA

2.2 Network data

The 132 kV network in the area near Hunza Power Project are as shown in Sketches in Appendix-B. The latest Generation Expansion Plan and Load Forecast of NTDC as per data permission letter no. GMPP/CEMP/TRP-333/3671-73 dated 31-08-2016 has been used as shown in Appendix-A. The network of FESCO in the vicinity of Hunza PP was verified during a visit held on 7th September 2016 by PPI engineers.



3. STUDY APPROACH AND METHODOLOGY

3.1 Understanding of the Problem

Hunza Power Private Limited would like to go for high pressure cogeneration with the aim of exporting a maximum of 44.8 MW supply to the grid during the Off-Season and 34.8 MW in Crushing Season. The site of proposed project is located at a distance of about 3 km from the 132 kV double circuit from 18-Hazari 132 kV G/S to Garh Maharaja 132 kV G/S. The proposed Power Project is going to be embedded in the transmission network of FESCO through this nearest available 132 kV network.

The adequacy of FESCO network of 132 kV in and around the proposed site of Hunza PP has been investigated in this study for absorbing and transmitting this power fulfilling the reliability criteria.

3.2 Approach to the problem

The following approach has been applied to the problem:

- Month of January 2019 has been selected for the study because it represents the maximum thermal dispatch conditions during the crushing season after the COD, December 2018, of Hunza PP. Thus, lines in the vicinity of this plant will be loaded to the maximum extent, allowing us to judge the complete impact of the plant on the transmission system in its vicinity.
- The month of September 2019, has also been completely analyzed for the system, considering maximum hydel dispatches.
- Load flow and short circuit studies have also been performed for September 2021 to see the performance of the proposed plant in extended term scenario.
- Interconnection scheme without any physical constraints, like right of way or availability of space in the terminal substations, have been identified.
- Perform technical system studies for peak load conditions to confirm technical feasibility of the interconnections. The scheme will be subjected to standard analysis like load flow, short circuit, and transient stability study to check the strength of the machines and the proposed interconnection scheme under disturbed conditions.



- Determine the relevant equipment for the proposed technically feasible scheme.
- Recommend the technically most feasible scheme of interconnection.



4.DEVELOPMENT OF SCHEME OF INTERCONNECTION

4.1 The Existing and Ongoing Network

The existing 66 kV network available around Hunza PP is being upgraded to 132 kV and will be completed before the COD of the project. The network around the proposed location of Hunza-PP is shown in Sketch-1 in Appendix-B.

Hunza PP is in District Jhang embedded in the distribution network of FESCO. Network is being fed from the sources substation of T.T. Singh-New 220/132 kV and Samundri 220/132 kV.

These are multiple feeding points in the vicinity which provides reliability and voltage support to the system. All these substations provide a strong 220 kV and 500 kV network around the proposed plant. A strong system helps in stable operation of a power plant.

4.2 The Scheme of Interconnection of Hunza-PP

Keeping in view of the above mentioned 132 kV network available in the vicinity of the site of the Hunza PP, the most feasible interconnection scheme would be looping in-out the 18-Hazari to Garh Maharaja 132 kV single circuit at the proposed 132 kV Hunza PP grid station. The looping distance would be 3 km long using Rail Conductor as shown in Sketch-2 in Appendix-B. The network of Hunza PP has been modeled at 132 kV and 11 kV.



5. DETAILED LOAD FLOW STUDIES

The base cases have been developed for the peak conditions of January 2019 using the network data of NTDC and FESCO available with PPI. The peak loads of the year 2019 for FESCO have been modeled as per the latest PMS Demand forecast as provided by NTDC. Detailed load flow studies have been carried out for January 2019, September 2019 and future case September 2021.

5.1 Peak Load Case January 2019

The peak load case in January 2019 has been studied in detail for the conditions of without and with Hunza PP.

5.1.1 Without Hunza-Power Plant

The results of load flow analysis without Hunza PP have been plotted under normal conditions in Exhibit 0.0 in Appendix-C. The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 5\%$ off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 0.1	18-Hazari to GM Raja 132 kV Single Circuit Out
Exhibit 0.2	Havel BS to 18-Hazari 132 kV Single Circuit Out
Exhibit 0.3	T.T.Singh-N to Havel BS 132 kV Single Circuit Out
Exhibit 0.4	T.T.Singh-N to Jhang 132 kV Single Circuit Out
Exhibit 0.5	T.T.Singh-N to Gojra 132 kV Single Circuit Out

5.1.2 With Hunza-Power Plant

The scenario of Hunza PP after the COD of the plant when it starts exporting 34.8 MW during crushing season to the FESCO network has been studied. The results of load flows with Hunza PP under normal conditions have been plotted in Exhibit 1.0 in Appendix-C.



The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 5\%$ off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit 1.1	Hunza-PP to GM Raja 132 kV Single Circuit Out
Exhibit 1.2	Hunza-PP to 18-Hazari 132 kV Single Circuit Out
Exhibit 1.3	18-Hazari to GM Raja 132 kV Single Circuit Out
Exhibit 1.4	Havel BS to 18-Hazari 132 kV Single Circuit Out
Exhibit 1.5	T.T.Singh-N to Havel BS 132 kV Single Circuit Out
Exhibit 1.6	T.T.Singh-N to Jhang 132 kV Single Circuit Out
Exhibit 1.7	T.T.Singh-N to Gojra 132 kV Single Circuit Out

We find that power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 10\%$ off the nominal for contingency conditions' criteria. We find no capacity constraints on 132 kV circuits under normal and contingency conditions.

5.2 Peak Load Case 2019: Summer Scenario

The scenario of Hunza PP during the summer season, for the month of September with maximum hydel dispatches, has been studied. The results of load flows with Hunza PP under normal conditions have been plotted in Exhibit 2.0 in Appendix-C.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 5\%$ off the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit-2.1	Hunza-PP to GM Raja 132 kV Single Circuit Out
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Exhibit 2.2	Hunza-PP to 18-Hazari 132 kV Single Circuit Out
Exhibit 2.3	18-Hazari to GM Raja 132 kV Single Circuit Out
Exhibit 2.4	Havel BS to 18-Hazari 132 kV Single Circuit Out
Exhibit 2.5	T.T.Singh-N to Havel BS 132 kV Single Circuit Out
Exhibit 2.6	T.T.Singh-N to Jhang 132 kV Single Circuit Out
Exhibit 2.7	T.T.Singh-N to Gojra 132 kV Single Circuit Out

We find that power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 10\%$ off the nominal for contingency conditions' criteria. We find no capacity constraints on 132 kV circuits under normal and contingency conditions.

5.3 Peak Load Case 2021: Extended Term Scenario

We have also studied the future scenario of September 2021 to assess the impact of the plant in the extended term of its installation as per NTDC requirement.

Exhibit 3.0 shows the normal case of 2021 of the region with Hunza PP. The total 44.8 MW of electrical power will be supplied to the national grid from Hunza PP.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 5\%$ off the nominal.

We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows:

Exhibit-3.1	Hunza-PP to GM Raja 132 kV Single Circuit Out
Exhibit 3.2	Hunza-PP to 18-Hazari 132 kV Single Circuit Out
Exhibit 3.3	18-Hazari to GM Raja 132 kV Single Circuit Out
Exhibit 3.4	Havel BS to 18-Hazari 132 kV Single Circuit Out
Exhibit 3.5	T.T.Singh-N to Havel BS 132 kV Single Circuit Out
Exhibit 3.6	T.T.Singh-N to Jhang 132 kV Single Circuit Out
Exhibit 3.7	T.T.Singh-N to Gojra 132 kV Single Circuit Out



The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 10\%$ off the nominal for contingency conditions' criteria.

We find that there are no capacity constraints in the proposed connectivity scheme even in the up-coming years i.e. 2021.

5.4 Conclusion of Load Flow Analysis

From the analysis discussed above, we conclude that the proposed interconnection scheme of looping in-out one of the 18-Hazari – Garh Maharaja 132 kV double circuit at Hunza-PP is adequate to evacuate the maximum 44.8 MW spillover power of Hunza PP under normal and contingency conditions.

It was found that in 2019 all the contingency cases the surrounding circuits remain within the rated capacity. Also the bus bar voltages were well within the permissible limits in all the contingency events.

The scenario of September 2019 and 2021 was also evaluated and found to be stable under normal and contingency cases.



6. SHORT CIRCUIT ANALYSIS

6.1 Methodology and Assumptions

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies.

The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the years 2019 and 2021 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Chapter.2 of this report.

6.2 Fault Current Calculations without Hunza PP Year 2019

In order to assess the short circuit strength of the network of 132 kV without Hunza PP for FESCO in the vicinity of the site of the Plant near 18-Hazari and Garh Maharaja, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions in the year 2019. These levels will give us the idea of the fault levels without Hunza PP and later on how much the contribution of fault current from Hunza PP may add to the existing levels. The results are attached in Appendix – D.

The short circuit levels have been calculated and plotted on the bus bars of 132 kV of substations lying in the electrical vicinity of our area of interest and are shown plotted in the Exhibit 4.0 attached in Appendix-D. Both 3-phase and 1-phase fault currents



are indicated in the Exhibit 4.0 which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-D for the 132 kV bus bars of our interest. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 25 kA or 31.5 kA for older substations and 40 kA for new substations.

Table-6.1
Maximum Short Circuit Levels without Hunza PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
18-Hazari 132kV	5.19	5.41
GM Raja 132kV	2.62	2.88
Haveli BS 132kV	7.72	7.98
Jhang 132kV	9.78	11.52
Gojra 132kV	21.26	20.67
T.T Singh-N 132kV	23.85	22.88
Kot Shakir 132kV	2.93	2.63
AP Sial 132kV	1.91	2.04

6.3 Fault Current Calculations with Hunza PP Year 2019

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at the 132 kV bus bar of Hunza-PP itself and other bus bars of the 132 kV substations in the electrical vicinity of Hunza-PP. The graphic results are shown in Exhibit 4.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV bus bars of the network in the electrical vicinity of Hunza-PP and the 132 kV bus bars of Hunza-PP itself are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2

Table-6.2
Maximum Short Circuit Levels with Hunza PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Hunza-PP 132kV	5.17	5.49
18-Hazari 132kV	5.99	6.46
GM Raja 132kV	3.82	4.06
Haveli BS 132kV	8.48	8.67
Jhang 132kV	10.24	11.93
Gojra 132kV	21.88	21.05
T.T Singh-N 132kV	24.55	23.29
Kot Shakir 132kV	3.18	2.83
AP Sial 132kV	2.48	2.51

6.4 Fault Current Calculations with Hunza-PP Year 2021

Fault currents have been evaluated for the peak case of 2021 in order to observe the maximum fault current on Hunza PP and the bus bars in its vicinity considering the future additions in the system. Fault types applied are three phase and single-phase at 132 kV bus bars of Hunza -PP itself and other bus bars of the 132 kV substations in the electrical vicinity of Hunza-PP. The graphic results showing maximum 3-phase and 1-phase fault levels are indicated in Exhibit 4.2. Both 3-phase and 1-phase fault currents are indicated in the Exhibit 4.2 which are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault currents are shown below the bus bar.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV bus bars of the network in the electrical vicinity of Hunza-PP are placed in Appendix-D. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.3

Table-6.3
Maximum Short Circuit Levels with Hunza PP

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Hunza-PP 132kV	5.88	6.13
18-Hazari 132kV	7.13	7.71
GM Raja 132kV	4.18	4.39
Haveli BS 132kV	11.54	11.64
Jhang 132kV	13.12	13.87
Gojra 132kV	22.21	21.78
T.T Singh-N 132kV	25.04	24.98
Kot Shakir 132kV	3.48	3.02
AP Sial 132kV	2.59	2.73

Comparison of Tables 6.1, 6.2 and 6.3 shows an increase in short circuit levels for three-phase and single-phase faults due to connection of Hunza-PP on the 132 kV bus bars in its vicinity; and a rise on 18-Hazari 132 kV bus bars because of direct connection with Hunza-PP. We find that even after some increase, these fault levels are much below the rated short circuit values of the equipment installed on these substations.

For Hunza PP 132 kV standard size switchgear of short circuit rating of 25 kA has already been proposed. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

6.5 Conclusion of Short Circuit Analysis

The short circuit analysis results show that for the proposed scheme of interconnection of Hunza-PP with 18-Hazari 132 kV and Garh Maharaja 132 kV Substation, we don't find any problem of violations of short circuit ratings of the already installed equipment on the 132 kV equipment of substations in the vicinity of Hunza-PP due to fault current contributions from this power house under three-phase faults as well as single phase faults.



The short circuit level of the Hunza-PP 132 kV is 5.88 kA and 6.13 kA for 3-phase and 1-phase faults respectively in the year 2021. Therefore industry standard switchgear of the short circuit rating of 25 kA would serve the purpose as per NTDC requirement taking care of any future generation additions and system reinforcements in its electrical vicinity.



7. DYNAMIC STABILITY ANALYSIS

7.1 Assumptions & Methodology

7.1.1 Dynamic Models

The assumptions about the generator and its parameters are the same as mentioned in Chapter.2 of this report.

We have employed the generic dynamic models available in the PSS/E model library for dynamic modeling of the generator, exciter and the governor as follows;

Generator	GENROU
Excitation System	EXST1
Speed Governing System	TGOV1
Inertia Constant	H = 1.1462 MW-sec/MVA

7.1.2 System Conditions

Month of January 2019 has been selected for the study because it represents the peak load season after the COD of Hunza Power Project and thus the loading on the lines in the vicinity of Hunza-PP will be maximum allowing us to judge the full impact of the plant.

The proposed Hunza-PP has been modeled in the dynamic simulation as per data provided by client.

All the power plants of WAPDA/NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

7.1.3 Presentation of Results

The plotted results of the simulations runs are placed in Appendix-E. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds. Usually all the transients due to non-linearity die out within 2-3 seconds after disturbance is cleared in the system.



7.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbance in the system. We have considered 3-phase fault in the closest vicinity of Hunza-PP i.e. right at the 132 kV bus bar of Hunza-PP substation, cleared in 5 cycles, as normal clearing time for 132 kV i.e. 100 ms, followed by a permanent trip of a 132 kV single circuit emanating from this substation. Also to fulfil the Grid Code criteria case of stuck breaker (breaker failure) single phase fault has also been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms.

7.2 Dynamic Stability Simulations' Results with Hunza-PP interconnected - January 2019

7.2.1 Fault at 132 kV Hunza-PP

We applied three-phase fault on Hunza-PP 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of a 132 kV single circuit between Hunza-PP and Garh Maharaja 132 kV substation. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 1.1 Bus Voltages

The bus voltages of 132 kV bus bars of Hunza-PP, Garh Maharaja, 18-Hazari, H.B. Shah, Jhang and T.T. Singh-New are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of Hunza-PP

The MW/MVAR output of Hunza-PP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.



Fig. 1.4 Speed and mechanical power of Generators at Hunza-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 MW Flow on Hunza-PP to 18-Hazari 132 kV circuit

Followed by clearing of fault, the trip of a 132 kV single circuit from Hunza-PP to Garh Maharaja causes the entire output of Hunza-PP to flow on the intact 132 kV circuit between Hunza-PP and 18-Hazari 132kV circuit. This causes significant loading on the Hunza-PP to 18-Hazari 132 kV circuit. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Hunza-PP, Liberty-P, SPS, Jinnah and Chashma 132 kV are plotted relative to machines at Guddu New 500 kV. The results show that the rotor angle of Hunza-PP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.2 Fault at 132kV Hunza-PP (Stuck Breaker)

We applied single-phase fault on Hunza-PP 132 kV bus bar, cleared fault in 9 cycles (180 ms), to simulate a stuck breaker case, followed by trip of a 132 kV single circuit between Hunza-PP and Garh Maharaja 132 kV substation. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 2.1 Bus Voltages

The bus voltages of 132 kV bus bars of Hunza-PP, Garh Maharaja, 18-Hazari, H.B. Shah, Jhang and T.T. Singh-New are plotted. The results show quick recovery of the voltages after clearing of fault.



Fig. 2.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 2.3 MW/MVAR Output of Generators of Hunza-PP

The MW/MVAR output of Hunza-PP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 2.4 Speed and mechanical power of Generators at Hunza-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 MW Flow on Hunza-PP to 18-Hazari 132 kV circuit

Followed by clearing of fault, the trip of a 132 kV single circuit from Hunza-PP to Garh Maharaja causes the entire output of Hunza-PP to flow on the intact 132 kV circuit between Hunza-PP and 18-Hazari 132kV circuit. This causes significant loading on the Hunza-PP to 18-Hazari 132 kV circuit. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 2.6 Rotor Angles

The rotor angles of the generators of Hunza-PP, Liberty-P, SPS, Jinnah and Chashma 132 kV are plotted relative to machines at Guddu New 500 kV. The results show that the rotor angle of Hunza-PP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations..

7.2.3 Fault at Garh Maharaja 132 kV

We applied three-phase fault on far 132 kV bus bar of Garh Maharaja to study the impact of a disturbance in the grid on the performance of the plant. The fault is cleared in 5 cycles (100 ms) followed by trip of 132 kV single circuit between Hunza



PP and Garh Maharaja. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 3.1 Bus Voltages

The bus voltages of 132 kV bus bars of Hunza-PP, Garh Maharaja, 18-Hazari, H.B. Shah, Jhang and T.T. Singh-New are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 3.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 3.3 MW/MVAR Output of Generators of Hunza-PP

The MW/MVAR output of Hunza-PP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 3.4 Speed and mechanical power of Generators at Hunza-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 3.5 MW Flow on Garh Maharaja to 18-Hazari 132 kV circuit

Followed by clearing of fault, the trip of a 132 kV single circuit from Hunza PP to Garh Maharaja, we have monitored the flow from Garh Maharaja to 18-Hazari. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 3.6 Rotor Angles

The rotor angles of the generators of Hunza-PP, Liberty-P, SPS, Jinnah and Chashma 132 kV are plotted relative to machines at Guddu New 500 kV. The results show that the rotor angle of Hunza-PP gets back after the first swing and damps down quickly.



Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.2.4 Fault at 18-Hazari 132 kV

We applied three-phase fault on far 132 kV bus bar of 18-Hazari to study the impact of a disturbance in the grid on the performance of the plant. The fault is cleared in 5 cycles (100 ms) followed by trip of 132 kV single circuit between 18-Hazari and Hunza-PP. We monitored different quantities for one second pre-fault and nine cycles after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – E and discussed as follows:

Fig. 4.1 Bus Voltages

The bus voltages of 132 kV bus bars of Hunza-PP, Garh Maharaja, 18-Hazari, H.B. Shah, Jhang and T.T. Singh-New are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 4.2 Frequency

We see the system frequency recovers back to normal quickly after fault clearance.

Fig. 4.3 MW/MVAR Output of Generators of Hunza-PP

The MW/MVAR output of Hunza-PP gets back to the pre-fault output quickly after fast damping of the oscillations in its output.

Fig. 4.4 Speed and mechanical power of Generators at Hunza-PP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 4.5 MW Flow on Garh Maharaja to 18-Hazari 132 kV circuit

Followed by clearing of fault, the trip of a 132 kV single circuit from 18-Hazari to Hunza-PP, we have monitored the flow from Garh Maharaja to 18-Hazari. We plotted



the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 4.6 Rotor Angles

The rotor angles of the generators of Hunza-PP, Liberty-P, SPS, Jinnah and Chashma 132 kV are plotted relative to machines at Guddu New 500 kV. The results show that the rotor angle of Hunza-PP gets back after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is strongly stable and very strong in damping the post fault oscillations.

7.3 Conclusion of Dynamic Stability Analysis

The results of dynamic stability carried out for January 2019 show that the system is very strong and stable for the proposed scheme for the severest possible faults of 132 kV systems near to and far of Hunza PP under all events of disturbances. Therefore there is no problem of dynamic stability for interconnection of Hunza PP; it fulfills all the criteria of dynamic stability.



8. CONCLUSIONS

- ❖ The study objective, approach and methodology have been described and the plant's data received from the Client is validated.
- ❖ The nearest grid facility is the 132 kV substations of 18-Hazari. It lies at about 10 km from the site of Hunza PP.
- ❖ Due to the location of Hunza PP, the most feasible interconnection scheme would be looping in-out one of the 132 kV double circuit between 18-Hazari to Garh Maharaja passes about 3 km from the proposed Hunza PP on rail conductor. The up-coming chapters discuss in detail the location and interconnection of the Hunza PP. A few approximate sketches are shown in Appendix-B.
- ❖ The proposed scheme will require two breaker bays of 132 kV at Hunza PP to connect with the 132 kV circuits each from 18-Hazari and Garh Maharaja respectively.
- ❖ In view of planned COD, of the Hunza PP in December 2018, the above proposed interconnection scheme has been assessed for steady state conditions through detailed load flow studies, short circuit analysis and stability criterion for January 2019 for maximum thermal power dispatches in the grid during winter which is the crushing season.
- ❖ Steady state analysis by load flows, short circuit and stability criterion reveals that proposed scheme is adequate to export 44.8 MW output of the plant under normal and contingency conditions.
- ❖ Since the plant operates during summer as well, the high-water season, its detail analysis has also been carried out for September 2019.
- ❖ In an extended term scenario, September 2021 has been studied to evaluate the performance of the proposed interconnection scheme. The system conditions of normal and N-1 contingency have been examined for all scenarios to meet the reliability criteria. Along with it, short circuit and dynamic stability analysis have been carried out for a complete check of the system.
- ❖ The short circuit level of the Hunza Power Project 132 kV is 5.88 kA and 6.13 kA for 3-phase and 1-phase faults respectively for the year 2021. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be



installed at 132 kV switchyard of Hunza Power Project taking care of any future generation additions and system reinforcements in its electrical vicinity and also fulfill the NEPRA Grid Code requirements specified for 132 kV switchgears. There are no violations of exceeding the rating of the equipment in the vicinity of Hunza PP due to contribution of fault current from it.

- ❖ The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability has been tested for the worst cases, i.e. three phase fault right on the 132 kV bus bar of Hunza PP substation followed by the final trip of 132 kV circuits emanating from this substation has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 132 kV protection system. Also the extreme worst case of stuck breaker (breaker failure) has been studied where the fault clearing time is assumed 9 cycles i.e. 180 ms for single phase fault. The stability of system for far end faults of 3-phase occurring at 18-Hazari 132 kV and Garh Maharaja 132 kV bus bar has also been checked.



FEASIBILITY REPORT

FEASIBILITY REPORT
FOR
2 x 24.9 MW COGENERATION PROJECT
AT

HUNZA POWER (PRIVATE) LTD.,
18 HAZARI DARGAI SHAH, DISTRICT JHANG
PUNJAB, PAKISTAN

SEPTEMBER 2016

CONSULTANTS



UAE

AVANT-GARDE ENGINEERS & CONSULTANTS (FZC.)
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Executive Summary

1.0 Introduction

- 1.1 The uncontrolled Green House Gas (GHG) emissions and its potential to cause serious environment changes are causing worldwide concerns. The climate changes' being experienced today confirms that the fears about the global warming and environmental damages are coming true. The frenetic pace of developments in the last few decades and the consequent energy guzzling are causing irreversible damages to Earth's eco-system. The consequences of global warming with changing weather patterns, water shortage, food shortage, inundation of low lying sea coast areas etc., are staring the mankind. The Earth is in such a precarious position, mainly because of the rapid growth in population, urbanization and fossil fuel consumption. It is important for any country, that the objectives of natural resource conservation and environment protection are integrated with the overall development process. The strategies to achieve the above objectives are encouraging fuel efficiency and preventing wasteful energy use and promoting technologies using renewable natural resources such as bio-mass, wind and solar energy.
- 1.2 Bagasse based Cogeneration, for additional and exportable power generation in the sugar industry, offers a number of advantages both to the sugar company and to the country. Apart from helping in bridging the gap between the demand and the supply in the power sector, the bagasse based Cogeneration offers an environmentally friendly solution for additional power generation, helps in reducing the dependence on the fossil fuels, saves on the foreign currency outflow from the country and improves the financial position of the sugar factory. Bagasse based Cogeneration is being extensively used in India where the installed generation capacity exceeds 2500 MW with

more plants under implementation. The other countries that had exploited bagasse based Cogeneration to a major extent are Mauritius (around 250 MW), Reunion Island (around 220 MW), Pakistan (120 MW), Brazil etc.

2.0 Background

- 2.1 Hunza Sugar Mills (Pvt) Limited (HSMPL), operates its sugar mill (Unit - 2) at 8 KM, Layyah Road, 18 Hazari, in the District of Jhang in the Punjab Province in Pakistan. This sugar mill has a present nominal crushing capacity of 6000 Tonnes of Cane per Day (TCD) and crushes for a period of about 110 days in a year. HSMPL was established in Pakistan in 2002 as a Private Limited Company.. The company's operations from the time it started commercial operations has been steady.. Hunza Group of Industries is the leading sugar, edible oil, vanaspati ghee, CO₂ and ethanol producer in Pakistan. The group has two Sugar plants with the other sugar unit (Unit - 1) located in Faisalabad district with a crushing capacity of 10000 TCD.
- 2.2 HSMPL's sugar mill is modern and they have installed the most modern plant & machinery in the sugar mill. HSMPL, with an excellent management team and the best machinery ensure good performance of the sugar mill and consequently, the mill is one among the Top Sugar Mills in the Punjab Province in terms of sugarcane crushing, production, recovery and efficiency. HSMPL is located in the Jhang District, an excellent cane growing area of the Punjab Province. The sugar mill, being located on the Layyah road, has good access by road. The factory is about 37 kms from the city of Jhang. The nearest air port is at Faisalabad and the nearest sea port is Karachi at a distance of about 1000 kMs. The factory is well connected by road to Islamabad and Lahore through the national high ways.
- 2.3 Considering the good cane potential in the command area of the sugar mill, HSMPL is planning to enhance the crushing capacity

of the sugar mill to 10,000 TCD from the present level of 6000 TCD.

3.0 Project Rationale & Drivers

3.1 While expanding the crushing capacity of the sugar mill, HSMPL is planning for the implementation of the high pressure Cogeneration program to generate grid quality exportable power. The best time to add Cogeneration in a sugar mill is at the time of crushing capacity expansion as the enhancement of the crushing capacity calls for additional steam and power requirements. Apart from the above, HSMPL is contemplating Cogeneration due to the following reasons:

- Contributing to the growth of the country's economy by generating the much needed electricity.
- Helping to reduce the foreign exchange outflow by using a local renewable fuel, instead of the costly imported fossil fuel for generating electricity.
- Putting an energy resource like bagasse to better use and maximizing the power generation with bagasse. The bagasse which is a renewable energy source contributes to the reduction in the green house gases.
- Improving the Energy efficiency of the plant, as inefficiency in any form is to be eliminated in this energy deficient world.

3.2 With the stabilization of the crushing at 10,000 TCD, the potential for additional power generation at HSMPL is very good. With Cogeneration in mind, the company had taken adequate care in ensuring the sustainability of the crushing. To that effect HSMPL has been concentrating on cane development to get assured cane for crushing. Also HSMPL,

with the view of enhancing the power export potential, is planning for conversion of the steam turbine drives of the mills and the cane preparatory devices to electric drives. They had already made adequate efforts in reducing the steam consumption and going in for the energy efficiency measure in the process area to reduce the thermal energy consumption. With these forward planning, the implementation of Cogeneration could become much easier in this sugar mill. With the implementation of the energy efficiency measures, there will be a remarkable reduction in the process steam and power consumption in the sugar mill, enhancing the energy export to the grid.

3.3 Currently Pakistan has an installed electric generating capacity of about 20,000 MW, with the demand far exceeding this installed capacity and the access to electricity in Pakistan is about 62%. With a fast-growing economy and demography, the projection for the demand in 2030 is forecast to be 100,000 MW. This calls for a tremendous growth rate in the power sector. The Government of Pakistan is making all out efforts to increase the generation capacity by tapping all conventional and non-conventional sources of electricity generation. Born out of this Government's initiative to augment the generation through non-conventional energy sources is the "National Policy for Power Cogeneration by Sugar Industry" promulgated in January 2008. **The Government of Pakistan has recognized that Bagasse based Cogeneration can play a significant role in the country's efforts to augment the electricity generation.**

3.4 The Government's pro-active policy on power Cogeneration created a lot of interest in the sugar Industry in Pakistan. The sugar Industry, suffering due to the vagaries of nature and global market fluctuations had been looking for support from the Government on the cogeneration initiative. However after the initial euphoria immediately after the announcement of the policy, the policy aimed at laying down clear guidelines about

tapping the bagasse based Cogeneration potential, did not evoke much of interest. The major and probable reasons, why there was not much of enthusiasm, were the minimum size of 60 MW and the treatment of the Cogeneration plants as IPPs. With no sugar mill coming forward to implement the Cogeneration program, the sugar industry has taken up the matter with the Government and the new initiative by the industry and the Government has brought about a new policy in 2013 and this promises great hopes for bagasse based Cogeneration in Pakistan.

4.0 Project Sponsors

4.1 For the implementation of the Cogeneration program, the sugar company has set up a new company called "Hunza Power (Private) Ltd., (HPPL). HPPL will be undertaking the power project development, construction and operation and maintenance activities. HPPL will sell the required power to HSMPL for the latter's operation and get bagasse in return. HPPL will sign the power purchase agreement with the off-taker and sell the surplus power to the off-taker. HSMPL will be a stake holder in HPPL.

4.2 The bagasse generation in the sugar mill is reasonably good, at 30.5% on cane, on account of the high fibre in cane, and the generated bagasse is not fully utilized presently. Even with the present crushing of 6000 TCD, HSMPL saves and sells bagasse. The high crushing capacity and the high percentage of bagasse make this sugar mill an ideal candidate for the implementation of the Cogeneration program. Fully aware of the benefits of Cogeneration to the company as well as to the power starved country, HSMPL has proposed the Cogeneration project and HPPL will take up the implementation of the Cogeneration project in the premises of HSMPL's sugar mill.

- 4.3 Under the present arrangement, the sugar plant's complete steam requirements are being met by two (2) number of boilers of capacity 70 TPH and 40 TPH with the outlet steam parameters of 24 bar(a) and 340 Deg.C. The complete electrical power requirements are met with One (1) numbers of 6 MW, One(1) No. Of 3.5 MW and One (1) No. Of 3 MW backpressure turbogenerators.. In addition there are steam turbine drives & DC drives to drive the mills, steam turbine for shredder and 3.3kV HT motor for cutter. All the power and the drive turbines exhaust the steam at a pressure of 2 bar (a) and at a temperature of about 160 Deg.C. Under the Cogeneration program, these existing low pressure boilers, the turbogenerators and the drive turbines will be retired. The entire steam generation will be in the new high pressure boilers and the complete power generation will be in the new high pressure turbogenerators. The entire quantity of the steam and power requirements of the sugar plant will be met by the new Cogeneration plant. The drive turbines will be replaced by electric motors.
- 4.4 Cogeneration had always been a priority for Hunza Sugar Mills (Pvt) Limited. They initiated action for setting up of 2x24.9 MW Cogeneration program in their sugar mills with the planned COD of July 2018. Being a progressive company HSMPL had already initiated measures to make the sugar mill energy efficient and consequently the steam consumption in the process is 44% on cane. For a sugar mill producing refined sugar this is an appreciable achievement. The sugar mill is running comfortably as the total installed capacity for steam generation is adequate for meeting this requirement. Using the steam generated the mill is generating enough electricity to meet with all the internal requirements.. HSMPL had employed energy conservation measures, to bring down the steam consumption to 44% with Cogeneration in mind, while the contemporary mills are consuming around 55%. During the capacity enhancement program, the steam consumption will be

further reduced to 42%. When the Cogeneration plant is installed and operating, the process steam consumption of 42% will be extracted from the Cogeneration plant. This steam quantity works out to 175 TPH for the crushing rate of 416.67 TCH, out of which 170.83 TPH will be drawn at 2.5 bar(a) and the balance of 4.17 TPH will be drawn at 4 bar(a). There will be no requirement of process steam for any other plant in the complex.

- 4.5 With the establishment of the proposed Cogeneration project, HSMPL will enter into agreement with HPPL, the operator of the Cogeneration plant, for selling bagasse and buying power.

5.0 Technology

- 5.1 For the proposed Cogeneration program HPPL is interested in going in for a technology that is the latest and proven. With the gasification of bio-mass/bagasse still not attained full scale commercial exploitation, the only technology available for using the bagasse is through the combustion route. The technology chosen is the conventional thermal power plant technology based on the Rankine Cycle. The bagasse will be combusted in a high pressure boiler and the steam generated will be fed to the steam turbine to generate power. The turbine will be different from the conventional thermal power plants as the turbine will be provided with a controlled extraction for extracting the low pressure process steam required for the sugar mill operation. To enhance the efficiency of operation, regenerative heaters are used in the feed water circuit. For the Cogeneration power plant proposed for HPPL, the Cogeneration cycle is based on the parameters of 110 bar(a) and 540 Deg.C at the boiler outlet, currently being used in many countries for the Cogeneration projects. The cycle chosen with the above parameters is the latest used in any of the bagasse fired installations around the world. These above selected parameters make the cycle more efficient and help in the generation of more units for the same

quantum of the fuel. There are already quite a few Cogeneration plants operating in India with these parameters and the operating experience of those plants, in synchronization with the sugar mill operation, has been smooth and without any hitch. The Cogeneration scheme for HPPLL proposes 2x135 TPH capacity boilers and 2x24.9 MW extraction condensing turbogenerators. Considering the off-season operation of the plant, the Cogeneration power plant boilers will be designed for firing the saved bagasse and a few other compatible bio-mass fuels.

5.2 Considering 110 days of crushing operation and an overall capacity utilization of 90%, HSMPL's sugar plant will generate around 301,942 MT of bagasse. Considering the bagacilo requirement of 9,907 MT for sugar plant, the balance bagasse available for the Cogeneration plant will be 292,035 MT. Much of the bagasse, about 239,369 MT will be used for running the Cogeneration plant during the crushing period. The season operation of the Cogeneration plant in synchronization with the sugar mill leaves a surplus of about 52,666 MT and the same could be used for the operation of the power plant for a period of about 31 days during the maintenance periods and during the off-season. The number of operation days in the off-season could be enhanced if suitable compatible bio-mass fuel is identified. Even if the bio-mass fuel is available during the seasonal operation, it could be used along with bagasse and more quantum of bagasse could be saved for more number of days of operation in the off-season.

5.3 The power requirement of the sugar mill during the season operation, excluding the auxiliary power requirement of the Cogeneration power plant is expected to be 10,833 kW. During the off-season period, the power requirement is estimated to be 500 kW, mainly for meeting the power required for the off-season maintenance of the sugar plant machinery and for meeting the colony and office power requirements. Apart from

the above, there will be no power requirement from the sugar mill, both during the season and off-season operation.

- 5.4 The gross power generation in the HPPL's Cogeneration power plant with in the Sugar mill complex, during the sugar mill's season operation, after the implementation of the Cogeneration program will be 49,800 kW. The sugar mill power consumption, as seen earlier, is 10,833 kW. The auxiliary power consumption of the Cogeneration plant during the season operation of the plant is estimated to be 4482 kW. Considering the above, the exportable power to the national Grid comes to 34,485 kW. The electrical power export from the Cogeneration plant, which includes the export to the sugar mill and to the national grid, will be 45,318 kW, during the season operation.
- 5.5 Considering the large investment and also the round the year power requirement of the grid, HPPL could operate the Cogeneration power plant in power plant mode during the off-season. The season operation of the Cogeneration plant consumes a lot of bagasse, but still leaves some surplus quantity for the off-season operation of the power plant. As seen earlier, the plant will operate with the saved bagasse for a period of 31 days in the off-season. If HPPL wants to operate the plant for more number of days the operation of the plant should be supplemented with compatible bio-mass fuel like rice husk, cane trash, wood chips etc.
- 5.6 During the off-season operation, the gross generation in the HPPL's power plant will be 49,800 kW, either with bagasse or with bagasse & bio-mass as the fuel. The auxiliary power consumption will be 4233 kW and the power supplied to the sugar mill for the maintenance and for meeting their other load requirements will be 500 kW. The power supplied to the grid will be 45,067 kW. However, the exportable power from the Cogeneration power plant works out to 45,567 kW, during the off-season operation, either with bagasse or with compatible

bio-mass or with a combination of bagasse and a compatible bio-mass as the fuel.

5.7 The plant and equipment for the new proposed Cogeneration system will consist of the high pressure boilers, extraction condensing turbogenerators, water cooled condensing system, Main and auxiliary cooling water system, water treatment plant system, condensate and feed water system, compressed air system and electrical system consisting of switchgears, LT distribution panels, Variable Frequency Drives, step up transformer to export the power, step down transformers for meeting the in-house power requirement, outdoor switchyard equipment etc.

5.8 The water requirement of the Cogeneration plant is proposed to be met mostly by the ground water through deep bore wells. The ground water aquifers get charged by the irrigation system developed with Chenab river as the source. The present raw water requirement of the sugar mill is being met by the drawl from these sources. The water from the borewells will be stored in a new water reservoir, and drawn for usage in the Cogeneration plant. A water treatment plant based on the reverse osmosis principle is proposed for the treatment of the entire feed water for the Cogeneration plant. There will be an adequately designed pre-treatment system with Multigrade filter and Ultra filtration system upstream of the RO plant.

6.0 Efficiency & Heat Rates

6.1 Under the season operation, the boiler working with bagasse as the fuel will operate with a thermal efficiency of 71% based on the HHV of the fuel. With the bagasse HHV and the LCV respectively at 9311.44 kJ/kg and 7457.09 kJ/kg, the boiler efficiency with the LCV works out to 88.6%. With the net usable electrical power output of 45,318kW from the Cogeneration plant, the plant electric efficiency based on the

fuel LCV comes to 21.72%. The plant heat rate works out to 16,575.65 kJ/kwhr. However considering the useful thermal energy output from the Cogeneration plant, the Combined Heat and Power (CHP) efficiency of the Cogeneration plant comes to 76.27%.

- 6.2 During the off-season operation, the plant operates in a power generation mode, without any process steam supply to the sugar mill. The net power output from the power plant will be 45,567 kW. Using the bagasse, the net electric efficiency based on the LCV of the bagasse works out to 28.41%. The corresponding plant heat rate works out to 12673.71 kJ/kwhr.

7.0 Generation & Grid Interconnection

- 7.1 The bulk of the power generated in the proposed Cogeneration plant is meant for export to the grid. The power generation in the new Cogeneration TGs will be at 11 kV level. The power plant's internal consumption requirement will be met by stepping down the voltage level to 415 V. Similarly the sugar mill's requirements will be met by stepping down the voltage from 11 KV to 415 V and from 11kV to 0.690 kV level to mill motors as the case may be. However considering the stability and the uninterrupted export of power, the exportable power will be stepped up to 132 kV and paralleled with the national grid at 132 kV level. In the case of HPPL's Cogeneration plant, the paralleling with the grid will be done with FESCO's grid to 18 Hazari 132kV Feeder through a loop in loop out (LILO) arrangement.

8.0 Implementation Schedule

- 8.1 The implementation of the proposed new Cogeneration system is expected to be completed within Twenty (20) months, from the date of placing of the orders for the procurement of the boilers and the turbogenerators. As the project is planned on a

fast track basis, it is important that while financial closure, permits and statutory authority clearances are being processed, tender enquiry documents could be floated for the procurement. The Commercial Operation Date (COD) of the cogeneration project is expected to be in July 2018. The boiler and the Turbogenerators could be ordered by the beginning of December 2016.

8.2 The size of the project calls for proper project management and control procedures to ensure implementation within the scheduled program. Adequate qualified and trained manpower shall be recruited to take care of the implementation of the new Cogeneration system. HPPL should plan early for engaging an Operation and Maintenance contractor to take over the O&M of the plant or plan for the appointment of the Operation and Maintenance staff to take over the O&M of the plant.

8.3 It is proposed that the project be executed through the EPC route with an EPCM consultants carrying out the Engineering, Procurement and Construction Management activities. The EPCM consultants make the basic design of the plant, divide the project into logical and manageable packages, prepares the procurement specifications and assists HPPL in the procurement of the packages. Once the packages are ordered, the EPCM consultant expedites with the contractors, reviews drawings, co-ordinates all the activities between the contractors and manages the implementation of the project. The complete Cogeneration plant civil works will be executed by a separate contractor. Based on the overall project guarantees, individual package guarantees are arrived at and specified in the contracts of the individual packages.

9.0 Works Cost Estimate

This Cogeneration project is proposed to be implemented through the EPCM route. Some of the equipment could be

sourced indigenously and the major equipment, specifically the boiler and TG could be imported. The complete civil works will be executed by a local civil contractor. The estimated works cost including all the civil, mechanical, electrical and instrumentation works is estimated to be US\$ 55.66 Million.

10.0 Conclusion

Bagasse based Cogeneration is being considered by many countries as an environment friendly way of augmenting the generation capacity. The Government of Pakistan has estimated a potential of 3000 MW of Cogeneration power from the existing sugar mills, and has decided to fast track these projects. HSMPL's sugar mill with 10,000 TCD of crushing per day will be able to generate 49.8 MW of power with the bagasse generated for a period of about 141 days. The proposed Cogeneration plant of HPPL, when implemented, will export a substantial quantum of power to the national grid. The proposed Cogeneration cycle is already proven and implementation of this project will benefit both the sugar mill and the country.

1.0 Introduction

1.1 The fact that known fossil fuel reserves are finite and will get exhausted one day has made people to think of alternate energy sources. The future will witness growing shortage of known fossil fuels like oil, gas and coal and escalating prices for the same. Fast paced developments over the last few decades and the consequent increased energy consumption are causing irreversible environmental damage. The Green House Gas (GHG) emissions, resulting from the indiscriminate energy consumption is posing a threat to earth's sustainable development. The damages to the Earth's eco-system due to global warming with changing weather patterns, water shortage, food shortage, inundation of low lying sea coast areas etc., are realities. It is important for any country, that the objectives of natural resource conservation and environment protection are integrated with the overall development process. The strategies to achieve the above objectives are encouraging fuel efficiency and preventing wasteful energy use and promoting technologies using renewable natural resources such as biomass, wind and solar Energy.

1.2 Cogeneration, the concept of utilizing the same fuel resource for meeting with the requirements of both thermal and electrical energy, is gaining wide acceptance and encouragement world over. Cogeneration enables the effective and efficient way of utilizing the energy content in a fuel and is widely practiced in the process Industries. Any process industry which employs low pressure steam for the process has the potential for Cogeneration and to become a virtual power house. With increasing concern on global warming, the use of renewable energy, which has the positive effect of not adding to the global warming, is being looked at with renewed interest. The Cogeneration cycle with its higher cycle efficiency, compared to the power cycles, ensures that the scarce natural resources are

put to better use. With Cogeneration utilizing a renewable energy source we get the double benefits of higher efficiency and the utilization of an environmentally friendly fuel source.

- 1.3 The sugar industry occupies an important place in the economy of many countries. Sugar factories are located in rural areas and they are the focal points of economic activities in their surroundings. This is one industry where the contact between industry and agriculture is close, direct and intimate which is contributing to the development of the rural areas. Cogeneration has always been practiced by the sugar mills using the in-house available bagasse. Until recently, most sugar mill boilers and the power house were designed primarily to meet the process steam and electricity needs of the mill and to incinerate the surplus bagasse which is a sugar cane waste, instead of maximizing electricity generation. There has been, of late, increasing awareness in the sugar industry of the advantages of installing high pressure, high efficiency bagasse based Cogeneration systems.
- 1.4 Bagasse based cogeneration for power export to grid is considered as a reliable source of getting grid quality power and hence has been adopted by many countries. Each sugar mill can become a Power Generation Company to export power to the electricity grid by installation of high pressure boilers and extraction condensing turbogenerators. Cogeneration plants with high pressure boilers and matching turbogenerators, exporting power to grid, have been installed in sugar industries in India, Pakistan, Mauritius, Thailand, Re-Union Islands, United States, etc. With the vast experience gained in high pressure Cogeneration, the sugar industry which started with boilers with the pressure levels of 11 bar(a), ages ago, have now come to accept pressure levels of even 110 bar(a) 540 Deg.C. With the advantages like no transportation of fuel, reduction in transmission losses, eco-friendly power generation, etc. sugar plants could perform as supplementary power

generating companies and make any country move towards self-reliance in power sector.

1.5 The bagasse based Grid connected Cogeneration has the following specific advantages:

- The bagasse based Cogeneration is environmentally benign, and it does not add to the existing pollution levels of the environment. This is mainly because of the carbon recycling. Thus there is a justification for these projects from the point of view of sustainable development.
- Saves on the consumption of the fossil fuels. There is no need to transport the fuel to the generating station as the cane in any case is transported to the factories and the bagasse is generated in the sugar mills.
- As the bagasse based Cogeneration plants will be located invariably in the rural areas, far away from the utility plants, the transmission and distribution losses are minimized. In addition these plants increase the quality of power supplied to the rural areas.
- There is a definite advantage with regard to the mobilization of the investment from private /Co-operative sectors in addition to the budgetary allocations for the power sector. In addition these projects present a business opportunity for the sugar mills from possible carbon trading.

1.6 Located in the Asian continent and facing the Arabian Sea, Pakistan shares borders with Afghanistan, Iran, China and India. It has an area of approximately 881,640 km² and an approximate population of 175 million. The structure of Pakistan's economy has changed from mainly an agricultural base

to a strong service base. Agriculture now accounts for approximately 20% of GDP with the service sector contributing to nearly 52% of the GDP. Important industries include, telecommunication, energy, textile, food processing, chemicals and Iron and Steel etc. Pakistan is a rapidly developing economy and this unprecedented development has triggered enormous economic activities, which has resulted in a substantial power demand in the country.

Currently Pakistan has an installed electric power generation capacity of about 20,000 MW, with the demand far exceeding the installed capacity and the access to electricity in Pakistan is about 62%. With a fast-growing economy and demography, the projection for the demand in 2030 is forecast to be 100,000 MW. This calls for a tremendous growth rate in the power sector. The Government of Pakistan is making all out efforts to increase the generation capacity by tapping all conventional and non-conventional sources of electricity generation. Born out of this Government's initiative to augment the generation through non-conventional energy sources is the "National Policy for Power Cogeneration by Sugar Industry" promulgated in January 2008. As this policy did not evoke substantial response from the sugar Industry, the Government has come out with a revised policy in 2013. However, the substantial potential for grid quality power generation in the sugar mills, has attracted considerable interest in Pakistan and both the Government of Pakistan and Industry are discussing the best ways to harness this potential. The Government of Pakistan has recognized that Bagasse based Cogeneration can play a significant role in the country's efforts in augmenting the electricity generation.

- 1.7 The Government's pro-active policies on power Cogeneration has created a lot of interest in the sugar Industry in Pakistan. The sugar Industry, suffering due to the vagaries of nature and global market fluctuations had been looking for support from

the Government on the cogeneration initiative. However after the initial euphoria, the 2008 policy aimed at laying down clear guidelines about tapping the bagasse based Cogeneration potential, did not evoke much of interest. The major probable reasons why there was not much of enthusiasm were the minimum size of 60 MW and the treatment of the Cogeneration plants as IPPs. With no sugar mill coming forward to implement the Cogeneration program, the sugar industry has taken up the matter with the Government and the new initiative by the industry and the Government has brought about a new policy which promises great hope for bagasse based Cogeneration in Pakistan. A new policy has been announced in May 2013, but this policy precludes the use of coal in the cogeneration plants. With the support of the new policy many of the sugar mills will be taking initiatives for the implementation of Cogeneration.

- 1.8 Hunza Sugar Mills (Pvt) Limited (HSMPL) was incorporated in 2002 as Private Limited Company. The company manufactures and markets white refined sugar and its by products, molasses and bagasse. Located at 8 Km Layyah Road, near the city of Jhang in the Punjab province of Pakistan, the Company commenced its commercial production in 2002. HSMPL has installed most modern plant & machinery. HSMPL, with an excellent management team has installed the most modern machinery in the sugar mill to ensure good performance and consequent to that the mill is one among the Top Sugar Mills in the Punjab Province in terms of sugarcane crushing, production, recovery and efficiency. To keep up with the state of art development in the sugar industry, the company has a continuous program of updating the technology with the aim of improving performance and energy conservation.
- 1.9 Hunza Group of Industries is the leading sugar, edible oil, Vanaspati ghee, CO₂ and ethanol producer in Pakistan since 2002. They have extensive sugar producing units which produce White Refined Sugar, Sugarcane Molasses, Ethanol, Industrial

Alcohol and other allied products, and state of the art ghee mills for edible oil and vanaspati ghee.

- 1.10 HSMPL is located in an excellent cane growing area in the District of Jhang of the Punjab Province. Located on the Layyah road, the mill has good access by road. The factory is about 37 kms from the city of Jhang. The nearest air port is at Faisalabad and the nearest sea port is Karachi at a distance of about 1000 kMs. The factory is well connected by road to Islamabad and Lahore through national high ways.
- 1.11 Sugar Industry in Pakistan is ranked as country's second largest agro based industry after textiles. Presently there are about 83 sugar mills in Pakistan producing about 3.5 million Metric Tonnes of sugar per annum. HSMPL with the daily crushing capacity of 6000 MT is one of the leading mills in the sugar industry. HSMPL is planning to further increase the crushing to 10,000 TCD. Realizing that the cane development is core to the business, the group has good cane development programs to assure continued cane supplies.
- 1.12 The progressive management of HSMPL, considering the very critical power situation in Pakistan and compelled by the eagerness to contribute to the national growth, has decided to get into grid connected power generation by installing a new cogeneration power project in their sugar mill at Hazari. This project will be implemented and operated by a SPV called Hunza Power (Private) Ltd (HPPL). HPPL proposes to implement a most modern high pressure bagasse based Cogeneration in their HSMPL's sugar plant, by replacing the existing low pressure boilers with high pressure boiler so that the factory can generate additional power for export to the power grid. Having decided to implement high pressure bagasse based cogeneration, HPPL have retained Avant-Garde Engineers And Consultants (FZC), Sharjah, as their consultants for the preparation of the Feasibility Report for the installation

of the high pressure bagasse based cogeneration system in their plant. Avant-Garde Engineers And Consultants (FZC) and their group company Avant-Garde Engineers and Consultants (P) Limited, India has vast experience in the design and implementation of High pressure bagasse based Cogeneration projects in India and in other countries.

- 1.13 The subsequent sections of the report highlights, the scheme proposed for the HPPL's Cogeneration project, features of the main plant and equipment, proposed scheme for the power distribution, site facilities, fuel and water schemes, evacuation of the generated power and grid interfacing, water system, environment aspects, estimate of the capital cost and the schedule for the implementation of the proposed project.

2.0 Present Factory Operation, Future plans and Cane availability

- 2.1 HSMPL is planning to upgrade the crushing capacity to 10,000 TCD from the present 6000 TCD. Leaving HSMPL to focus on the core business of sugar, the Hunza Group wants to implement the Cogeneration program at HSMPL through Hunza Power (Private) Ltd (HPPL). HPP, a separate entity, will install the Cogeneration plant and operate the same at/near the premises of HSMPL. When it comes to Cogeneration, unlike in any power plant, the success of the enterprise depends also on the performance of the process plant. In bagasse based Cogeneration, the interaction with the process plant and the power plant is not only limited to steam and power, but includes the fuel supply to the power plant for a substantial period of operation of the power plant and the uncontaminated condensate supply to the power plant. Hence it is imperative that this feasibility report also looks into the status of operation of the process plant and the raw material availability for a reasonably assured fuel supply.
- 2.2 Hunza Sugar Mills (Pvt) Limited (HSMPL) is a 6000 TCD sugar plant operating for an average of about 110 days in a year. The factory has a crushing capacity of about 250 TCH (on 24 hour basis) and the factory is basically a milling plant.
- 2.3 The fibre content on cane is high and hence the bagasse generation in the plant is 30.5% on cane. After a deduction of 1% towards the use of bagacillo (fine bagasse used for enhancing filtration) in the sugar process and towards losses, a bagasse quantity of 29.5% on the cane crushed is available for use in the boilers. In terms of absolute numbers, the generated quantum of bagasse, the quantity used in the process and the quantity available for consumption in the boilers are respectively 76.25 TPH, 2.5 TPH and 73.75 TPH. Because of

this huge bagasse generation, the mill saves quite a lot of bagasse, in its annual operation. The factory presently sells the surplus bagasse to the nearby consumers.

2.4 The plant is located at an altitude of about 158 meters above mean sea level. The global co-ordinates of the plant is 31° 07' 03" N (latitude) and 72° 03' 20" E (Longitude). The average daily maximum temperature varies from around 20 Deg.C in December and January to around 48 Deg.C in April and May. The average daily Minimum temperatures vary from around 6 Deg.C in December and January to around 26 Deg.C in June and July. The average rainfall is insignificant, more often less than 15 mm per annum. The water requirement of the plant is being met from water drawn from bore wells. The ground water availability is good.

2.5 Steam and power are the most essential input for the operation of the sugar process plant. The entire steam and power requirements of the HSMPL's plant are being met from internal generation. HSMPL processes 250 MT of cane every hour and the present steam requirement for processing is 44 % of the cane processed. This works out to an absolute value of 110 TPH. This quantity of steam is used in heating the juice extracted from cane, evaporating the water from the juice in multiple effect evaporators to make syrup and then to concentrate the syrup further to crystallize the sugar from the syrup. The majority of the steam requirement i.e. 107.5 TPH is at a pressure of 2.5 bar(a) and at about 130 Deg.C at the consumption points in the sugar mill and the remaining 2.5 TPH is at pressure of 4 Bar(a) and 150 Deg.C. The total electric power consumption of the sugar mill, as of now is about 6500 kW. Part of the power requirement of the sugar mill is also being supplied by the steam turbine drives (Mill No.1, shredder and cutter No.2) and the balance requirement is being met from in house power generation.

- 2.6 Using the fuel (bagasse) generated in-house HSMPL generates the total steam and power requirements internally. The total steam generation for the plant is being met from two (2) steam boilers. One of the boilers is with the MCR capacity of 70 TPH and the second boiler is with the MCR generation of 40 TPH. All the two existing boilers have the same outlet steam parameters of 24 bar(a) and 340 Deg.C. The boilers are designed to burn bagasse. All the boilers are designed with a feed water inlet temperature of 105 Deg.C, with the feedwater heated in a deaerator. With 110 TPH of aggregate steam generation capacity, both of the boilers will be operating, although under lower capacity, to meet with the process steam requirements of 110 TPH. The boilers are provided with mechanical dust collection systems as the dust collection equipment to capture the ash from the flue gases. Considering the construction and design of the boilers, the steam to bagasse ratio in the boiler, which reflects on the efficiency of the boiler, could be 2.2.
- 2.7 As seen elsewhere in this report, part of the motive power requirements of the plant is supplied by the steam turbine drives. The equipment that are provided with the steam turbine drives are Mill No.1, Shredder and Cutter No.2 of the sugar plant. All the drive turbines are of the backpressure type. The electric power requirement of the sugar plant is being met by three (3) backpressure turbogenerator each of capacity 6 MW, 3.5 MW and 3 MW respectively. The inlet steam parameters to all the turbogenerators as well as the drive turbines are in the range of 22 to 23 bar (a) and about 340 Deg.C. The exhaust temperature is at around 160 Deg.C. This exhaust steam is de-superheated with spray water to around 130 Deg.C and taken to the sugar process. During normal operation, the exhaust steam from the turbines meets with the low pressure process steam requirements. The 4 bar (a) steam and the steam requirement of the unit is being met from the steam drawn through the Pressure Reducing and Desuperheating stations.

- 2.8 Presently, the total power requirement of the plant could be about 26 kW per Tonne of cane crushed and for a crushing rate of 250 TCH, the total power requirement works out to about 6.5 MW. As seen elsewhere, part of this power requirement is presently being met with steam turbine drives and the balance is met through the electric power generation in the turbogenerators. There is one DG set with the capacities of 800 kW with the generation voltage of 415 V. The DG set is used for providing the start up power and emergency power requirements. Apart from this, the plant also has grid power connection with a maximum capacity of 630 kVA. Generally the power drawn from the utility is around 350 kW.
- 2.9 HSMPL has a proper effluent management system in operation. The solid wastes generated in the plant are bagasse, ash and filter cake. The bagasse is used to meet the requirements of the boiler. The surplus bagasse is being sold. The ash and filter cake are good soil nutrients and hence are disposed off to farms and to cane farmers. The liquid effluents are the final molasses and the waste water. The waste water containing washings and leakages is mainly constituted with sugar solution and molasses and hence calls for the proper treatment system before disposal. The wastewater treatment system consists of lagoons for the anaerobic and aerobic processes and then let out to cane fields. The molasses is sold off.
- 2.10 **Future Plans**
- The plant with the present crushing capacity of 6000 TCD is operating quite well. Presently the plant produces more than adequate bagasse to be used as fuel for supplying all the steam and power requirements of the plant. The plant's steam and power consumptions are already optimized. Considering the good cane potential in the area, HSMPL is planning to increase the crushing capacity to 10,000 TCD or 416.67 TCH and the

capacity upgradation will be coincided with the implementation of the Cogeneration program. The implementation of Cogeneration will give a fillip to the energy conservation measures and bring down the sugar plant's energy consumption. With the new Cogeneration plant, the existing boilers, turbogenerators and the drive turbines will be retired. The mills will be driven by AC electric motors through AC variable frequency drives and the shredder will be driven by AC electric Motors. It is expected that the electrical energy consumption in the sugar mill, exclusive of the power consumption in the power plant, will be 26 kW per MT of cane crushed.

3.0 Cogeneration Plant Technology and Scheme Proposed for the Project

3.1 Cogeneration Technology

3.1.1 Cogeneration is defined as the coincident generation of useful thermal energy and Electrical power from the same fuel source. Any process plant requiring steam for the processing, the pressure of steam required for most of the process applications being low, holds very good potential for Cogeneration of Power. With the process steam pressure being low, the high pressure steam produced in the boiler can go through a large expansion in the turbine to generate more power at the turbine shaft. Such a system will supply both power and process steam for the process plant operation and the surplus power could be exported to the grid. With high pressure Cogeneration, a process hitherto producing just the process steam or just producing process steam and adequate power for running the process could generate more power and export to the grid. With the adoption of Cogeneration, the need for new energy projects can be reduced, resources can be preserved, and energy costs and environmental damage can be minimized, and these benefits can be the greatest when renewable bio-mass is used as the fuel for running the Cogeneration plant.

3.1.2 Sugar Plants are particularly interesting applications for Cogeneration, since bagasse, one of the waste product from the mill, is available readily as feed stock to fuel the steam generators of the Cogeneration plant. The sugar manufacturing process requires thermal energy in the form of steam and also the bulk of the steam required for the processing is needed at low pressure such as 2.5 bar(a). This process steam is required for concentrating the sugar cane juice to a super saturation level where the sugar (sucrose) starts crystallizing. Sugar plants also need a lot of power for powering the various

equipment and almost all the sugar mills are designed with self generation of power using the steam required for the process. As sugar plants, hitherto, had limited power and heat generation to meet only their own in-house demands, their existing energy potentials had not been fully exploited. However the scenario is fast changing throughout the world, for good, with sugar mill bagasse based Cogeneration already implemented in many countries and other countries following suit.

- 3.1.3 One of the major advantages with the bagasse based Cogeneration projects is that the fuel, atleast for a substantial period of operation of the power plant will be generated within the sugar mill. The cane residue, what remains after the juice is squeezed out, is called the bagasse and is an excellent fuel. In the sugar mills, the bagasse conventionally had been combusted in a boiler, to provide the required energy for the operation of the sugar mill. With Cogeneration, which aims at putting the bagasse to better use, it is important that we look at the technology options available which could use the bagasse in the most efficient way.
- 3.1.4 Gasification is the most promising technology and could be the technology of the future for most of the bio-mass fuels. A lot of work is going on in this field and a few small scale projects had also been put up. However the technology has not come to a stage where large scale plants, such as the one planned for HPPL, could be put up without any commercial risk. Hence this option of gasification is not pursued. The only other option to use the bagasse effectively is the combustion route, where the bagasse is combusted in a boiler to generate steam. The boiler technology today is well advanced and a range of technologies like the travelling grate, atmospheric fluidized bed combustion (AFBC), circulating fluidized bed combustion (CFBC) and pulverized fuel (PF) combustion are available for firing solid fuels. However because of the nature of and characteristics of

bagasse, the fluidized bed technologies (both AFBC and CFBC) and the pulverized fuel combustion technologies are not suitable for the stand alone combustion of bagasse. The boilers designed with these technologies, can fire a quantum of bagasse equivalent to only a small percentage of the total heat input to the boiler, along with coal. Increasing the coal consumption in these plants just to accommodate the combustion of the bagasse will not be a viable proposition. Some attempts had been made to integrate the travelling grate or pinhole grate technology with a PF technology, but the applicability of this design for firing stand alone bagasse/coal firing, the cost and efficiency are questionable. So, for all practical purposes, the travelling grate technology will be the best suited for this specific bagasse based Cogeneration application. The travelling grate technology may not be the best for coal, as other technologies like CFBC and PF are the best suited for coal, but however with two totally different types of fuels and with other technologies not suitable for bagasse, we need to compromise and settle for the travelling grate. So, the plant for using bagasse as the fuel will look like a regular power plant, operating on the Rankine Cycle, with a travelling grate fired boiler and with a turbine which is designed to supply the process steam from its extraction ports.

- 3.1.5 High pressure and high temperature cycles are crucial for increasing the operating efficiency and the power output from the Cogeneration Plants. **The choice of the level of the pressure and temperature for the cycle depends on the level of confidence in the plant operators, quality of the feed water and the water treatment systems available and the cost of the high pressure/temperature boiler and Turbogenerator systems and the financial benefits realizable from the Cogeneration plant by way of the sale of the exportable power.**

- 3.1.6 Thermodynamically, energy recovery from the Rankine Cycle is more dependent on the steam inlet temperature than the pressure and the higher the inlet steam temperature, higher the cycle efficiency. However, the practically attainable limits of temperatures are influenced by the metallurgy of the boiler tubing, piping and the turbine components and the complexity of the Creep fatigue interaction for the materials at higher temperatures. Also due to the peculiar properties of steam and water, to extract the maximum energy from steam, it is necessary to appropriately increase the pressure of steam while increasing the temperature of steam.
- 3.1.7 The operation of the Cogeneration Units commissioned so far in the sugar mills, have given valuable information with regard to the performance of the Units specifically in respect of the superheater performance and the steam outlet temperatures. Enough operating experience is now available to evaluate the performance of high pressure and high temperature units in a sugar plant environment. Having gained a lot of experience with the operation at superheater temperatures at 480 Deg.C and later with 510 Deg.C and finding that there is no problem in operating the high pressure and high temperature boilers, it has been decided to look at the enhancement of the operating parameters to get a much better cycle efficiency. The technology with this high a superheater temperature has been finetuned and plants based on these steam temperatures are already in operation. Looking at the present state of art of technology, worldwide and the experience gained so far, it has been decided to go with the steam temperature of 535 Deg.C, at the inlet of the turbine.
- 3.1.8 Looking from purely the Cycle Efficiency point of view, with the selection of 535 Deg.C as the steam temperature, the Thermodynamic laws, typical construction of the turbine blading and the practical extent of steam expansion possible in the turbines, limitation on the moisture percentage in the

exhaust steam etc., dictate the limits of cycle pressures. Looking into all these factors it has been decided to go with the turbine inlet steam pressure of 105 bar(a).

- 3.1.9 Based on the considerations enumerated in the preceding paragraphs, the cycle parameters are decided as 105 bar(a) and 535 Deg.C at the turbine throttle valve inlet. Correspondingly the boiler outlet parameters shall be 110 bar(a) and 540 Deg.C, accounting for the pressure and temperature losses in the piping. Plants with the above parameters have been commissioned and are operating successfully in India. Plants with similar parameters are also in operation in the Reunion Island (France). Recently, 2 x 31.2 MW cogeneration plant with the same parameters are commissioned and successfully in operation for last eight months in Pakistan. The operating experience so far has shown that there are no technical barriers for the design and building of high pressure and high temperature Cogeneration systems in sugar mills, based on the above steam parameters. However the same experience has also shown that prudent operating practices are required to ensure high efficiency and high availability of these plants. With the cost of energy increasing, it is only prudent that the available energy sources are put to better use by going in for the latest and efficient technology at the same time taking care of the stringent requirements of the operation and

3.2 Cogeneration Plant Proposed for HPPL

The Cogeneration plant proposed of HPPL will be based on the boiler outlet steam parameters of 110 bar (a) and 540 Deg.C. The steam parameters at the inlet of the turbine will be 105 bar(a) and 535 Deg.C. The plant will be capable of meeting all the process steam and power requirements of HSML's sugar mill's expanded capacity at 10,000 TCD crushing. Operating in synchronization with the sugar mill and with the national electricity grid and using the bagasse generated in the sugar

mill during the season operation, the Cogeneration plant will export power to the sugar mill and to the grid. During the off-season the sugar mill does not operate but the Cogeneration power plant will operate, in full power generation mode, on the saved bagasse and / or on compatible bio-mass fuel to export bulk of the power generated to the grid.

3.3 Basis of the Feasibility Study

The following points pertaining to the plant operating parameters, availability of raw materials, process steam requirement, operation of the existing boiler & turbogenerator etc., are the basis on which the program for the implementation of the Cogeneration project at the complex of HSMPL is developed.

- 3.3.1 The nominal cane crushing capacity of the sugar plant, for designing the Cogeneration plant, will be 10,000 TCD in 24 hours or 416.67 Tonnes of Cane per Hour (TCH). The plant will continue to be with the milling system for juice extraction.
- 3.3.2 The nominal crushing period for the HSMPL's sugar plant will continue to be an average of 110 days in a year. The plant crushes continuously for the above period and then the plant is taken for the off-crop maintenance. During the crushing period the plant will operate continuously but for occasional shutdowns for plant cleaning and maintenance and for reasons of non-availability of cane for short durations.
- 3.3.3 HSMPL being relatively a new mill a lot of improvements had been incorporated over the contemporary mills to enhance the efficiency of operation and to optimize the energy consumption. The present crushing capacity of 6000 TCD will be upgraded to 10,000 TCD to coincide with the implementation of the Cogeneration plant. Considering the efforts being made by HSMPL and cane development programs being initiated by them

it is expected that the overall plant capacity utilization will not be less than 90% when the crushing capacity is up rated to 10,000 TCD and the Cogeneration program is implemented.

- 3.3.4 The average bagasse percentage on cane is 30.5% and a provision of 1.0% is made for meeting with the requirements of bagacillo for vacuum filtration and to account for losses. The balance of 29.5% (on cane) of bagasse will be available for the operation of the Cogeneration plant. With 416.67 TCH of crushing the bagasse generated in the plant will be 127.08 TPH. Out of this 4.17 TPH of bagasse (about 3.2% of the bagasse generated) is set aside for meeting with the above indicated bagacillo requirements, losses and the start up requirements of the boiler and the balance is taken to be available for using in the Cogeneration plant. This much quantum of bagasse will be available in HSMPL for sale to HPPL.
- 3.3.5 The bulk of the process steam requirement of the sugar mill, at the consumption point, is at the pressure of 2.5 bar(a) and at saturated temperature at 127.43 Deg.C. The requirement of this low pressure steam shall be 41% of the cane crushed. In addition to the above the process also needs 1% of the cane crushed at 8 bar(a). The temperature of this 4 bar(a) steam will be 140 Deg.C. On the whole the total process steam consumption comes to 42% on cane. Considering the fact that HSMPL manufactures white refined sugar, this steam consumption may be only slightly on the higher side. As HSMPL is constantly modernizing and updating the technology, this steam consumption could also come down to 38 to 40% on cane. The actual quantities of 2.5 bar (a) and 8 bar(a) steam required by the mill are respectively 170.83 TPH and 4.17 TPH.
- 3.3.6 With the view of enhancing the export from the Cogeneration plant, HSMPL/HPPL will be replacing the inefficient steam turbine drives in the sugar mill with electric motors drives. Mill No.1 Shredder and cutter No.2 is presently driven by steam

turbine and the same will be replaced with electric motors. The power requirement of the sugar mill, once the energy conservation measures are implemented, exclusive of the power requirements of the Cogeneration plant will be 26 kW per MT of hourly cane crushed. The total consumption comes to 10,833 kW. After the implementation of the Cogeneration plant, all the rotating equipment in the sugar mill will be electric motor driven and there will be no steam driven drives. This entire power requirement of the complex will be met from HPPL's Cogeneration plant.

- 3.3.7 The sugar mill presently operates 1x70 TPH and 1x40 TPH boilers, with the outlet steam parameters of 24 bar (a) and 340 Deg.C. HSMPL also operates 1 x 6 MW, 1 x 3.5 MW & 1 x 3 MW backpressure type Turbogenerators. With the commissioning of HPPL's Cogeneration plant, all the existing low pressure boilers and turbogenerators at HSMPL will be retired.
- 3.3.8 The Cogeneration plant boilers will be designed with a travelling grate with hydraulic drive to burn bagasse, and compatible bio-mass. The outlet steam parameters will be 110 bar (a) and 540 Deg.C. Each boiler MCR capacity will be 135 TPH and there will be two (2) boilers. The inlet feed water temperature will be 210 Deg.C, with the feed water heated in two stage high pressure feed water heaters. The deaerator outlet water temperature will be around 130 Deg.C, depending on the extraction pressure.
- 3.3.9 The proposed new turbogenerators will be of 24.9 MW nominal capacity each and there will be two (2) turbogenerators. The turbines will be extraction condensing type machines. The turbine steam inlet parameters will be 105 bar (a) and 535 Deg.C and there will be three steam extractions from the turbine. Out of the three, two will be un-controlled extractions and the third will be a controlled extraction. The first un-controlled extractions will be at 22 bar (a) and the extracted steam will be used for the feed water heating in the second

high pressure feed water heater. The second un-controlled extractions will be at 10 bar(a) and the extracted steam will be used for the feed water heating in the first high pressure feed water heater and for meeting the plant's 8 bar(a) process steam requirements. The controlled extraction will be at 3 bar(a) and this steam will be used in meeting the requirements of the sugar process at 2.5 bar(a). The extraction steam at 3.0 bar(a) will also be used for feed water heating in the Cogeneration plant's deaerator. The exhaust steam from the turbine will be condensed in the turbine water cooled surface condenser.

- 3.3.10 The deaerator will be serving the dual purpose of deaerating the feed water as well as heating the feed water, to raise its temperature, with the extraction steam. The deaerator will be operating at around 2.7 bar(a) pressure, with the deaerated feed water temperature at around 130 Deg.C. The deaerator will receive the condensate from the surface condenser, the condensate of the heating steam from the sugar process and the feed water make up. The condensate of the heating steam from the feed water heaters will be cascaded to the deaerator, to optimally use the energy in the feed water heating steam.
- 3.3.11 Once the Cogeneration program is implemented, the entire process steam requirement of the sugar mill will be catered by the steam drawn from the turbine extraction. Suitably sized pressure reducing and de-superheating stations will be provided for meeting the total process steam requirement of HSMPL, in case of any problem in drawing the steam from the turbine extraction. The turbine extraction could get disabled when there is a grid failure and the turbine is forced to operate only for meeting the house loads.
- 3.3.12 The power generation in the new Cogeneration turbogenerators will be at 11 kV level. The new turbogenerators will be operating in parallel with the national grid. Entire power

requirement of the sugar plant and the entire power requirement of the auxiliaries of the new Cogeneration boiler and TG system will be met by the power generated in the new turbogenerators. The balance of the power generated in the plant will be exported to the grid.

- 3.3.13 The exportable power will be stepped up to 132 kV and will be connected to the FESCO and 18 Hazari 132kV feeder with loop in loop out (LILO) arrangement which is approximately 3 km from the plant.
- 3.3.14 As discussed in detail elsewhere in this report, the water requirement of the sugar mill is presently being met by the drawls from the deep bore wells. With the excellent system of irrigation with Chenab River as the source there could never be any problem of water availability. As the availability of water is good it has been decided to go with water cooled condensing system for the Cogeneration plant. For meeting with the makeup water requirements of the plant, the raw water from the existing bore wells will be used and in case of any shortage additional bore wells will be made for the drawl of more water. The existing deep bore well system in the sugar plant is having a yield of about 300 Cu.m/hr and the present consumption in the sugar mill is about 100 Cu.m/hr. possibly additional deep bore wells will have to be arranged. The new system will include the storage reservoir, Ultra-filtration, Reverse Osmosis and De-mineralization system and the storage tanks.
- 3.3.15 Presently there will be no distillery or any other chemical process plant with in the complex of the sugar mill.
- 3.3.16 The primary responsibility of the Cogeneration plant, during the season operation, is to provide the process steam and the required electrical energy to the sugar mill. The export of power to the grid comes after meeting with the above in-house requirements. As the bagasse percentage in cane is high, even

after meeting with the requirements of the operation of the new Cogeneration plant there will be some surplus bagasse left. This surplus bagasse will be used for the operation of the Cogeneration plant during the maintenance days and also for a few days in the off-crop period. Once the Cogeneration plant is commissioned even if the sugar mill stops for maintenance work, the power plant will keep running. During such periods of running, there will be no requirement of process steam and the Cogeneration plant will essentially operate in a condensing mode and will generate power. Power supply to the grid will be maintained continuously.

3.4 Description of the Proposed Cogeneration Scheme

3.4.1 The Cogeneration scheme proposed, at HPPL, envisages two identical units of 24.9 MW capacity each. Each unit will be designed with a 135 TPH capacity boiler with the outlet steam parameters of 110 bar(a) and 540 Deg.C, with the feed water inlet temperature of 210 Deg.C. Each of the Turbogenerators will be of 24.9 MW nominal capacity and designed with an extraction (with two uncontrolled extractions and one controlled extraction) condensing turbine. The Cogeneration plant will be designed with all the auxiliaries for the new boilers and the turbogenerators and with all the auxiliary plant and systems like the fuel and ash handling system, Cooling water system, feed water system, Raw water and DM water system, Instrument air system, Electrical system for its successful operation.

3.4.2 The Power generation in the Cogeneration turbogenerator will be at 11kV. Step down transformers will be provided to step down the 11 kV voltage for feeding the sugar and Cogeneration plant equipment and auxiliaries. The additional power from the turbogenerator will be stepped up to 132 kV for paralleling with the national grid at FESCO-18-Hazari 132kV Feeder through

Loop in Loop Out Arrangement (LILO), which is a distance of 3km from the plant.

- 3.4.3 The new Cogeneration turbine will be provided with a controlled extraction at 3.0 Bar(a) for meeting the entire 2.5 bar(a) process steam requirements of the sugar plant. There will be one uncontrolled extraction at 10 bar(a), for meeting the feed water heating requirements in the first high pressure feed water heater. Another uncontrolled extraction at 22 bar(a) will meet with the requirements of the second high pressure feed water heater. As the plant is designed to operate during the off-season period, the turbine surface condenser will be sized for taking in the off-season exhaust flow and the system will meet comfortably with any fluctuating steam demand from the sugar process.
- 3.4.4 The 2x24.9 MW Cogeneration plant consisting of the new 2x135 TPH boiler and the 2x24.9 MW turbogenerator and all the auxiliary plants and systems will be located within the sugar mill complex. The locations of the various plants with in the sugar mill complex are elaborately dealt with in the subsequent section on the "Site Features and Plant layout".
- 3.5 **Operation of the proposed Cogeneration System**
 - 3.5.1 **Season Operation**
 - 3.5.1.1 Fig. 3.1 gives the Scheme of operation of one 24.9 MW Unit of the proposed new 2x24.9 MW Cogeneration plant. **All descriptions pertaining to the configuration of the power plant below are given for a single unit.** There will be two such identical units in the Cogeneration plant. This system is configured with a 135 TPH boiler and an extraction-condensing 24.9 MW turbogenerator. During the normal crushing period operation, the 135 TPH boiler will generate 135 TPH of steam with the outlet parameters of 110 bar (a) and 540 Deg. C.,

while taking in the feed water at 210 Deg.C from the high pressure feed water heaters. During the season operation, the boiler essentially operates on bagasse and consumes 50.37 TPH of bagasse, for the generation of the above said 135 TPH of high pressure steam.

- 3.5.1.2 The entire steam generated in the boiler is fed to the extraction-condensing turbogenerator. The un-controlled extraction from the turbine at 22 bar(a) gives 10.22 TPH of steam at a temperature of 321.7 Deg.C. The entire quantum of 22 bar(a) steam will be used in the high pressure feed water heater II for raising the feed water temperature from 170 Deg.C to 210 Deg.C. The un-controlled extraction at 10 bar(a) gives 11.23 TPH of steam approximately at a temperature of 233.4 Deg.C and this meets with the requirements of the high pressure feed water heater I, 4 bar(a) steam requirements of the sugar mill process and the requirements of the ejector in the condenser. A quantity of 8.63 TPH is supplied to the high pressure feed water heater, to heat the feed water from 130 Deg.C to 170 Deg.C, a quantity of 2.1 TPH goes towards meeting part of the sugar mill process requirements and the balance of 0.5 TPH of steam will be used in the ejector for pulling vacuum in the surface condenser.
- 3.5.1.3 The controlled extraction at 3.0 bar(a) provides 90.76 TPH of steam at around 133.5 Deg.C. Out of this 85.42 TPH of steam is taken to the sugar process, for heating and boiling the sugar cane juice in the evaporator system. Considering the piping pressure drop, the steam pressure available at the calandria of the sugar mill evaporator section will be 2.5 bar(a), as required by the process. About 5.34 TPH of steam will be supplied to the deaerator for deaeration of the boiler feed water and for heating the condensates and the makeup water to 130 Deg.C.
- 3.5.1.4 A condensate quantity of 167.4 TPH of process steam supplied to the sugar mill, will be returned back to the deaerators to be

used as boiler feed water. There will be a loss of a maximum of about 3% of the quantity of steam supplied and the balance is returned to the Deaerator as condensate.

- 3.5.1.5 One of the most important aspects of operating a Cogeneration plant in synchronization with a process plant is to ensure uncontaminated condensate return from the process plant. The sugar process generates a lot condensate in the multiple evaporator system and in the pans and most of these condensates are used in low pressure boilers. However as the high pressure boilers are very sensitive to the feed water quality, most of the condensate from the sugar process cannot be used as boiler feed water. Usage of the exhaust/extraction condensate, from the first body of the multiple evaporator system, only is permitted as boiler feed water. This condensate will be available almost at 115 Deg.C and could be directly inducted into the Cogeneration plant's deaerator. However the condensate temperature of 100 Deg.C is assumed in arriving at the heat and mass balance. The cycle make up water for the operation of the Cogeneration plant will be only de-mineralized water, from a new RO system based water treatment plant.
- 3.5.1.6 The difference in the steam supplied to the turbine and the steam extracted through the two extractions, being approximately 15.93 TPH, is taken through the LP stages of the turbine and exhausted to the turbine surface condenser. The condenser operates at about 0.075 bar(a) pressure¹ and all the steam condenses and the condensate collected in the condenser hot well is pumped through the condensate extraction pumps to the Deaerator water storage tank. In addition to the above quantity, the condensate from the gland steam condenser and

¹ The condenser is basically designed for condensing the steam exhausted during the off-season operation. The off-season exhaust flow is high compared to the season exhaust flow. As the exhaust flow is less during the season, the vacuum will be better and the condenser operating pressure will be lower than 0.1 bar(a) during the season operation.

the ejector condensers is added to the feed water system through the hotwell.

3.5.2 Power Balance during the Season Operation

3.5.2.1 With the installation of the new 2x24.9 MW Cogeneration plant, the total power generation in the sugar plant, under 416.67 TCH crushing will be 49,800 kW, and the Fig. 3.2 gives the power balance for the plant, during the seasonal operation. The power generation will be at 11 kV level in the new Cogeneration plant. The power consumption of the auxiliary equipment of the new Cogeneration plant will be 4,482 kW. This comes to about 9.0% of the electrical power generated. The total power requirement of the sugar plant including the power requirement of the colony, ETP, administration buildings etc., is estimated to be 10,833 kW.

3.5.2.2 With the in-house auxiliary consumption of 4,482 kW and with the power export of 10,833 kW to the sugar mill complex, the export power to the national grid comes to 34,485 kW. This exportable power at the generation voltage of 11 kV will be stepped up to 132 kV in the generator transformer in the plant's switchyard and supplied to FESCO grid at 132kV level by Loop in Loop out arrangement in FESCO-18 Hazari 132kV Feeder, which is at a distance of 3 km from the plant..

3.5.3 Off-Season Operation

3.5.3.1 This mode of operation, in addition to its application in the off-season period, is applicable even for the sugar plant maintenance period. On the days when the sugar plant is shut down for maintenance, there is no need for the Power plant to be shutdown. The Power plant could run in power generation mode as it will operate during the off-season period.

- 3.5.3.2 Fig.3.3 enclosed to this section of the report gives the scheme for the operation of the 49,800 MW Power plant system during the off-season period of the sugar plant. **The description given below for the plant operation pertains to the operation of one of the two units.** Each of the 135 TPH boilers will generate 143.6 TPH of steam at the outlet parameters of 110 bar(a) and 540 Deg.C. The generation in the boilers is restricted to match with the turbogenerator requirement for generating 24.9 MW under operation with no steam extraction from the turbine port for the sugar mills process. The gross power generation in each of the turbogenerators will be 24.9 MW. The feed water will be supplied to the boilers at 201.5 Deg.C., from the high pressure feed water heaters. This is mainly because of the reduction in the uncontrolled extraction pressure during the off-season period, due to the reduction of steam flow to the turbine, consequent to the condensing mode of operation with no steam extraction. Each of the boilers consumes 38.73 TPH of bagasse, if operated with bagasse. Once the available compatible bio-mass fuel is identified, the quantity of fuel to be consumed by the boiler could be worked out.
- 3.5.3.3 The total steam quantity of 98.75 TPH generated in the boiler will be fed into the 24.9 MW turbine. The uncontrolled extraction at 22 bar(a), now supplying steam only at 16.54 bar(a) will be 6.18 TPH at about 319.5 Deg.C. The entire steam quantity will be supplied to the second stage High pressure feed water heater. The second uncontrolled extraction at 10 bar(a), now supplying steam at only 7.86 bar(a) will be supplying 6.69 TPH of steam. Out of this 6.19 TPH will go to the first stage high pressure feed water heater and the balance of 0.5 TPH will be supplied to the ejectors. There will be no process steam requirement, to the sugar mill under the off-season operation. The controlled extraction gives 8.89 TPH and the entire quantity will be supplied to the deaerator. The balance quantity of steam input to the turbine less the extractions

amounting to approximately 75.06 TPH is supplied to the LP section of the turbine and is then exhausted into the surface condenser at a condenser operating pressure of 0.1 bar(a). The condensate collected in the condenser hot well is evacuated with the condensate extraction pumps to the power plant's deaerator. After deaeration, the water collected in the deaerated water storage tank will be pumped to the boiler by the boiler feed water pumps.

- 3.5.3.4 With the above given steam input and extractions the 24.9 MW turbogenerator generates 24,900 kW at the generator terminals.

3.5.4 Power balance during the off-season Operation

The total gross power generation from the 2x24.9 MW TG systems will be 49,800 kW. The Fig. 3.4 gives the power balance for the off-season operation. The sugar plant just needs power for the running of the workshop, for meeting its maintenance loads, for meeting the requirement of the colony and for meeting the estate loads, the total of which is estimated to be 500 kW. The auxiliary power consumption for the 2x24.9 MW Cogeneration system is estimated to be 4,233 kW, during the off-season. Even though there will be some reduction in the power consumption of the boilers, compared to the season operation, there will be increased consumption in the fuel handling and in the cooling towers. With the in-house auxiliary consumption of 4,233 kW and with the power export of 500 kW to the sugar mill complex, the export power to the national grid comes to 45,067 kW.

4.0 Fuel for the Power Plant & Plant Efficiencies

4.1 Design Fuel

4.1.1 The proposed Cogeneration power plant of HPPL will be designed for operation with bagasse as the main fuel and with other compatible bio-mass fuels. Bagasse is the cane residue that remains after the extraction of the juice from cane and this bagasse will be supplied to HPPL under the fuel sale agreement with HSMPL. This bagasse will be supplied to HPPL during the cane crushing operation of HSMPL. After the completion of the cane crushing period, the power plant will operate with the bagasse saved during the season operation after exhausting the saved bagasse the power plant operation will continue depending on the availability of acceptable bio-mass fuels. HPPL will look for compatible bio-fuels to supplement bagasse so that the plant could be run for a longer duration with bio-mass fuels. Even if such a compatible bio-mass fuel is available during the season operation, the same could be used during the crushing season with bagasse and an equivalent amount of bagasse could be saved to be used in the off-season. As of now, for the purpose of this feasibility report only bagasse is considered as the fuel. HPPL will undertake a study on the availability of the bio-mass fuel in the plant's vicinity and the decision to use those fuels will be taken after a detailed study of the fuel and ash characteristics.

4.1.2 Bagasse

4.1.2.1 Bagasse is a bio-mass fuel and is considered to be belonging to the category of renewable energy source. Bagasse, as is the sugar cane crop, is a product of photosynthesis and hence is renewable. As long as the cane crushing continues in the sugar mill, the bagasse will be available year after year. Bagasse, being a bio-mass is considered to be carbon neutral and hence is

environment friendly. The constituents of the bagasse are given under Section-6 "Cogeneration Plant Design Criteria" of this report. Bagasse is considered to be a good fuel, except that the moisture content in the as milled bagasse is quite high at about 50% and the average bulk density of the milled bagasse is at around 150 kg/Cu.m. The quantity of bagasse generated in the sugar mill and the quantity made available for the operation of the HPPL are dealt with in the Section 3 "Technology and Proposed Scheme for the Project".

- 4.1.2.2 The major advantage of using the bagasse in the Cogeneration power plant, located within the sugar mill complex, is that no transportation of the fuel is involved. The bagasse will be consumed in the vicinity where it is generated. The milled bagasse will be transported to the Cogeneration plant through conveyors and the surplus bagasse will be stored for future use.

4.2 HHV and LCV of the Fuel

- 4.2.1 The Higher Heating Value (HHV) or the Gross Calorific Value (GCV) includes the heat of vaporisation of water in the heating value of the fuel. In addition to the moisture in the fuel which vapourizes during the combustion, water vapour is formed during combustion of all fuels that contain hydrogen. The heat content of a fuel depends on the whether this water vapour remains in vapour state or is condensed to liquid, to recover the latent heat of water vapour. HHV considers that the water vapour is condensed and hence the heat of vaporization is included in the heating value. The Lower Heating Value (LCV) of the Net Calorific Value (NCV) considers that all the water vapours released in combustion remains in the vapour state and the latent heat of vaporization is not available as the heating value of the fuel.

- 4.2.2 The design fuel, namely the bagasse, is with the HHV of 9311.44 kJ/kg. As the plant efficiencies, referred by the

Regulatory Authorities are based on the Lower Calorific Value (LCV) of the fuels, the following gives the calculation of the LCVs from the HHVs for the design fuels.

- 4.2.3 For solid fuels the HHV and the LCV, in SI units, are related by the following formula:

$$LCV = HHV - (218.55 * H_2\% + 24.28 * H_2O \%)$$

- 4.2.4 For Bagasse, $LCV = 9311.44 - (218.55 * 2.895 + 24.28 * 50)$

$$LCV = 7457.09 \text{ kJ/kg}$$

4.3 Fuel Balance during the Seasonal operation

- 4.3.1 Fig.4.1 attached to this section, gives the fuel balance for the operation of the Cogeneration plant with the bagasse supplied from the sugar mill. With the bagasse (50% average moisture) percentage in cane being 30.5%, on an average, and with the crushing rate of 416.67 TPH of cane the bagasse generated will be 127.08 TPH. Out of this about 4.17 TPH of bagasse is set aside for accommodating the requirement of bagacillo for vacuum filtration, the losses during the conveying, windage and to meet with the additional bagasse requirement during the start up of the boilers. However considering the cane qualities, stoppage in crushing, fibre content in cane etc., the quantum of bagasse generation, all contributing to about 90% capacity utilization, the seasonal bagasse generation will be 301,942 MT.

- 4.3.2 Generating 135 TPH, each of the Cogeneration plant boilers consume 50.37 TPH of bagasse. Both the boilers consume 100.74 TPH and the seasonal consumption comes to 239,369 MT. This leaves a surplus of 52,666 MT and the same is stored for the operation of the Cogeneration plant during the maintenance period of the sugar mill and in the off-season period.

- 4.3.3 The plant sizing and the quantum of bagasse generated, make it possible that the plant operates on bagasse throughout the seasonal operation. However it is to be understood that the cane availability to the sugar mill depends on the climatic conditions and the yield of the sugar cane per acre. This also depends on how the farmers find the sugar cane crop attractive compared to the other crops in the region. HPPL's idea is to operate the plant more as a plant using the renewable bio-mass fuels rather than running the plant on any fossil fuel. However it is to be understood that the cane availability follows no logic and during some years which comes in cyclically, the cane availability, could go down. Under those conditions, the plant will be operating with bagasse, whatever is available, supplemented by compatible bio-mass fuels. The boilers are designed for such an operation.

4.4 Fuel Balance for the off-season Operation

- 4.4.1 As seen earlier, after the consumption of the bagasse in the season operation, a quantity of 52,666 MT of bagasse will be left out for the operation of the power plant during the off-season. For the off-season operation, the bagasse requirement will be 38.73 TPH per boiler, aggregating to 77.46 TPH for both the boilers. With this saved bagasse the power plant can run for about 31 days in the off-season. The number of off-season operation days could be improved with the availability of some compatible bio-mass fuels. The Fig.4.2 attached to this section gives the fuel balance for the off-season operation.

4.5 Efficiency of Operation during the Season

- 4.5.1 It is proposed to operate the new high pressure Cogeneration plant boilers with bagasse during the seasonal operation. The boiler designed for bagasse could also use other compatible bio-mass fuels comfortably, but the quantum of such fuel usage

depends on the fuel and ash characteristics. However for the purpose of this report it is assumed that enough bagasse will be available under the normal circumstances for the full seasonal operation. The boiler efficiency with HHV of bagasse is estimated to be an average of 71%.

- 4.5.2 The boiler efficiency with LCV of bagasse will work out to 88.6%. The HHV and the LCV of 50% moisture bagasse respectively are 9311.44 kJ/kg and 7457.09 kJ/kg.
- 4.5.3 The net electrical output of the power plant during the season operation will be 45,318 kW, considering the auxiliary power consumption of 4482 kW in the Cogeneration plant. However a Cogeneration plant gives both electrical and thermal energy outputs. The thermal energy output is supplied through the process steam supplied to the sugar plant. The total process steam supplied to the sugar mill is 170.83 TPH at the parameters of 3 bar (a) and 131 Deg.C and 4.2 TPH at 4 bar(a) and 175 Deg.C. Each kg of 3 bar (a) process steam carries a thermal energy of 2702.8 kJ and the each kg of 4 bar(a) process steam carries a thermal energy of 2752.78 kJ. The condensate received from the sugar mill carries a heat energy of 418.92 kJ/kg.
- 4.5.4 The fuel supplied for the operation of both the boilers will be 100.74 TPH of bagasse with the gross calorific value of 2224 kcal/kg or 9311.44 kJ/kg. The LCV of the fuel will be 1781.09 kcal/kg or 7457.09 kJ/kg. The Fuel heat input, based on LCV of the fuel, to the boilers per hour will be 751.227 GJ /hr.
- 4.5.5 The Cogeneration plant efficiencies are expressed in many ways. The electric efficiency of the plant is the plant will be electrical energy generated as a percentage of the total fuel heat input. This is not the true reflection of the plant efficiency as this omits the thermal energy output from the plant altogether. **However the net electric efficiency of the**

plant will be 21.72% ($45318 \times 3600 \times 1000 / 751.227 \times 10^9$). This is the efficiency during the season operation of the Cogeneration plant. Taking into consideration the thermal energy supplied from the Cogeneration plant, the efficiency, called the Combined Heat and Power (CHP) Efficiency works out to 76.27%.

- The net electric power : 45,318 kW
: 163.145 GJ/hr.
- Heat energy supplied to
Sugar process : 476.46 GJ/hr
- Heat Energy returned to
Cogeneration plant : 66.63 GJ/hr
- Net Thermal Energy Supplied : (476.46 - 66.63)
per Hour : 409.83 GJ.

CHP Efficiency : $((163.145 + 409.83) / 751.227) \times 100$
: 76.27%

4.6 Efficiency of Operation during the Off-Season

4.6.1 As seen earlier in this section of this report, the plant will be operating with bagasse and compatible bio-mass fuels during the off-season. However for the purpose of this report the off-season fuel is restricted to saved bagasse from the season operation. Under bagasse firing, the boiler efficiency with HHV of bagasse is estimated to be 71%. The boiler efficiency with LCV of bagasse will be 88.6%.

4.6.2 The net electrical output of the power plant during the off-season operation will be 45,567 kW, considering the auxiliary power consumption of 4,233 kW while plant running in the power plant mode. During the off-season operation there will

be no requirement of process steam for the sugar mill and hence there will be no thermal energy output from the plant to the sugar mill. The Cogeneration plant will supply electric power to the sugar mill for the maintenance work of the sugar mill and also for meeting with the requirements of the colony and the offices. The requirement of the sugar mill's off-season power is estimated to be 500 kW. The power export to the grid will be 45,567 kW.

4.6.3 The fuel supplied for the operation of both the boilers, under bagasse firing will be 77.46 TPH. The Fuel heat input to the Cogeneration power plant, based on LCV of bagasse, per hour of off-season operation will be 577.238 GJ/hr.

4.6.4 The net electric efficiency of the plant, based on LCV, under bagasse firing will be 28.41% $(45,567 \times 3600 \times 1000 / 577.238 \text{E}09)$.

4.7 **Commentary on the Plant Efficiency**

4.7.1 Conventionally the bagasse fired boilers in the sugar mills had been designed for lower operating pressure and temperatures (24 bar(a) & 350 Deg.C), as these were expected to meet only the in-house steam and power requirements. With the advent of the concept of additional power generation in the Cogeneration plants in the sugar mills, the steam parameters were gradually increased to enhance the power generation from the same fuel quantity. However, still the sizes of these plants remain in the Industrial plants category. Systems like feed water heating were introduced, later, to improve the plant efficiency. Still these efficiencies and heat rates cannot compete with even the sub-critical utility thermal plant efficiencies. The following gives a few of the reasons for the lower efficiencies of these plants compared to utility plants:

- a. With the Cogeneration plant sizes being small, the boilers and turbines are designed only for medium pressures (60 bar to 110 bar pressure are in the medium pressure range). On the temperature front the modern plants come closer to the sub-critical utility parameters, but the pressure still remains lower.
- b. The boilers and Turbine manufacturers have typical Industrial equipment standards and try to fit these plants into the existing designs.
- c. These sizes of plants typically do not use reheat cycle.
- d. The size of the turbines does not allow many extractions and hence the extent of use of regenerative feed water heating is limited.
- e. As discussed in the section on "Technology and Proposed Scheme for the Project" only travelling grate design boilers will be suitable for these applications and this limits the boilers efficiencies atleast by 2 to 3%.

However the cycle and the scheme proposed for this plant are with the best efficiencies possible for such applications.

5.0 Justification for the Project

5.1 To meet Country's Growing Energy Need

5.1.1 Pakistan's fast growing economy and demography put matching demand on the energy availability. With the current installed generation capacity of about 20,000 MW, it is estimated that the demand for electricity in 2030 will grow to 100,000 MW. About 33% of the current installed generation comes from Hydro electric plants and the rest of it comes from thermal plants. However a substantial part of the thermal power, to the extent of 65% comes from gas and oil and about one percent comes from coal fired power plants. Contrary to this the neighbouring China and India almost generate about 70% of the electricity from coal. The country's hydroelectric potential is estimated to be about 25,000 MW and the full exploitation of the potential has been constrained by resources. The large dependence on oil and gas could pose problems in the long run and it is imperative that the use of local coal is encouraged in the power generation. Even though the estimated reserves are close to 185 billion MT, hardly a fraction of this is considered as proved recoverable reserves. As the bulk of the coal available is belonging to the category of "Lignite" and sub-bituminous, the cost of mining and adopting the latest clean coal technologies is quite high.

5.1.2 A substantial part of the coal being used in Pakistan, both for the thermal power generation and for industrial use like cement manufacturing, brick making etc, comes from import. The annual import is estimated to be around 4 million Metric tonnes. The cost of imported coal is high and is likely to increase. There are various factors that are impacting the international coal prices, and the country should exploit the indigenously available energy sources to reduce the costs of import. Considering the fast growing energy demand, it is imperative that the generation

capacities are augmented. With the cost of oil and gas increasing internationally, to keep the generation costs down, the generation capacity additions should be based on coal as the fuel. With the exploitation of the indigenous coal reserves taking time, depending on the imported coal for the country's progress will drain the foreign exchange outflow.

5.1.3 Exploitation of the indigenous renewable energy resources will help in reducing the consumption of costly fossil fuels and will help in reducing the environmental threats resulting from the use of the fossil fuels. Renewable energy resources may not be able to make a major dent in meeting the energy requirements of the country, but however could provide a supporting role in meeting the country's energy requirements. Even among the renewable energy based thermal projects, the bagasse based Cogeneration projects score mainly because of the facts that the fuel need not be transported over long distances and the combined cycle efficiency in a Cogeneration project will be much higher.

5.1.4 The HPPL project will approximately replace 75,000 MT of coal per annum, based on the electrical energy exported to the grid using the bagasse. Apart from saving in the foreign exchange outflow, this will have a very great mitigating effect on the green house gas emissions to the atmosphere. The above justify the project from the point of view of augmenting the generation capacity without much deleterious effect on the environment. In addition to the above, the project will add the much needed additional generating capacity to the grid.

5.2 **From the Sugar mill's point of view**

5.2.1 The present crushing capacity of HSMPL is 6000 TCD and this could be achieved through 24 hours of operation of the plant. HSMPL has adequate steam and power generation capacities for meeting the total steam and power requirements of the sugar

plant. The present steam consumption is 44% on cane and the steam generation capacities are adequate even for meeting these requirements.

- 5.2.2 The existing boilers are with the steam parameters of 24 bar(a) and 340 deg.C., which are on the lower side compared to the modern day sugar mill boilers. The total aggregate steam generation capacity in the sugar mill is 110 TPH. Although these boilers are not very old, the fuel consumption in the boilers is quite high with the steam to fuel ratio of about 2.2. Eventhough the fuel is generated in-house, considering the fuel value of bagasse and realizing the available potentials for the better utilization of bagasse, the above consumption in the boilers is quite high and the operation is inefficient, compared to modern day standards. All the existing turbogenerators in the plant operate with an inlet steam parameters of around 23 bar (a) and 340 Deg.C. Here again the turbines are of older design and not comparable to the new generation of turbines with regard to the efficiency.
- 5.2.3 The sugar Industry, world over, is passing through a difficult period. The sugar prices are low and on the other hand the cost of the basic raw material which is the sugar cane and the production costs keep increasing. The sugar industry can hope to come out of this situation only by cutting down the cost of production, by adopting energy efficient processing, and going in for Cogeneration of Power and for the better utilization of molasses and bagasse, the by-products from sugar manufacturing.
- 5.2.4 Under the above scenario, where there is a potential to improve the energy efficiency of the sugar plant by retiring inefficient boilers and turbogenerators, it is prudent for the sugar mill to go in for new high pressure and high efficiency boilers and matching turbogenerators. Such systems, in-addition to generating additional power for export which improves the

bottom line of the sugar mill operations, improves the energy efficiency of the sugar mill process itself. With the selection of the controlled extraction cum condensing turbines for such applications, as the extraction steam requirements are very large in the sugar mill applications, the extraction steam pressure is maintained almost constantly and this helps in larger vapour production and less use of the exhaust steam in the process.

- 5.2.5 The above justifies the need for HPPL's Cogeneration plant to be operated in parallel with HSMPL's sugar mill. Eventhough there is a justification for going in for high pressure boilers and energy efficient systems from the point of view of improving the energy efficiency of the plant, HSMPL's plant could go ahead with the present operation without resorting to Cogeneration or any of these proposed changes. For the enhanced crushing to 10,000 TCD, the steaming capacity available with the existing two (2) boilers will not be adequate for the plant's operation. As a business proposition HSMPL will be interested in the implementation of Cogeneration and other energy efficiency improvement programs in the sugar mills, provided the revenue stream from such a project is attractive. Also as the investment is high, the project will be implemented through a separate company called Hunza Power (Private) Ltd, a SPV for this specific purpose. Nevertheless the technical advantages that accrue to the sugar mill as discussed above will make the project justifiable from the point of view of the sugar mill.

5.3 From the point of view of a clean sustainable development:

- 5.3.1 Life is possible on earth because of the natural greenhouse effect of the gases like water vapour, carbon-di-oxide, methane, nitrous oxide etc. These gases, called the Green House Gases (GHG), naturally present in the atmosphere holds a delicate balance between the heat energy received from the

sun and the loss of the heat by re-radiation back to the space. These gases keep earth at about 60 Deg.F warmer than it otherwise would be. Without this effect life would not be possible on earth. With industrialization and population growth, the GHG emissions have consistently increased over the years. The result is that the atmospheric level of CO₂, the most important human derived GHG has increased from 280 ppm to 360 ppm over the last hundred years. The overall emissions of the GHG are growing at about 1% per year. If the emissions increase unabated, and we proceed on a "business as usual" path, the CO₂ level in the next hundred years will reach more than 700 ppm, and will result in serious climate changes in the planet. It is to be noted that the recent studies indicate a much accelerated pace of deterioration of the earth's ecology. The consequences are dreadful like, worsening health effects, rising sea levels, droughts and floods, disruption of water cycle and affecting crop yields and food supply.

- 5.3.2 Electric utilities contribute greatly to the emission of the GHG to the atmosphere. Where ever, the bulk of the installed power generation capacity is based on coal, the utilities become one of the largest contributors of GHG emissions due to its high carbon content and low conversion efficiencies. In the case of developing and underdeveloped countries, due to the fast rate of growth, the GHG emissions become much higher and can even go up more than double the world average. It is obvious that greater pressure will be brought on developing countries to take possible steps to reduce the emission of the GHGs. The world community and the future generations have the right to a cleaner environment and even a small effort in reducing the emission of the GHGs is a positive step towards a better future.
- 5.3.3 The renewable energy projects and specifically the bagasse based cogeneration projects fit very well into our objective of achieving a clean sustainable development without damage to

the environment. All such projects deserve serious encouragement, and the concerned Governments and the Electricity companies should come forward to promote such projects. It is a social obligation and there should be no profit or loss accounting and the electric utilities should accommodate the renewable energy projects even at the cost of backing down on their generations. Mostly the developers of such renewable energy projects are not endowed with huge financial resources, and the tariff for the purchase of the power generated through the renewable energy projects, should be attractive to encourage more developers. As the bagasse based Cogeneration projects play a vital role in containing the GHG additions to the atmosphere, there is an urgent need to promote such projects as our contribution to a clean sustainable development of the society.

5.4 As a future Business opportunity

5.4.1 The necessity for the reduction in the emission levels of GHGs, presents a new market based technology transfer instrument called the Clean Development Mechanism (CDM) promising financial flows to the developing countries. There is a cap imposed on the GHG emission levels for developed countries, and the emission reduction target for the developed countries is five percent of the 1990 emission levels by the year 2012. The CDM evolved out of the Framework convention on the Climate change, helps the developed countries meet the set emission level targets. Under the CDM, a company from a developed country can invest in clean technology projects in developing countries, and later claim to have met its emission reduction targets. So the CDM works in two ways, one is that it provides new opportunities for the sustainable development in the developing countries and the second, it reduces local and global pollution problems and helps developed countries to achieve GHG reductions cost effectively.

- 5.4.2 There are a lot of issues involved like determination of the base line technology, ways of ensuring that there will be additionality in carbon savings over savings which would have happened anyway, etc. Nevertheless CDM presents a good business opportunity to the developing countries, and there is likely to be large capital coming into the country.
- 5.4.3 Considering the above business opportunity, and the likely business in carbon trading, it is essential to go into the business of renewable energy based power generation and Cogeneration projects.
- 5.4.4 The current status of CDM is not very encouraging as there has been no further agreement between the countries, subsequent to 2012, on the mechanism to be adopted. However considering the importance of the role renewable energy sources can play on the environment, it is expected that similar or a better mechanism will be agreed between the countries. Hence basically the business opportunity presented by the CDM will be available in some form or other.
- 5.4.5 Looking at the project from the above perspective, there is ample justification for HPPL to go ahead with the project implementation at the earliest.

6.0 Cogeneration Plant Design Criteria

6.1 General

6.1.1 This section gives the basic plant design criteria and the design criteria to be followed in the design of the mechanical equipment of the proposed Cogeneration plant. The design criteria for the electrical equipment, Controls and Instrumentation and the civil works are covered in the respective sections dealing with those equipment.

6.1.2 The proposed new cogeneration facility at Hunza Power (Private) Ltd (HPPL) will be operating 110 days during the cane crushing season and will be operating during the off-season period with saved bagasse. All the plant and systems shall be designed to achieve the best possible efficiency under the specified operating conditions. The Cogeneration power cycle for the plant shall be designed with two HP heaters and a deaerator, which will use the turbine extraction for feed water heating. This Cogeneration facility will be located adjacent to sugar plant complex of Hunza Sugar Mills Pvt. Ltd., (HSMPL). The cogeneration plant at HPPL consists of two units of 24.9 MW. Each unit comprises of one (1) 135 TPH capacity boiler along with other auxiliaries and one 24.9 MW Turbogenerator.

6.1.3 The condensate from the sugar mill evaporators will be taken back to cogeneration plant deaerators after necessary quality checks, from the sugar plant. Accordingly the cogeneration plant power cycle is designed, taking into consideration the return condensate from the sugar mill.

6.1.4 The complete plant instrumentation and control system for the cogeneration plant shall be based on Distributed Control System (DCS) philosophy, covering the total functioning

requirements of measuring, monitoring, alarming and controlling, logging, sequence interlocks and equipment protection, etc.

- 6.1.5 The plant layout shall make optimum use of the land and facilities to minimize the cost of installation. The optimum arrangement of the equipment shall be determined by the considerations of functional requirements, economy of piping and electrical cables, economy of equipment supports, installation and maintenance access requirements, ventilation requirements and equipment generated noise and vibrations.

6.2 **Plant & Machinery design criteria**

This section of the report gives the basic criteria for the design of the plant. The design parameters like the size, layout, ratings, quantities, materials of construction, type of equipment etc., described in this report are approximate. **Necessary changes could occur as the detailed engineering of the plant progresses and such changes are permitted as long as the detailed engineering of the plant achieves the intent of this report.**

6.2.1 **Ambient Conditions**

Plant Elevation above Mean Sea Level (MSL): 158 meters

6.2.2 **Temperatures**

- Maximum Temperature : 48.0.0 Deg.C
- Minimum Temperature : 6.0 Deg.C
- Plant Design Temperature : 30 Deg.C
(Performance design)
- Plant Design Wet Bulb Temperature : 28 Deg.C
- Plant Design Temperature for Electrical Equipment : 50 Deg.C

6.2.3 Relative Humidity

- Maximum : 96.0 %
- Minimum : 36.0 %
- Plant Design Relative Humidity : 70.0 %

6.2.4 Precipitation

- Total Annual Rainfall : 15 mm average

6.2.5 Wind

- Wind Direction : West
to
East
- Design Wind Velocity : 170 Km/Hr

**6.2.6 Seismic Coefficient : as per UBC
Vol.II, 1997**

6.2.7 Soil Bearing Capacity:

- At 1.5 m Depth (MT/Sq.M) : 10

6.3 Design & Guarantee Fuel for the new cogeneration plant

6.3.1 The design and guarantee fuel for the cogeneration plant will be bagasse generated from the sugar mill as specified hereunder.

6.3.2 HPPL receives bagasse from HSMPL's sugar plant and it generates bagasse during its cane crushing operation and the bagasse percentage on the cane is an average of 30.5%. With the crushing rate of 10,000 TCD or 416.67 Tonnes per Hour (TPH), the bagasse generated per hour will be 127.08 Tonnes per Hour. This 127.08 TPH bagasse will be with 50 % moisture

content. Out of the generated bagasse, 4.17 TPH will be used for meeting the process requirements and the balance of 122.90 TPH will be made available for the Cogeneration boilers operation. This bagasse will be consumed in the cogeneration boilers during the season operation and saved bagasse will be stored in the bagasse yard. In the off-season operation or during cleaning days of sugar plant, the power plant will be in operation with this saved bagasse.

6.3.3 The following gives the ultimate and ash analysis of design bagasse:

a. Ultimate Analysis (As Fired Basis)

Carbon	:	23.96%
Hydrogen	:	2.93%
Oxygen	:	21.36%
Moisture	:	50%
Nitrogen	:	0.07%
Ash	:	1.55%
Sulphur	:	0.15%
Total	:	100%
HHV	:	2224 kcal/kg

b. Typical bagasse ash analysis:

ASH ANALYSIS	Design	Minimum - Maximum
Fe ₂ O ₃	18.10	15.0 to 21.0
MnO	1.04	0.5 to 1.5
Cr ₂ O ₃	0.13	0.05 to 0.20
V ₂ O ₅	0.13	0.05 to 0.20
TiO ₂	0.65	0.03 to 1.00
CaO	2.87	1.50 to 3.50
K ₂ O	3.26	2.00 to 12.00
P ₂ O ₅	1.83	1.00 to 2.50

ASH ANALYSIS	Design	Minimum - Maximum
SiO ₂	54.80	45 to 75
Al ₂ O ₃	7.80	5.00 to 10.00
MgO	9.10	7.00 to 15.00
Na ₂ O	0.10	0.1 to 1.0
Cl	0.02	0.01 to 0.05
S	0.01	0.01 to 0.05
ASH FUSION TEMPERATURES (°C)		
Reducing & Oxidising Conditions		
Deformation		1110
Softening		1222
Hemispherical		1250
Flow		1322

6.4 Raw Water

6.4.1 The raw water supply for the plant will be from the bore wells located in the plant. This raw water will be used as a source for make up for the losses in the process steam, boiler blow down, cooling tower blow down, service water, make up water, etc. .

6.4.2 The design of the water treatment system will be based on the values indicated in the table.

Turbidity	7.0 NTU
Total suspended solids (Particles retained on 1.2 µm membrane filter)	10.0 mg/l
Smell	N.D
Colour (APHA)	Colorless
pH at 25°C	7.30
Electrical conductivity	626.0 µs/cm
Colloidal silica as SiO ₂	3.15 mg/l
CHEMICAL EXAMINATION	
CATION	

HUNZA POWER (PRIVATE) LTD
2 x 24.9 MW COGENERATION PROJECT

Calcium as Ca	72.0 mg/l
Magnesium as Mg	16.0 mg/l
Sodium as Na	70.0 mg/l
Potassium as K	2.0 mg/l
Ammonium as NH ₄	N.D
Barium as Ba	0.03 mg/l
Copper as Cu	N.D
Iron as Fe	0.02 mg/l
Manganese as Mn	N.D
Zinc as Zn	0.04 mg/l
Strontium as Sr	N.D
ANION	
Chloride as Cl	22.0 mg/l
Fluoride as F	N.D
Nitrate as NO ₃	N.D
Nitrate Nitrogen	N.D
Nitrite as NO ₂	N.D
Phosphate as H ₂ PO ₄	2.3 mg/l
Sulphate as SO ₄	146.0 mg/l
Sulphide as S	N.D
Lime as CaO	1.20 mg/l
Reactive silica as SiO ₂	5.91 mg/l
Total volatile solids	53.0 mg/l
Total fixed solids	339.0 mg/l
Total dissolved solids (Residue at 105°C)	392.0 mg/l
Total hardness as CaCO ₃	248 mg/l
Methyl Orange Alkalinity as CaCO ₃	106.0 mg/l
Phenolphthalein Alkalinity as CaCO ₃	N.D
ORGANIC CONSTITUENTS	
Biochemical Oxygen Demand (BOD)	<2.0 mg/l
Chemical Oxygen Demand (COD)	<2.0 mg/l
Dissolved Oxygen as O ₂	5.5 mg/l
Total Organic Carbon	0.1 mg/l
Ammonical Nitrogen as N	N.D
Albuminoid Nitrogen as N	N.D

TOXIC SUBSTANCES	
Lead as Pb	N.D
Cynide as CN	N.D
Mercury as Hg	N.D
Chromium as Cr	N.D
Nickel as Ni	N.D
Cadmium as Cd	N.D
Arsenic as As	0.02 mg/l
Sulphide as H ₂ S	N.D
Free carbon Dioxide as COS ₂ S	8.2 mg/l
Ammonia as NHS ₃ S	N.D
MICROBIOLOGICAL EXAMINATION	
Total Bacterial count	28.0 cfu/ml
Bicarbonates HCO ₃	129.0 mg/l
Carbonate as CO ₃	N.D

6.5 Steam Generator & Auxiliaries

- 6.5.1 The new steam generating system for the Cogeneration plant will consist of two (2) nos. bagasse fired boiler with a Maximum Continuous Rating (MCR) of 135 TPH each, with the outlet steam parameters at 110 bar(a) and 540 Deg.C. The tolerance on the superheater outlet temperature shall be ± 5 Deg.C. The combustion system of the boiler shall be travelling grate with spreader stoker. The boiler efficiency, firing 100% bagasse, shall be a minimum of 70% on the HHV basis.
- 6.5.2 The dust Concentration in the flue gases leaving the boiler shall be a maximum of 50 mg/N.Cum.
- 6.5.3 The design of the boiler shall be of single drum, natural circulation, radiant furnace with water cooled membrane walls, Three stage superheater with two stage desuperheater and balanced draft. The boiler shall be top supported and shall be of semi-outdoor type. The boiler shall be capable of a peak generation of 110% of the MCR generation for a period of One

(1) Hour in a shift. The operating excess air percentage at the outlet of the boiler shall be a maximum of 30 %.

6.5.4 Boiler Feed Water

The boiler shall be capable of operating with the following feed water quality requirements.

i. pH	:	8.8 - 9.2
ii. Oxygen	:	0.007 ppm
iii. Hardness	:	0
iv. Total Iron	:	0.01 ppm
v. Total Copper	:	0.01 ppm
vi. Total Silica	:	0.02 ppm
vii. Hydrazine	:	0.01-0.02 ppm
viii. Specific Electrical Conductivity at 25°C measured after Cation exchanger in the H + form and after CO ₂ removal (max)	:	0.5 micro-ohms/cm

6.5.5 Steam Purity

The boiler shall be capable of supplying uninterrupted steam at the MCR rating with the following steam purity levels.

- Total Dissolved Solids : 0.1 ppm (max)
- Silica (max) : 0.02 ppm

Performance Guarantee Tests

- Maximum Continuous Rating (MCR) of the boiler while firing bagasse, with the feed water temperature of 210°C and superheater outlet parameters of 110 bar (a) and 540°C.
- Boiler Efficiency at MCR on HHV basis while firing bagasse.

- Auxiliary Power Consumption under MCR operating conditions.
- Steam purity for all operating loads.

Dust Concentration in the flue gases leaving the ESP, while firing Bagasse.

6.6 **Turbogenerator & Auxiliaries**

6.6.1 The TG shall be a 2 nos. Of 24.9 MW nominal capacity each, triple extraction condensing machine. The speed of the turbine shall be preferably around 6000 rpm, however a turbine directly driving the alternator without a gear box is preferred. The first extraction will be an uncontrolled type and this extraction meets the steam requirement for HP heater II. The second extraction will be an uncontrolled type and this extraction meets the steam requirement for HP heater I, and Process steam requirement for sugar plant. The third extraction will be a controlled extraction and meets the complete low pressure steam requirement for Sugar process and steam requirement for Deaerator. The condensing system will be a water cooled Condenser and steam is exhausted at 0.1 bar(a) during non crushing season. Due to lesser steam flow to the condenser and due to the lower cooling water temperature during the season which is mostly winter, it is possible that the condenser operates at a much lower pressure during the season operation.

6.6.2 The generation voltage shall be at 11 kV and the system should operate in parallel with National grid. The grid voltage will be 132 kV and the system frequency is 50 Hz. The complete electrical systems will be designed to meet with the requirements of the National Grid Code.

6.6.3 Performance Guarantee Tests

The performance test shall be conducted for the following parameters as per ASME PTC 6 and DIN 1943:

- Power Output at Generator Terminals with the Inlet steam parameters of as specified.
- Auxiliary Power Consumption under Guarantee conditions.
- Cooling Water Consumption under guarantee conditions
- Maximum temperature rise in the generator windings.

6.7 Auxiliary Plant and Equipment

6.7.1 Fuel handling

6.7.1.1 The fuel for the cogeneration plant operation during the season is bagasse from the HSMPL's sugar plant. The bagasse from the existing bagasse conveyor in the bagasse yard will be tapped off and taken to the cogeneration boiler through belt conveyors and chain conveyors. The system shall have provision for returning the excess bagasse to the storage yard and also the provision for back feeding the bagasse from the storage yard to the boiler. The bulk density of bagasse shall be 150 Kg/Cum. Allowable inclination for the belt conveyor is 18 Deg. The Belt speed shall be approximately 1.1 meters/sec. The maximum moisture percentage in bagasse shall be 56%. The conveyor capacity will be 185 TPH for the conveyors from the sugar mill up to the bagasse yard and 150 TPH for the conveyors provided from the bagasse storage yard to Boilers.

6.7.2 Ash handling

- 6.7.2.1 The ash handling system envisaged for the cogeneration plant is of two types and shall be provided for two boilers individually:
- Sub-merged scrapper conveyor system for grate ash
 - Dense phase handling system for fly ash
- 6.7.2.2 The ash received in the grate discharge hoppers will be around 500°C, with ash lumps of size 200 mm maximum. The ash from ash riddling hopper will be dry and powdery in nature and occasionally with hot solids. The temperature of the ash will be around 200°C maximum.
- 6.7.2.3 The fly ash from Electrostatic Precipitator Hoppers will be dry and powdery in nature and occasionally with hot solids. The temperature of ash will be around 200°C maximum.
- 6.7.2.4 The fly ash from the Air Heater Hopper will be dry and powdery in nature and occasionally with hot solids. The temperature of the ash will be around 300°C maximum. The design ash density to be used for capacity calculations shall be 150 Kg/Cu.M and that to be used for load calculations shall be 600 kg/Cu.M for bagasse ash.
- 6.7.2.5 All the ash will be collected in storage silo having a suitable capacity & will be disposed-off by trucks / trailers.
- 6.7.3 Cooling Tower
- 6.7.3.1 The RCC cooling tower shall be designed for catering to both the seasonal and off-seasonal operations, and shall be of counter flow induced draft type. The capacity of the cooling tower for one unit of 24.9 MW shall be a minimum of 6300 M³/Hr, and there shall be a minimum of two (2) Cells. For 2 x 24.9 MW, there will be 4 cells each of capacity 3150 M³/Hr. The cooling tower shall be designed for a cooling range of 10°C, and an approach of 5°C while operating under the atmospheric

wet bulb temperature of about 28°C. The RCC frame of the tower shall be integral with the basin. The cooling tower shall be carefully sited such that there is no re-entrainment of the vapours into the cooling tower. The cooling water system will be provided with Sodium Hypo Chloride / chlorine-di-oxide dosing system and circulating water chemical treatment system to prevent against algae growth and to maintain the circulating water quality.

6.7.3.2 The following codes & standards shall be followed for the design of cooling tower.

- a. ACI 350 / BS 8007 - Design of RCC Cooling tower basin & cold water channel
- b. ACI 318 / BS 8110 (Superstructure) - RCC Frame Tower
- c. ACI 318 / BS 8110 - Concrete Staircase ladder

Suggested parameters for cooling tower design :

- | | | |
|----|--------------------------------------|-----------------------|
| a. | Water loading | 7.5 to 15 TPH / sq.m. |
| b. | Air inlet velocity
at tower inlet | 3.5 to 4.5 m/sec. |
| c. | Air exit velocity at stack
outlet | Minimum 6 m/sec. |
| d. | L / G ratio | 1.5 to 1.75 |
| e. | Average fill air velocity | Minimum 1.8 m/sec. |
| f. | Velocity pressure ratio | Minimum 5 |

- Velocity pressure ratio is the ratio of system pressure drop from air inlet to drift eliminator to velocity pressure of average entrance velocity

- | | | |
|----|----------------------|--|
| g. | Plenum pressure drop | Above 10% of the system pressure drop |
| h. | Fan coverage | Minimum 80%, if a circle is projected on the drift eliminator plan area at 45 Deg. angle from fan cylinder opening |

6.7.4 Pumps

6.7.4.1 The head / flow characteristics of pumps will be such that the head continuously rises with decreasing capacity until a maximum head is reached at zero flow. Maximum run-out of flow should atleast 130% of duty point flow.

6.7.4.2 The shut off head should be atleast 1.1 times the duty point head and should not be more than 1.2 times the duty point head.

6.7.4.3 The power curve should be of non-overloading type with the maximum power occurring at or near duty point or towards maximum run out flow.

6.7.4.4 NPSHR curve should be a continuously rising one in the range of operation, from the minimum flow in the range to the maximum flow in the range. Required NPSH values shall not exceed available values over the entire range from minimum to rated flow

6.7.5 Condensate System

The Sugar plant generates more condensate than the process steam it receives. The extraction from the turbine is taken to

the sugar plant evaporator for processing of sugar juice. The condensate from this evaporator bodies is a pure condensate and taken to the cogeneration plant deaerators after necessary online quality checks. Under the normal circumstances the makeup water for the cycle will be Demineralised water.

6.7.6 DM / RO Plant

6.7.6.1 The RO plant shall be designed to have a two streams of 36 Cu.M / Hr. Based on the water quality the following scheme is proposed for the treating the raw water:

Multigrade Filter(MGF) → Ultra Filtration System (UF)→ First Pass Reverse Osmosis system(RO-I) → Second Pass Reverse Osmosis system (RO-II) → Electro De-Ionisation (EDI) with standby Mixed bed (MB) Polishing System

6.7.6.2 The Demineralised water quality at the outlet of the RO plant shall be as follows:

♦ Hardness (ppm)	:	0
♦ pH @ 25°C	:	8.8 - 9.2
♦ Conductivity @ 25°C (MicroSiemens / Cm)	:	0.5
♦ Oxygen (maximum) (ppm)	:	0.007
♦ Total Iron (maximum) (ppm)	:	0.01
♦ Total Copper (maximum) (ppm)	:	0.01
♦ Total Silica (maximum)(ppm)	:	0.02
♦ Residual Hydrazine (ppm)	:	0.01-0.02

6.7.6.3 All vessels shall be designed with adequate free board. Only seamless pipe shall be used wherever rubber lining is done.

6.7.6.4 The regenerants like HydroChloric Acid and Caustic Soda shall be stored in bulk in the RO plant premises, and pumped to the

RO plant for regeneration. Manual handling of the regenerants shall be avoided to the maximum extent.

6.7.6.5 Adequately sized neutralizing pit shall be provided near the RO plant for collecting the discharges from the RO plant and effectively neutralizing the same before pumping the waste to the sugar plant's effluent treatment system.

6.7.7 Crane for the Turbogenerator Building

6.7.7.1 An Electrically operated overhead travelling (EOT) crane with the main hook lifting capacity of 65 Tonnes suitable for erection and maintenance requirement of turbogenerator and an auxiliary hook lifting capacity of 5 Tonnes shall be provided to facilitate maintenance of the Turbogenerators and their auxiliaries. The crane travel will cover the entire length of the Turbogenerator building.

6.7.7.2 The crane shall be electrically operated, bridge type and shall be designed and equipped for indoor operation complete with all accessories. The crane bridge shall consist of bridge girders each one carrying a rail on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkways with safe hand railing are required along the full span length on either side of the bridge girders. Bridge and trolley trucks shall be of cast steel or fabricated structural steel sections. Wheel trucks of cast or welded construction shall be stress relieved as per accepted standards. Spring buffers shall be provided on the trolley and bridge structural frames at suitable places to absorb the shock of impact without transferring to the structural frame.

6.7.8 Vessels & Heat Exchangers

6.7.8.1 The design shall be as per ASME Section VIII, HEI and TEMA. All heat exchangers and vessels for steam application shall be

designed for full vacuum conditions. The heat exchangers shall be provided with start up vent connections. The design shall have provision for complete drainage on both shell and tube sides. The heat exchangers shall be provided with emergency drains, shell side safety valves, and individual bypass with manual valves. A minimum corrosion allowance of 1.6 mm shall be provided. The tube bundle shall be of removable type. The tube material shall be stainless steel, unless otherwise specified in the specifications.

6.7.9 Tanks

6.7.9.1 The cogeneration plant tanks will have storage capacities as required by design of the systems. Tanks will be of the closed top type. Tanks will be fabricated in accordance with guidelines established by API or AWWA, as determined by the service. A corrosion allowance of 1.5 mm shall be provided.

6.7.9.2 Overflow connections and lines shall be provided where required and will be at least one pipe size larger than the largest input line or combination of inputs that can discharge simultaneously.

6.7.9.3 Maintenance drain connections shall be of adequate size to facilitate drainage of tanks within a reasonable time. Manholes where provided on tanks and pressure vessels shall be of size NB 400. Ladders and cleanout doors will be provided on large tanks. DM water tank shall be internally lined with natural rubber or painted with three coats of Epoxy Coating, after necessary surface preparation. Make up water tank shall be internally painted with epoxy coating after necessary surface preparation.

6.7.10 Compressed Air System

6.7.10.1 The Cogeneration plant will require instrument air for the operation of pneumatic instruments like I/P converters, purge

instruments, pneumatic actuation of control valves, dampers, etc. for different systems. Service air will be required for cleaning of filters, strainers and general purpose. Compressed air system is envisaged to supply the air of required quality and quantity. A common compressed air system shall be provided for meeting both the requirements of instrument air and service air. There will be three (3) compressors for 2 x 24.9 MW, Screw Compressor, two operating and the one remaining as standby. The capacity of each of the compressors shall be calculated based on the requirements but shall be a minimum of 400 N.Cu.m/hr (2W+1S). An air receiver of required capacity, designed as per pressure vessel design codes/standards, to meet with the specification requirements shall be provided. The requirement of the service air will be tapped off from the receiver, and the required instrument air will be passed through the dryers. The quality of the instrument air after passing through the dryers will be such that the dew point is less -40 Deg.C at the atmospheric pressure.

6.7.11 Piping

6.7.11.1 All piping system shall be designed as per ASME B 31.1. In addition, statutory requirements of Pakistan Boiler Regulations shall be complied with.

6.7.11.2 Stress Analysis shall be carried out for all possible operating modes and shall be as per ASME B 31.1 requirements. Supports, guides, Directional Anchors shall be selected to satisfy all the operating conditions.

6.7.11.3 All piping shall be sized considering the allowable velocity and allowable pressure drop in the system. The suggested flow velocities of various mediums are,

- Superheated Steam : 45 to 55 M/Sec
- Saturated Steam : 15 to 30 M/Sec

- Boiler Feed Water
 - * Pump Suction : < 1M/Sec
 - * Pump Discharge : 2.5 to 4 M/Sec
- Water
 - * Pump Suction : < 1M/Sec
 - * Pump Discharge : 2.5 M/Sec
- Condensate
 - * Pump Suction : 0.6 to 0.7 M/Sec
 - * Pump Discharge : 2.5 M/Sec
- Compressed Air : 12 to 18 M/Sec
- Lube Oil & molasses
 - * Pump Suction : 0.3 to 0.4 M/Sec
 - * Pump Discharge : 1.0 M/Sec

6.7.11.4 Piping Materials

The piping material selection shall be based on the following recommendations.

- For temperatures above 510°C, SA 335 Gr. P22/SA 335 Gr.P 91 shall be used.
- For temperature 400°C to 510°C, SA 335 Gr. P11/P12/P22 shall be used.
- For temperature 399°C & below SA 106 Gr.B/C or ASTM A- 53 seamless shall be used.
- For HP/LP chemical dosing SA 312 TP 304, Stainless Steel shall be used.
- All pipe fittings other than those mentioned shall confirm to ASTM A 234 standard and dimension as per ANSI B 13.9 / B 13.28 / B 13.11.

- For Cooling water, Raw water, Service Water, Safety/ Relief valve exhaust carbon steel ERW pipes shall be used.
- For Service air applications the piping shall be carbon steel Black Medium Class.
- For instrument air applications: SS 304 / Galvanized pipe shall be used.

6.7.12 Insulation

6.7.12.1 All exposed portions of the plant which operate at temperatures of 60°C and above during normal operation shall be thermally insulated so that the temperature on the outer surface of the cladding shall not exceed by more than 20°C above ambient, based on an ambient temperature indicated in site data. The specified insulation thickness shall not include the thickness of wire netting, finishing cement or any other finishing or weatherproofing application. Insulation shall not fill the contours of the expansion bellows. Piping and equipment that are not insulated but having a surface temperature exceeding 50 Deg.C shall be insulated for personnel protection. In refractory walls suitable expansion gaps shall be provided at regular intervals.

6.7.13 Ventilation System and Air Conditioning system

6.7.13.1 The following areas will be envisaged with exhaust ventilation system:

- TG hall
- Water Treatment plant Equipment room
- Chemical Storage area in WTP (water treatment plant) building
- Muffle furnace, Hot oven, etc room in WTP building
- WTP MCC panel room

- Fire Pump House
- Toilets

6.7.13.2 The exhaust ventilation system will maintain the temperature rise within 5 Deg.C above ambient temperature.

6.7.13.3 The following areas of power plant will be envisaged with Ductable type, ceiling suspended air conditioning system:

- PCC, MCC, VFD, Auxiliary MCC panel rooms in TG building
- Control Room in TG building
- Battery room

6.7.13.4 The following areas of power plant will be envisaged with Hi-Wall split air conditioning system:

- SWAS panel room in TG building
- WTP DCS operator station room in WTP building
- WTP laboratory room in WTP building
- Office and Conference Room

6.7.13.5 The air conditioning system will maintain a temperature of 22 Deg. C inside the rooms.

6.7.14 Fire Fighting System

6.7.14.1 The following fire fighting systems will be envisaged for the power plant:

- Fire Hydrant system for the entire power plant including fuel storage areas.
- Automatic Fire detection and alarm system for the TG building
- Portable Fire extinguishers for the TG building
- High Velocity water spray system for Switch Yard Transformer

- 6.7.14.2 The fire hydrant system shall consist of two numbers of pumps (one working and one standby). The main pump will be of diesel engine driven and standby pump will be of electrical motor driven. In addition to the above two pumps, there will be an electrical motor driven jockey pump. The fire hydrants, water monitor, hoses and nozzles shall be located throughout the power plant. All the fire water pumps shall be located near raw water reservoir in cogeneration plant taking suction from the raw water reservoir. The suction for the other pumps drawing water from the raw water reservoir will be located such a way that the minimum storage of water in the reservoir will be maintained for meeting the fire water requirements.
- 6.7.14.3 The fire alarm system shall consist of smoke detectors, heat detectors, fire alarm panel, hooter, manual call point etc. The detectors shall be located in all the electrical panel rooms, control room and battery room. The manual call point and hooters shall be located throughout the entire TG building. The detectors will sense the fire automatically and will generate fire alarm through Fire alarm panel.
- 6.7.14.4 The portable fire extinguishers shall consist of dry chemical powder type, carbon-di-oxide type, foam type fire extinguishers. The extinguishers shall be located strategically inside the TG building.
- 6.7.15 Industrial Elevator
- 6.7.15.1 An Industrial type elevator, designed to the requirements of BSEN81, for carrying passengers and goods shall be provided, common, for both the boilers. The elevator structure shall be integrated with the boiler structure and the sides shall be covered by zinc and aluminium alloy coated cladding sheets of 0.6 mm thickness. The elevator shall be suitable for carrying a load of 500 kg. The number of landings shall be a minimum of

six (6), selected judiciously. Collapsible doors made out of mild steel and painted shall be provided for the car and the landing entrance. The elevator shall be complete with all safety and interlocks for the operation. The elevator duty motor shall be of the squirrel cage type, suitable for frequent starting, stopping and reversing operations. The motor shall be suitable for approximately 300 starts per hour, with class "F" insulation and with the temperature rise limited to class "B". As a minimum requirement, all the electrical equipment shall be dust and weather proof.

6.8 Codes & Standards

6.8.1 Systems and equipment will be designed in accordance with the applicable sections of the following codes, standards and regulations in effect at the date of this Contract. Applicable sections of codes, standards and regulations will be defined in specifications.

6.8.1.1 American Society of Mechanical Engineers (ASME)

ASME Section I : Rules for construction of power Boilers
ASME Section IX : Welding & Brazing and Fusing Qualifications
ASME Section VIII: Unfired Pressure Vessels Code

6.8.1.2 ASME Performance Test Code

ASME PTC 4 : Fired Steam Generator
ASME PTC 4.3 : Air Heaters
ASME PTC 3.0 : Guide for evaluation of Measurement Uncertainty in Performance test of Steam Turbine

ASME PTC 19.11 : Steam and water sampling,
conditioning and analysis in the power
cycle

ASME PTC 25 : Pressure Relief Devices

6.8.1.3 American National Standards Institute

ASME B16.5 : Pipe flanges and flanged
fittings

ASME B 16.9 : Butt welding fittings

ASME B 16.11 : Socket Welding and Threaded
fittings

ASME B 31.1 : Code for Power piping

6.8.1.4 IEEE Standards

IEEE:80 : Guide for safety in AC
Substation Grounding

IEEE:141 : Recommended Practice for
Electric Power Distribution for
Industrial Plants

IEEE:142 : Recommended Practice for
Grounding Of Industrial and
Commercial Power Systems

IEEE:241 : Recommended Practice for
Electric Power Systems in
Commercial Buildings

IEEE:242	:	Recommended Practice for Protection And Coordination of Industrial and Commercial Power Systems
IEEE:399	:	Recommended Practice for Industrial and Commercial Power System Analysis
IEEE:446	:	Recommended Practice for Emergency And Standby Power for Industrial and Commercial Applications.
IEEE:493	:	Recommended Practice for the Design Of Reliable Industrial and Commercial Power Systems.

6.8.1.5 IEC Standards

IEC:60034	:	Rotating Electric machines
IEC:60044	:	Instrument Transformers
IEC:62271-100	:	HVAC circuit breakers
IEC:60071	:	Coordination of Insulation
IEC:60076	:	Power Transformers
IEC:60085	:	Thermal evaluation and classification of Electrical insulations
IEC:60099	:	Surge Arrestors

IEC:62271-102	:	Alternating current disconnectors (isolators) and earthing switches
IEC:60947-1	:	Degrees of protection of enclosures for low Voltage switchgear & controlgear
IEC:60137	:	Insulated Bushings for Alternating Voltages above 1000 V
IEC:60183	:	Guide for selection of HV Cables
IEC:60214	:	On load tap changers
IEC:60227	:	PVC insulated electric cables
IEC:60255	:	Electrical relays
IEC:60269	:	LV Fuses
IEC:60270	:	High Voltage Partial discharge requirements
IEC:60296	:	Insulating oils for Transformers and Switchgear
IEC:62271-200	:	AC metal enclosed switch gear and control gear for rated voltages above 1 kV and upto and including 52 kV
IEC:60076-7	:	Loading guide for oil immersed Power transformers

IEC:60376	:	Specification of Technical gradesulphur hexafluoride(SF6) for use in Electrical equipment
IEC:61439	:	LV switch gears and control Gear assembly
IEC:60502	:	Extruded solid dielectric insulated power for Rated voltages from 1 kV upto 30 kV
IEC:60529	:	Classification of degree of Protection
IEC:60214-2	:	Application guide for on load tap changers
IEC:60076-8	:	Application guide for power Transformers
IEC:885	:	Electric test methods for electric cables
IEC:60909	:	Short-circuit current calculation in three phase AC systems
IEC/TR:61439-0	:	LV switch gears and control Gear
IEC:62052-11	:	Electrical Metering Equipment - Part 11 - Metering Equipment
IEC 62271-1	:	High voltage switchgear and Control Gear, Part 1 - Common Specification

6.8.1.6 Industry Standards

- American Gear Manufacturers Association (AGMA)
- American Petroleum Institute (API)
- American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Handbook
- American Society for Testing and Materials (ASTM)
- American Water Works Association (AWWA)
- American Welding Society (AWS) Structural Welding Code (AWS D1.1)
- Conveyor Equipment Manufacturers Association (CEMA)
- Cooling Tower Institute (CTI)
- Heat Exchange Institute (HEI)
- Hydraulic Institute (HI)
- Institute of Electrical and Electronics Engineers (IEEE)
- Instrument Society of America (ISA)
- Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Pipe Fabrication Institute (PFI)
- Tubular Exchanger Manufacturers Association (TEMA)

6.8.1.7 Turbine:

- IEC Recommendation Publication No: 60045-1
- DIN 1943

6.8.1.8 British Standards

BS 4592	:	Industrial type metal floors, walkways and Stair treads
BS 5395	:	Stairs, ladders and walkways
BS:EN 13001	:	Permissible Stresses in Cranes
BS:466	:	EOT Cranes for general use in factories, workshops and Warehouses.
BS:En ISO 9906	:	Rotidynamic pumps - Hydraulic Performance Acceptance Testing Grade 1,2 and 3.

7.0 Plant and Machinery (Mechanical) for Cogeneration Plant

7.1 General

7.1.1 The proposed new cogeneration plant at HPPL will consist of two boilers and two turbogenerators for the power generation. This section of report describes the plant and machinery (mechanical) for the cogeneration plant.

7.2 Steam Generating system

7.2.1 The steam generating system for the HPPL's Cogeneration plant will consist of two (2) boilers with all their independent auxiliaries. The boiler shall be a semi-outdoor unit and shall be of single drum, natural circulation, balanced draft, membrane wall radiant furnace design with Three (3) stage superheaters and two stage Desuperheater.

7.2.2 The fuel used in the boiler will be 50% moisture bagasse during season operation and saved bagasse during the off-season operation.

7.2.3 The Feed Water Quality Requirement for the boiler shall be,

a.	pH	:	8.8 - 9.2
b.	TDS	:	1 ppm
c.	Oxygen	:	0.007 ppm
d.	Hardness	:	0
e.	Iron	:	0.01 ppm
f.	Copper	:	0.01 ppm
g.	Silica	:	Max. 0.02 ppm
h.	Hydrazine	:	0.02 to 0.04 ppm
i.	Conductivity	:	2 microsiemens/cm

7.2.4 With the above feed water quality, the boiler shall be capable of giving the following steam purity.

- a. Solids content : 0.10 ppm
- b. Silica : 0.02 ppm

7.2.5 The following are the basic technical requirements for the steam generator:

7.2.5.1 The steam generator shall be provided with one steam drum and the drum shall be of fusion welded type. At higher pressures the latent heat duty comes down and consequently the boiler bank area comes down. Without the boiler bank there will be no need for two drums. A single drum design reduces both the manufacturing and erection time compared to a two drum design. The steam drum shall be liberally sized to assure low steam space loading, with adequate space to accommodate the internals. The steam drum internals shall be provided with internals of proven design to assure the required steam purity, and the internals shall be of bolted connection. The necessary nozzle connection for the steam outlets, safety valves, feed water inlets, down comers, continuous blowdown, level indicators, chemical dosing, sampling connection, drains and vents shall be provided on the drums. All nozzle connections shall be of welded type. The drum design pressure shall have a minimum margin of 6% over drum operating pressure.

7.2.5.2 The furnace envelope shall be constructed of fully water cooled membrane / fin welded walls and they shall be adequately supported. The construction shall be gas pressure tight and the furnace shall be strengthened by providing buckstays and tie-bar system. The buck stay system shall be adequately designed to stiffen the furnace walls against the internal and external pressures and also to transfer the wind and seismic loading from the boiler envelope to the boiler structures through suitably designed guides. The minimum design pressure

for the buckstay system shall be ± 4 kPa, with the buckstay members reaching 60% of the yield strength. In addition the buckstay members shall be sized to limit the deflection to "L/360", where "L" is the buckstay span, under "Operating pressure + 2 kPa (puff)".

- 7.2.5.3 The furnace EPRS should be so selected to give acceptable furnace outlet temperatures, not exceeding 920 Deg.C, while firing bagasse. The furnace shall be adequately sized for burning bagasse, with the volumetric heat release rate, based on fuel heat input, not exceeding 1.045GJ/hr.m³. The furnace will be sized to give a minimum residence time of 3 seconds for bagasse and the calculation of the residence time shall be based on the average gas temperature in the furnace, and the furnace volume calculated up to the furnace outlet plane. The average gas temperature shall be calculated using the following formula.
- 7.2.5.4 Furnace absorption = $A \cdot \sigma (\xi_g \cdot T_g^4 - \alpha_g \cdot T_s^4)$, where A is the EPRS, σ is the Stefan-Boltzmann Constant, ξ_g is the gas emissivity, T_g is the average gas temperature, α_g is the gas absorptivity and T_s is the wall temperature. The wall may be assumed to be radiatively black. The furnace absorption is to be calculated based on the NHI and the gas heat leaving the furnace. The temperature T_g is to be calculated by an iterative procedure.
- 7.2.5.5 The furnace design shall incorporate necessary man holes, peep holes and openings for fuel distributors etc. The downcomers, supply pipes and risers sizing shall be based on circulation calculations.
- 7.2.5.6 The superheater system shall be of three (3) stage design with two stage desuperheating to achieve the rated steam temperature over 60% to 100% MCR load, under bagasse firing. The superheater shall be of convection type or

combination of convection and radiation type. The tube spacing of the superheater shall be designed to minimize bridging and tube erosion and shall be suitable for proper on-load cleaning by means of soot blowers. Suitable spacers shall be provided for both along and transverse to the gas flow direction. The superheater system shall be complete with seamless pipe headers, interconnecting piping, tube spacers, valves, fittings, supports, vents and drains etc. The sealing at the superheater tube penetrations with the boiler roof or with the wall shall be 100% leak tight.

7.2.5.7 The economiser shall be located upstream of the air-preheater. The economiser shall be of bare tube construction, inline arrangement, counter flow type and the economiser shall be designed for inlet temperature as indicated above. Economiser shall be arranged such that there is space for the future addition of about 10% of the installed heating surface area without disturbing the existing coils. Suitable number of soot blowers shall be located in the economiser for effective cleaning of the heat transfer areas. Economisers may be divided into suitable number of banks to accommodate the soot blowers and for maintenance of the soot blowers. The economiser gas path shall be pressure type construction with proper design of the seals at the tube penetrations with the casing. The economiser shall be complete with seamless inlet / outlet headers with drains and vents, coil supports, supporting structures for the complete economiser, interconnecting piping, access galleries, stairs etc.

7.2.5.8 Air heater shall be arranged as the last heat recovery section downstream of economiser. Air heater shall be recuperative type with flue gas flowing over the tubes and the combustion air flowing inside the tubes. The arrangement shall be provided for adequate access and for replacing the tubes. Adequate soot blowers shall be located in the air heater for effective cleaning of the heat transfer areas. Considering the high

moisture in the flue gases, suitable precautions shall be taken to prevent the tube corrosion at the air inlet side of the air heater.

- 7.2.5.9 The steam generator shall be designed for the fuels as specified elsewhere in these specifications. The bagasse from the sugar mill or from the storage yard shall be made available at the inlet of the feeding system through the slat conveyors. The bagasse feeding system shall include a bagasse storage silo with storage capacity of atleast for 10 minutes of the MCR requirement or the height of silo is less than twelve meters, whichever is lower, inlet chutes, feeders, feed chutes and the distributor. The bagasse input to the steam generator shall be regulated by the feeding system. Suitable isolation gates shall be provided between slat conveyor and bagasse silo. The inlet and the feed chutes shall be designed to prevent choking of bagasse and necessary poking facilities shall be given. The distributor shall be of pneumatic type with provision to distribute the fuel uniformly across the furnace.
- 7.2.5.10 The firing system for the steam generator shall consist of spreader stoker with travelling grate. The grate assembly shall include the keys, air compartments, air seals, tensioning mechanism, rails, lubrication system etc. Pull chord switches shall be provided in the travelling grate to trip the grate drive motor in case of the breakage of the grate bars.
- 7.2.5.11 The grate area loading shall not exceed 9.80 GJ/hr.m^2 , under bagasse firing. A grate design that is highly resistant to air flow is desirable to achieve even air distribution across the grate surface and to achieve even combustion conditions. The differential pressure across the grate shall be a minimum of 500 Pascals (50 mmWC).

The lubrication system used for the grate shall be a proven one and graphite bearings shall be provided in the travelling grate.

- 7.2.5.12 The combustion air from the FD fan, heated in the airheater to a temperature not more than 200 Deg.C, shall be uniformly distributed under the grate. The hot secondary air for distribution and for meeting the overfire air requirements shall be supplied by the secondary air fan.
- 7.2.5.13 The Draft system for the steam generator shall be suitable of producing a balanced draft with sub atmospheric pressure conditions in the furnace. The system shall be comprising of,
- a. 2 x 50% FD fans for each boiler with variable frequency drives (VFD) motor and complete, with necessary base frames, base plate, foundation bolts, supports, covers, couplings, lubrication system, vibration monitoring system, etc.
 - b. 2 x 60% ID fans for each boiler with variable frequency drives (VFD) motor complete with necessary base frames, base plate, foundation bolts, supports, cover, couplings, lubrication system, vibration monitoring system etc.
 - c. 2 x 50% SA fans for each boiler with variable frequency drives (VFD) motor and inlet guide vane complete, with necessary base frames, base plate, foundation bolts, supports, covers, couplings, lubrication system, vibration monitoring system, etc.
 - d. 2 x 100% Cinder refiring air fan for each boiler with a constant speed motor and inlet guide vane complete, with necessary base frames, base plate, foundation bolts, supports, covers, couplings, lubrication system etc.
 - e. All air and flue gas ducting with required stiffeners, expansion joints, guide vanes for bends, dampers, insulation, cladding, supports etc.

- 7.2.5.14 The steam generator shall be provided with a complete system of soot blowers to effectively dislodge the deposits from the heat transfer areas. The soot blowers shall be motor operated with steam, taken from the boiler, as cleaning medium. In the zones where the gas temperature exceeds 700 Deg. C, only long retractable soot blowers shall be used. For the gas temperatures exceeding 600 Deg. C the lance material shall be a minimum of stainless steel.
- 7.2.5.15 Air pollution control system comprising of one Electrostatic Precipitator with all its accessories for each boiler. The ESP shall be designed to provide an outlet dust concentration level of 50 mg/Ncu.m, with the boiler operating with the fuels indicated above. The aspect ratio of the ESP shall be optimally selected, so as to minimise re-entrainment and carryover of the collected dust, and for assured performance. The system shall be complete with inlet and outlet funnel, deflector plates, ash hoppers, Collecting electrode system, rapping mechanism, high voltage transformer, automatic voltage control system, insulators with thermostats, Motor control centre, high voltage bus duct connection, complete lifting and handling arrangement for the transformers, expansion bellows at inlet and outlet funnels, stairways and walkways, sliding supports for thermal expansion of casing etc.
- 7.2.5.16 Boiler integral piping consisting of all interconnecting piping between the economiser inlet stop valve and the superheater outlet header. The piping shall be properly supported and provided with necessary tappings for instruments for measurements. Necessary supporting materials, towers, trestles to support the piping shall be supplied. The design of the piping system shall be based on the ASME B 31.1. The correct locations of hangers and supports shall be considered for the flexibility analysis. Suitable expansion loops, restraints and anchors shall be provided so as to ensure code

compliance's and to limit the stresses within the allowable values. The materials for the piping and fittings shall be properly selected for the various services in the boiler integral piping. Complete boiler integral piping shall be provided with valves, fittings, drains & vents, safety valve exhaust piping, start-up vent with silencer, blow down systems etc.

- 7.2.5.17 Steam generator shall be provided with High pressure (HP) dosing and Low Pressure (LP) dosing system. The HP dosing system shall be based on 'trisodium phosphate' dosing and this shall be dosed in boiler water to take care of the ingress of the hardness salts and to increase the boiler water pH. The LP dosing system shall be based on "non hydrazine and non ammonia" dosing and this is dosed in the feed water to scavenge the last traces of oxygen and to increase the feed water pH. Each dosing system comprises of positive displacement pumps, tanks, agitators, required interconnection piping , valves , fittings, etc., The complete dosing system shall be skid mounted.
- 7.2.5.18 One Blowdown tank (BD) shall be provided. The blow down tank will be common for collecting the continuous blow down & intermittent blow down from the drum and high pressure drains from the boiler. Flash steam from the tank shall be piped to the atmosphere and the drain will be let off into the trench.
- 7.2.5.19 One (1) Deaerator along with the deaerated water storage tank for each boiler, of deaerating capacity equal to Twenty percent (20 %) higher than the gross MCR steam generation capacity of the boiler shall be provided. The deaerated water storage tank shall be with a net useful capacity (Normal water level to Low water level) equivalent to twenty minutes (20 minutes) of MCR generation capacity of the boiler. The deaerator shall be of either spray-cum-tray type or spray type with counter flow of steam and water. The deaerator and storage tank shall be complete with all the fittings and mountings like vents,

controlled vent, drains, gauge glasses, pressure indicators, relief valves, steam and water inlet and outlet nozzles, etc. The complete deaerator pressure and level control systems with all the piping, fittings, valves, control valves, instrumentation etc., shall be provided.

- 7.2.5.20 4 x 42% High pressure Boiler feed water pumps (three working and One standby) for each boiler, along with variable frequency drive motors, bed plates, sole plate, coupling, coupling guard, automatic recirculation valves, vibration monitoring system, suction strainers, lubrication system for pump and motor, vent and drain connections, balancing leak off lines . All integral piping and valves, thermal insulation and painting, foundation bolts, lifting and handling provisions and connecting flanges.
- 7.2.5.21 Boiler refractory, insulation and inner and outer casing with all fixing material for boiler, ducting, piping, valves, fittings and equipment's etc.
- 7.2.5.22 Handling system including monorails, lifting tackles, support structure for monorails etc., for handling ID fan, SA fan, FD fan, Feed pumps and drive motors etc.
- 7.2.5.23 Supporting structures, steel work, platform, ladders, galleries, and staircases with fabricated floor grating including complete roof, side cladding above the drum operating floor level along with cladding structures for protection against rain and other climatic conditions. The floor grills and handrails shall be hot dip galvanized.
- 7.2.5.24 Ash hoppers with outlet gate for furnace and motor operated rotary discharge valve for other hoppers.
- 7.2.5.25 Chimney connecting flanges, counter flanges, expansion joints near chimney and all fasteners for the connections.

- 7.2.5.26 Industrial Lift (common for two boilers) with carrying capacity of 600 kgs
- 7.2.6 The drawing Nos.9-16083-800-0016, 0017 and 0018 gives the schemes for the steam & water system and air & flue gas system for generator and auxiliaries.
- 7.3 **Steam Turbines and Auxiliary System**
- 7.3.1 The turbogenerators for the HPPL's cogeneration plant will be 2 numbers of 24.9 MW nominal capacity extraction cum condensing machine.
- 7.3.2 The turbine will be designed for the operation with the inlet steam parameters as given in the specification. Each of the turbine will be designed to provide the uncontrolled extraction steam approximately at 22 bar (a), uncontrolled extraction steam at 10.0 bar(a) and the automatic controlled extraction steam at 3 bar(a). The balance of the steam supplied to the turbine flows through the LP section of the turbine into the water Cooled condenser. Speed of the turbine shall be below 6000 rpm, however a turbine directly driving the alternator without a gear box is preferred.
- 7.3.3 The turbine shall be a horizontal, single cylinder, extraction cum Condensing type. All casings and stator blade carriers shall be horizontally split and the design shall be such as to permit examination of the blading without disturbing shaft alignment or causing damage to the blades. The design of the casing and the supports shall be such as to permit free thermal expansion in all directions.
- 7.3.4 The turbine shall have solidly forged and machined rotor with integral disks. The rotor after fully machined and bladed shall be dynamic balanced accurately in the shop and shall be given an over speed test under vacuum. None of the critical speeds of

the rotor shall fall within the range of 20% above and 20% below the normal running speed of the rotor. The rotor shall be designed to withstand the maximum shock loading that may occur during any power system disturbance. Such shock loading values shall be taken for the design of the generator rotor. The material of construction shall be consistent with proven practices and standards.

- 7.3.5 The blading shall be designed to withstand all vibrations, thermal shocks, and other loading that may be experienced during service and system disturbances. The blades shall be machined from forged bars or die forged and the materials used shall be chromium steels consistent with proven experience and standards.
- 7.3.6 The glands shall preferably be of labyrinth type and sealed with steam. The gland packing shall be of 13% chromium stainless steel. The labyrinths shall be of multi-section spring backed type which would allow for any temporary deformation of the rotor shaft without overheating the rotor due to friction.
- 7.3.7 The Turbine shall be provided with liberally rated hydrodynamic radial and thrust bearings. A liberal flow of lube oil under pressure shall be supplied to all the bearings for lubrication and cooling. A pressure lubrication and control oil system shall be furnished for the turbo generator unit to supply oil at the required pressure to the steam turbine, generator bearings and governing system. For the hottest ambient conditions to be encountered at the site the oil outlet temperature at any bearing shall neither exceed the maximum permissible temperature for the bearing metal nor the maximum safe operational temperature of the oil.
- 7.3.8 A pressure lubrication and control oil system shall be furnished for the turbo generator unit to supply oil at the required pressure to the steam turbine, gear box, generator and

governing system. The lubrication oil system shall supply oil to the turbine generator under all the load conditions, including the turning gear operation. The oil system of the turbogenerator shall be designed with adequate redundancy and emergency provisions such that a failure of a single active component will not prevent the safe operation or a safe shutdown of the turbogenerator. Oil in the reservoir shall be maintained at an appropriate temperature when the TG set is idle by providing suitable electric heaters and temperature controls if required. The oil pumps shall consist of one main oil pump driven by AC Motor, one auxiliary oil pump driven by AC motor, One DC Emergency oil pump and emergency oil gravity system.

- 7.3.9 Separate oil filters for lube oil and control oil shall be provided. The lube oil filter size shall be less than 40 microns & control oil filter size shall be less than 20 microns. The oil coolers shall be water cooled with a duplex arrangement and changeover valves. The coolers shall be of shell and tube type with removable tube bundle. The coolers shall be constructed in accordance with TEMA class C. The provided surface area shall be adequate to cool the oil with 33 Deg.C inlet cooling water temperature even with 20 % of the tubes plugged.
- 7.3.10 The sizing of the coolers shall consider a tube side (water side) fouling factor of 0.0002 Hr.Sq.M.Deg.C/Kcal. The water velocity shall be not less than 1.5 M/sec.
- 7.3.11 The condenser shall be of non-contact surface type condenser designed as per the requirements of Heat Exchange Institute Standards for Steam Surface Condensers and ASME Section VIII Division 1. Necessary steam jet air ejectors for evacuating the non-condensable gases shall also be provided. The ejectors shall be one hogging ejector with two running ejectors (1 working & 1 standby)

- 7.3.12 The cooling water for the condenser will be supplied from the cooling tower basin through cooling water pumps. The water velocity through the tubes shall not be less than one (1) meter per second and the fouling resistance on the tube side shall be 0.0002 hr.sq.m.Deg.C/kcal. The total water side pressure drop in the condenser shall not exceed 8 MLC.
- 7.3.13 The condenser design and supply shall be complete with the turbine-condenser interconnecting piping, condensing chamber and tubes, tube sheets, hot well, water boxes, relief valve, air removal vents and accessories. The tubes shall be of size 19.05 mm OD with 18 BWG thickness, and the material shall be admiralty brass or stainless steel. The shell, water box and the tube sheet material shall be of ASME A 36 or equivalent. The shell and the tubesheet thickness shall be respectively a minimum of 12 and 40 mm.
- 7.3.14 The hot well at the condenser bottom shall have a minimum capacity of 2 minutes storage while handling maximum quantity of exhaust steam. The hot well shall be provided with level gauges and connections for condensate extraction and drain. A suitably designed level control system shall be provided. Make up water will be added in the condenser hot well both during season & off-season operation.
- 7.3.15 The condenser shall preferably be of divided water box design, and the water boxes shall provide easy accessibility to the tubes. It shall be possible to operate the condenser, albeit under reduced capacity, with one half of the tubes operating and the other half taken for cleaning.
- 7.3.16 Three numbers fifty percent (50%) capacity vertical condensate extraction pumps to pump the condensate from the condenser hot well shall be provided. One of the pumps will be operating in season and two pumps will be operating in the off-season. The pump shall be selected for a normal

continuous flow rate equivalent to the maximum steam flow to the condenser under all the operating conditions.

7.3.17 As the condenser will be designed with divided water box construction and also as the cost of the automatic cleaning system for this size of condenser is high, no automatic condenser cleaning system is envisaged for this project.

7.3.18 The turbine governing system shall be electro-hydraulic designed for high accuracy, speed and sensitivity of response. The electrical/electronic and hydraulic components of the control system shall be selected on the basis of reliability over a wide range of operating conditions. All components used shall be well proven to assure overall system reliability and shall be designed for easy and quick replacement when necessary. The governor shall be configurable in the field.

7.3.19 The governing system shall have the following important functions:

- Speed control
- Over speed Trip
- Load control
- Steam pressure control

7.3.20 The turbine shall be provided with a trip system for the complete and rapid closure of steam valves effectively preventing all steam admission to the turbine independently of the closure of the governing valves. In order to avoid sudden re-admission of steam to the turbine the trip system shall be fitted with interlocking devices so that trip resetting cannot take place until steam admission can only be achieved as per normal starting up procedure. Essential trip circuits to be provided are:

- Steam inlet pressure falling below pre-determined level.

- Steam temperature falling below pre-determined level.
- Condenser vacuum falling below pre-determined level.
- Lubricating oil pressure falling below pre-determined level.
- Axial thrust wear trip.
- High temperature trip for LP stage steam flow.

7.3.21 A direct coupled turbine and generator system without the intervening gear box will be preference for this project. However depending on the experience of the selected manufacturer and if the commercial implication of the direct coupled machine is high, then a reduction gear box may be used. If provided the reduction gear box between the turbine and the generator shall be provided with double helical type with a minimum service factor of 1.3. The overlap ratio shall be adequate to ensure a quiet operation. The gears shall be dynamically balanced before assembly. The gear box shall be capable of transmitting the maximum rating of the set and be able to withstand 20% overspeed over a period of minimum five (5) minutes. The gear box design shall be as per the requirements of AGMA. The flexible couplings between the turbine and the gear box and between the gear box and the generator shall be provided.

7.3.22 The turbine, shall be provided with a barring gear of mechanical type driven by an A.C motor, to rotate the turbine and generator after shutdown to prevent thermal distortion of the rotor. The barring gear shall be capable of starting the rotor from rest and run it continuously at low speeds. The barring gear shall be interlocked with the lubrication system to prevent its operation without lubrication.

7.3.23 The turbine control shall be through the centrally located Distributed Control System, described in another section of this Report. The control system shall provide redundancy for key functions by use of separate sensors and monitors. The

control system shall include all the standard control monitoring and alarming. Only proven equipment that have been used in similar systems before shall be provided. Control panels shall be supplied fully wired and complete with all necessary special wiring for interconnection of panels. Vibration detectors/ proximity meters/ axial position detectors monitors shall be provided for all bearings including the bearings of the generator. Solid state annunciation units wherever located shall be of the first out type. Individual alarm windows shall be provided for all critical points parameters. The alarm sequence shall be as per international standards. Separate windows shall be provided for pre-alarm and shutdown with simultaneous alarm.

7.4 High Pressure Feed Water Heater

7.4.1 The cogeneration plant cycle is designed with one Low pressure Heater (Deaerator) and Two High Pressure (HP) Feed water heaters. Each unit of 24.9 MW will be provided with one LP heater and two HP heaters. First HP Heater is provided with heating steam from the Uncontrolled extraction at 10 bar (a) and second HP heater is provided with heating steam from the uncontrolled extraction at 22.0 bar (a).

7.4.2 The HP Feed Water heaters shall be of shell and tube design and shall have provision for complete drainage of both shell and tube sides. The heater shall be designed for the operating conditions and full vacuum. The tubes shall be of seamless construction. Stainless Steel to ASME SA 213 Gr.TP 304 or equivalent specification and the tube bundle shall be removable. The tube to tube sheet joint shall be fully rolled and seal welded. U tubes when used shall consist of one continuous bent tube. The shell and tube sheet shall be to Carbon Steel ASME SA 516 Gr.70 or equivalent specification.

- 7.4.3 Tube nests shall be suitably baffled to prevent vibration and to obtain uniform distribution of steam and free drainage of the condensate of the tubes. Baffles and support plates shall be of rolled plates. All baffles shall be designed to eliminate, as far as practicable, dead fluid spaces between adjacent passes. Baffles and support plates shall be provided with notches required for shutdown drainage or for removal of condensate where necessary.
- 7.5 **Crane for the Turbogenerator Building**
- 7.5.1 An Electrically operated overhead travelling (EOT) crane with the main hook lifting capacity of 65 MT and an auxiliary hook lifting capacity of 5 MT, shall be provided to facilitate erection and maintenance of the Turbogenerators and their auxiliaries. The crane travel will cover the entire length of the Turbogenerator building. The crane shall be electrically operated, bridge type and shall be designed and equipped for indoor operation complete with all accessories.
- 7.5.2 Electro-magnetic brake and electro hydraulic thruster brake shall be provided for each of main and auxiliary hoists. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions. Hooks shall be solid forged heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball or roller thrust bearings with hardened races.
- 7.5.3 Hoist ropes shall be extra flexible, improved plough steel rope with well lubricated hemp core and having six strands of 37 wires per strand with an ultimate tensile strength of 160 to 180 kg/sq.mm of right hand ordinary (RHO) lay construction.
- 7.5.4 Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel conforming to BS:466. The ratio of

diameters of drum to rope and lead angle of rope shall also be as per BS:466.

- 7.5.5 The crane motors and control circuit components for the long and cross travel motions of the crane shall be suitable for reversing plugging control. Electrical brakes provided for long and cross travel motions shall operate when the power is off. Speed control of various motors shall be achieved by adjusting the resistances in the rotor circuit of the drive motors.

7.6 Fuel Handling System

- 7.6.1 The high pressure and high temperature steam generator with membrane walls and minimum refractory are very sensitive to fuel feed and to ensure steady operation a continuous fuel feed system should be adopted. The conventional system of feeding the steam generator with the bagasse coming directly from the mill has the drawback of a complete stoppage of the fuel feed to the steam generator, if and when the mill stops and such occasions are not infrequent. Even though provisions for back feeding the bagasse on to the return bagasse conveyors are available, because of human intervention, there is always a time delay and the steam generator starves for fuel. To overcome this problem of time delay, attempts have been made, with good amount of success, to provide a storage silo in front of the steam generator, at least to cater to about 10 Minutes requirements of the fuel at MCR rating.

7.6.2 Bagasse handling system:

- 7.6.2.1 The bagasse handling system envisages the following feeding paths for bagasse. The handling system is designed keeping the following possibilities in mind.

- Feeding the bagasse to the new Cogeneration steam generators directly from the existing sugar Mill.

- Feeding the bagasse to the new Cogeneration Steam generators from the Storage yard.

7.6.2.2 Bagasse Belt conveyor assembly (BC-1, BC-2, BC-3, BC-4, BC-5 & BC-6) including conveyor belts, drive assembly, all type of pulleys, all type of idlers, bearing assembly, inlet / outlet chutes, take-up assembly, support frames, scrappers, walkway, structural etc. Apart from the above conveyors, few of the existing conveyors will also be running. Slat Chain conveyor (SC-1) including trough, chains, drive assembly, support frames, walkways, structural etc.

7.6.2.3 The following paragraph gives the details of the paths:

Path I:

This path feeds the bagasse from the mill directly to the cogeneration boiler.

- The bagasse from the existing bagasse carrier in the bagasse yard will be fed to the Belt Conveyor BC-1 which runs in the East to West direction. The Head end of this conveyor will be provided with two way chute. One chute will feed the Bagasse from BC-1 conveyor to conveyor BC-2 which runs in South to North Direction. If bagasse moisture is high, the bagasse from BC-1 will be diverted to BC-3. Bagasse from this conveyor, bagasse will be fed to the chain slat conveyor SC-1 located in front of the boiler, runs in South to North direction. The bagasse will be discharged on the bottom deck of SC-1 conveyor in the Northern side, from BC-2 and the bagasse travels from North to South direction. On its travel it feeds the bagasse to both the boilers. The excess bagasse from this conveyor is fed to another conveyor BC-3 which carries the bagasse to bagasse yard.

This conveyor runs in North to South direction and feeds bagasse to another conveyor BC-4 which runs in East to West direction. The conveyor BC-4 discharges bagasse to the closed Bagasse storage yard.

- The bagasse from BC-4 conveyor is diverted in the storage yard by fixed ploughs and the balance bagasse is fed to another conveyor BC-5 which carries the bagasse to the open storage bagasse yard. This conveyor is provided with ploughs and runs in North to South direction. This conveyor also feeds bagasse to conveyor BC-6.

In this path the conveyors BC-1, BC-2, SC-1, BC-3, BC-4 & BC-5 will be running.

Path -II:

This path feeds the bagasse from the storage yard to the cogeneration boiler.

- This path works when the sugar plant is not working, or there is a temporary stoppage of the mill and the Cogeneration plant has to run. The bagasse will be reclaimed from the storage yard and sent to the steam generator. The stored bagasse could be that excess bagasse stored during the operation of the sugar plant stored in the yard.
- The bagasse from the covered storage yard will be pushed on to the underground conveyor BC-6, with the front end loaders or bulldozers. This conveyor runs below the ground level, along the West to East direction, and this in turn will feed belt conveyor BC-2 which runs in South to North direction. This conveyor feeds the slat chain conveyor SC-1. Further bagasse feeding to the

boiler and the excess bagasse flow to the yard will be same as that described under path I.

In this path the conveyors BC-6, BC-2, SC-1, BC-3, BC-4 & BC-5 will be running.

- 7.6.2.4 The drive assembly shall include motor, gearbox, couplings, holdback, common base frame, Motor & coupling guards etc.
- 7.6.2.5 The belt shall be of Nylon-Nylon type with suitable top and bottom rubber cover. The number of plies and weight of deck shall be suitably selected with due regard to load / flexibility of troughing. Hot vulcanising shall be considered for the belt joints. The rating of the belt should be such that the maximum tension induced in the belt should not exceed 80 % of the maximum recommended belt tension. The rating and duty conditions shall be decided on the maximum tension anticipated in the belt. The safety factor shall be 10.
- 7.6.2.6 The idlers shall be made of ERW steel tubes. The idler roller shall be fitted with deep groove ball bearings, which are seize-resistant and lifelong lubricated. The shaft material shall be of EN-8.
- 7.6.2.7 The conveyor pulley shall be of welded steel construction with closed ends. The pulley diameter shall be designed for maximum belt life and confirm to BS: 8438:2004 specification. The entire assembly of the pulleys shall be balanced and rubber lagging shall be provided. The grooving for head pulley shall be of herring-bone design with 12 mm thk rubber lagging. The depth of the groove shall be 6 mm. natural rubber and plain rubber lagging of 10 mm thk. for other pulleys. The hardness of rubber lagging on pulleys shall be 55 to 65 shore A scale.
- 7.6.2.8 The slat chain conveyor will be of double trough design. The chain conveyor shall be of all steel construction suitable for

outdoor duty and for the specified conveying capacity. The linear speed of the conveyor shall be within 30 m/min. The conveyor shall have two strands of roller chain and shall confirm to applicable standards. The pitch of the chain shall be 200 mm. The breaking strength of the chains shall be minimum of 100,000 Kgs. The sprockets shall be of cast steel with machine-cut teeth. The idler sprockets having machine cut teeth shall be provided wherever there is change in direction and long horizontal portion of the conveyor at regular intervals. The shafts shall be machined from EN 8 material. The shaft bearing shall be housed in cast steel housings.

- 7.6.2.9 Junction towers including cladding, operating platforms, staircase, landings, hand railing, toe plate etc.
- 7.6.2.10 Hood for all conveyors with Perspex window of size 200 x 200 mm, shall be provided at a spacing of 20 meters.
- 7.6.2.11 The Drawing Nos. 3-16083-800-0019 and 0020 gives the scheme for fuel handling system for bagasse and ash handling system.

7.7 Ash Handling System

- 7.7.1 The ash handling system envisaged for the cogeneration plant shall of two types and shall be provided for both the boilers individually.

- ♦ Submerged belt conveyor system for Travelling grate ash
- ♦ Dense phase ash handling system for fly ash

- 7.7.2 The submerged belt conveyor shall discharge the wet ash directly to trailers, which will be pulled away once it is filled and a new empty one placed in its position. Submerged ash Belt conveyor (SBC-1) assembly, including conveyor belts, drive

assembly, all type of pulleys, all type of idlers, bearing assembly, inlet / outlet chutes, take-up assembly, trough assembly, support frames, walkway, structural safety switches, water inlet / outlet / drain nozzles etc., as required.

- 7.7.3 As the grate ash from the steam generator is taken care of, the remaining is only the fly ash from the collection points at the air heater hopper(s) and the electrostatic precipitator hopper(s). The ash collected at these two places will be dry and powdery and hence is more suitable for dense phase pneumatic handling. It is proposed to use this system for the handling of the fly ash from the boiler.
- 7.7.4 The fly ash shall be collected at ESP & APH etc. through hoppers, provided below these equipment. Below the hoppers chain/hand wheel operated knife / plate valves and metallic bellow type expansion joints shall be provided. The hoppers shall be provided with level probes. ESP hoppers shall be provided with fluidizing pads for ash fluidization. The Dense phase system blow down ash vessels with all accessories like pneumatic operated dome valve, vent valve and conveying air blow valve etc shall be provided below the knife gate valves. All valves mounted on the blow down vessel shall be remote operated.
- 7.7.5 The fly ash collected in the blow tanks shall be conveyed to the fly ash silo through MS pipes and long radius ACTI bends. Proper vent filters shall be provided at the top of silo for controlling the dust generated in the silo. Target box / Terminal box shall be provided to terminate the ash pipe at silo top. Suitable level switches (high, high-high) shall be provided in silo for ash level control. Silo shall be provided with suitable manhole, pressure relief valve and ash fluidizing pads.
- 7.7.6 Silo outlet shall be provided with power cylinder operated knife/plate valve, rotary feeder, ash conditioner with flexible

chute, motor operated retractable chute/unloading spout for disposal of the ash through trucks or by other means of transport. For the purpose of air fluidization in the silo blowers will be provided and blowers shall be rotary twin lobe type, one working and one standby, along with electric air heater with suitable interlocks. The conical portion of the silo shall be lined with 3 mm thick Stainless steel 304 sheets.

- 7.7.7 The compressors supplying the conveying air shall be non-lubricated type, with one working and one standby. The required conveying air for Dense phase system shall be supplied by this compressors through air receiver of adequate capacity.
- 7.7.8 The ash handling system shall be designed and constructed aiming for totally dust free operation. Fugitive dust emission in any area shall not exceed 50 mg/m^3 for all solid particles.
- 7.7.9 The design of equipment shall ensure maintenance of noise and vibration levels within the limits specified below. Measured noise level produced by any rotating equipment shall not exceed 85 dB at a distance of 1 m from it in any direction.
- 7.7.10 All parts subject to wear shall be provided with quick and easily replaceable parts. The estimated life of such parts shall be stated clearly when it is less than 10000 operational hours.
- 7.7.11 The control and monitoring of fly ash handling system shall be through the DCS located in the control room.
- 7.7.12 Design Ash Density to be used for capacity calculations shall be 150 kg/Cu.m and that to be used for load calculations shall be 600 kg/Cu.m for bagasse ash.
- 7.7.13 The Drawing Nos.3-16083-800-0020 gives the scheme for ash handling system.

7.8 Water system

The water system includes both process water and utility water. The water system consists of the following sub-systems.

- Cooling water system
- DM water system
- Service and potable water system

7.8.1 Cooling Water System

7.8.1.1 This system caters to the cooling water requirements of the auxiliaries of the Turbogenerator including condenser, the auxiliaries of the steam generator and the auxiliaries of the cogeneration plant. For each of the 24.9 MW unit, A two cell, induced draft counter flow cooling tower of total capacity 6300 Cu.M/Hr, with each cell capacity of 3150 Cu.M/Hr, will supply the cooling water requirement for the cogeneration plant. The hot water returning from the TG and boiler auxiliaries are cooled in the cooling tower designed for a cooling range of 10 Deg.C and an approach of 5 Deg.C while operating under the atmospheric wet bulb temperature of about 28 Deg.C. The cooling tower shall be of RCC construction.

7.8.1.2 The cooling tower shall be complete with RCC frame, fills, supporting material, fasteners and mechanical equipment as described below. The tower shall be of double inlet, counter flow type of construction. The tower shall be of induced draft type with the fan located on top of the tower. The air entry is only from sides and not from end, as there will not be any air opening at the ends.

7.8.1.3 The complete superstructure including exterior walls and partitions shall be of reinforced concrete construction (RCC) with a minimum of 40 mm thickness over reinforcement bars.

The casing and the beams shall be of monolithic type and the opening for recovery cone shall be suitably provided.

- 7.8.1.4 Induced draft fan assemblies for each cell. Fans shall be of open type, axial flow, multi blade construction with the blades of aerofoil section. The number of blades shall not exceed twelve. The material of the fan blades shall be of FRP with epoxy resins. The fan blade tip speed shall not exceed 65 m/sec. Fan blades shall be of cast or moulded construction.
- 7.8.1.5 Fan drives shall be electric motors with reduction gears. The gears shall be of spiral bevel or helical type. All gear drives shall be of enclosed type and shall operate in oil bath.
- 7.8.1.6 Tubular, floating type drive shaft assemblies with flexible couplings & bearings for each cell.
- 7.8.1.7 Fan drive motor with base frame for each cell. The drive motor shall be of energy efficient and shall be suitable for VFD application.
- 7.8.1.8 Extended gear reducer oil line of stainless steel material with dipstick assembly, oil filling and drain arrangement for each cell
- 7.8.1.9 Independent vibration switch and low oil level switch (total of 2 switches) with 1 NO and 1 NC contacts for each cell. One number of FRP fan stack for each cell.
- 7.8.1.10 Access door along with the frame for FRP fan stack for each cell. The access door shall be air tight.
- 7.8.1.11 Access door on cooling tower deck including steel frame to be fixed on the steel frame embedded in R.C.C. The Access door shall be air-tight and to be provided at the suitable location.

- 7.8.1.12 Main, Auxiliary Hot water inlet puddle pipes embedded in RCC hot water trough as shown in the tender drawing.
- 7.8.1.13 PVC headers along with the lateral distribution pipes.
- 7.8.1.14 PVC Drift Eliminators. PVC film type fills and polypropylene spray nozzles. The fill material shall be capable of withstanding temperature upto 55 Deg.C without damage or permanent distortion. The sheet thickness of the fill media shall be uniform with a minimum thickness of 0.25 mm. The fill media shall be UV stabilised.
- 7.8.1.15 Supporting arrangement for fills. The fills shall be of suitable size for easy erection.
- 7.8.1.16 The mechanical equipment handling facility at fan deck level shall be provided for installation / removal of material like fan, gear box and motor from fan stack area and lower down the same to ground level.
- 7.8.1.17 Basin screen handling facility consisting of one monorail beam for each cell and one no: of chain pulley block.
- 7.8.1.18 Mechanical equipment support shall be mounted on RCC beams using MSHDG frames.
- 7.8.1.19 Cage ladder for cooling tower and inspection ladder for fills for each cell
- 7.8.1.20 Complete lightning protection system with all copper strips and interconnection upto ground level.
- 7.8.1.21 To prevent / minimise the growth of algae in the cooling water system chlorine dosing is proposed. Provision will be made for shock dosing at 3 ppm or continuous dosing at 1 ppm. Adequate Chlorine generators will be provided in the system to generate

chlorine for dosing in the cooling towers. If the local regulations preclude the use of chlorine, or if Chlorine tonners are not easily available, chlorine-di-oxide dosing will be provided. The chlorine-di-oxide will be produced at the site in the chlorine-di-oxide generator using sodium chlorite and hydrochloric acid.

- 7.8.1.22 The Drawing Nos.3-16083-800-0021 gives the scheme for the cooling water system.

7.8.2 DM Water System

- 7.8.2.1 As seen elsewhere in this Specification, the Cogeneration plant's make up water requirements will be met from the bore wells located in the plant. The Water treatment system will cater to both the cycle make up and the cooling tower make up. For the make up for the cycle, it is proposed to take the raw water through a Water Treatment Plant with the following treatment scheme.

Multigrade Filter → Ultra filtration system → First pass Reverse Osmosis system → Second pass Reverse Osmosis system → Electro De-Ionisation with Standby Mixed bed Polishing System

- 7.8.2.2 The Multi Grade Filter will be designed for the UF feed flow rate of 82 Cu.m/hr. The Ultra filtration system shall be sized for the permeate flow rate of 73 cu.m/hr. The first pass RO shall be designed for a minimum permeate flow rate of 55 cu.m/hr with a permeate output of 946 cu.m in 22-24 hours of operation. The Second pass RO shall be designed for a minimum permeate flow rate of 46 cu.m/hr with a permeate output of 858 cu.m in 22-24 hours of operation. The Electro De-Ionisation system shall be designed for the flow rate of 40 cu.m/hr and the standby mixed bed polishing system shall be

designed for a minimum flow rate of 45 cu.m/hr with a OBR of 3240 cu.m in 72 hours of operation.

7.8.2.3 The water treatment plant capacity will be provided with all the required system for back washing, regeneration etc. The treated water produced from water treatment plant will be stored in a DM water storage tank for use in the cycle make up.

7.8.2.4 The Demineralized water quality at the outlet of the water treatment plant after MB shall be as follows:

*	Hardness (ppm)	0
*	pH at 25 Deg.C (after pH correction)	8.5 - 9.2
*	Conductivity at 25 Deg.C (Microsiemen/cm)	< 0.2
*	Total iron max. (ppm)	NIL
*	Reactive silica max. (ppm) SiO ₂	0.02
*	Colloidal silica (ppm)	NIL
*	Total CO ₂	NIL
*	Permanganate No (Max.)	NIL
*	Sodium as Na and Potassium as K	<0.01 ppm
*	TDS (ppm)	0.1 before pH correction dosing
*	Total suspended solids	NIL
*	Oil	NIL
*	Residual phosphate	NIL

7.8.2.5 The following gives the details for the of water treatment plant:

- Multigrade filter (MGF) including blowers with frontal pipe work and initial charge of sand bed with all valves and interconnecting piping & blower. Multi Grade Filters shall be sized for feed flow rate of RO system with a normal surface velocity of 11 cu.m./hr/sq.m. (m/hr.) with one back wash per day of not more than 15 minutes.
- Micron cartridge filters upstream of RO skid. Two (2) Nos. of RO High pressure pumps (one working and one standby) with motor.
- RO Skid consisting of RO membrane block, pressure tubes with necessary piping, valves and local instruments etc. The maximum recovery shall be 75%.
- Electro De-Ionisation system shall be designed for a flow rate 40 cu.m/hr.
- MB (as a standby for EDI) shall be designed considering 1% of the ionic balanced raw water quality and OBR of 792 m³
- Blowers with motor (one working and one standby) for Mixed Bed Exchanger regeneration.
- Side stream filters with frontal pipe work and initial charge of sand bed with all valves, instruments and interconnecting piping and blowers
- Bulk Sulphuric acid handling system with necessary transfer pumps & other accessories
- Necessary dosing system & antiscalent dosing system with interconnecting piping, valves & instruments

- Circulating water treatment system for the cooling tower comprising of dosing pumps, interconnecting piping, Corrosion test rack, Bio-film monitor, Scaling deposit monitor and equipment for data logging, analysis and prediction.
- The Drawing No.3-16083-800-0024 gives the scheme for raw water, DM water and condensate system.

7.8.3 Service and Potable Water System

The service water system supplies water to toilets, general washing, gardening, dust suppression system, make up water for air conditioning plant etc. To meet the service and potable water requirements of the plant, separate facilities are provided like water pumps, PVC / HDPE piping, water filters, etc.

7.9 Compressed Air System

7.9.1 The requirement of compressed air for instruments and the control systems of the cogeneration plant will be supplied by Three (3) instrument air compressors with Two (2) working and One (1) standby. Each of the compressor shall be rated for 400 N.cu.m/hr at 7 bar(g). The air compressor shall be of lubricated screw compressor with suitable pre and after oil filters Air driers, Air receivers and control panel.

7.9.2 The air drier unit shall comprise of 2 x 100% absorber towers with one of the towers in operation and the other one in regeneration mode. The towers shall be fabricated from SA 515 Gr.70 material and filled with Alumina. The air drier shall be provided with sequence timer for automatic changeover and change over valves. The entire drying system shall be skid mounted.

7.9.3 The air receiver capacity shall be 2.0 Cu.m, fabricated from SA 515 Gr.70 material. The internal surface shall be galvanised. The air receiver shall be fitted with all accessories including safety valves, moisture separators, etc.

7.9.4 The Drawing No.3-16083-800-0022 gives the scheme for the compressed air system.

7.10 **Air Conditioning System**

7.10.1 The following areas of power plant will be envisaged with ductable type, ceiling suspended air conditioning system:

- PCC, MCC, VFD, Auxiliary MCC panel rooms in TG building
- Control Room in TG building
- Battery room

7.10.2 The following areas of power plant will be envisaged with Hi-Wall split air conditioning system:

- SWAS panel room in TG building
- WTP DCS operator station room in WTP building
- WTP laboratory room in WTP building
- Office and Conference Room

7.10.3 The condensers will be located above the plant A.C. room and the conditioned air will be distributed by means of ducting in the control room. Suitable humidity control devices shall be provided. A temperature of $22.2^{\circ}\text{C} \pm 1.1^{\circ}\text{C}$ and a relative humidity of $55 \pm 5\%$ will be maintained in the control rooms.

7.10.4 Compressor shall be of hermetically sealed, scroll type. Condensers shall be air cooled type. The cooling fans shall be of higher diameter and a lower speed. Cooling coil shall be fin and tube type with aluminium fins firmly bonded to the tube.

Air handling fan shall be of centrifugal type with forward curved blades. Package unit filters shall be cleanable polythene type. Refrigerant piping shall be carried out between package unit and condenser out of hard copper pipe of minimum 10 G thick sufficient thickness.

7.11 Ventilation System

7.11.1 The exhaust ventilation system is envisaged for the cogeneration plant. Area which need exhaust ventilation and have adjacent sufficiently large wall to fix exhaust fans.

7.11.2 The following areas will be envisaged with exhaust ventilation system:

- TG hall
- Water Treatment plant Equipment room
- Chemical Storage area in WTP (water treatment plant) building
- Muffle furnace, Hot oven, etc room in WTP building
- WTP MCC panel room
- Fire Pump House
- Toilets

7.11.3 The exhaust ventilation system will maintain the temperature rise within 5 Deg.C above ambient temperature.

7.12 Fire Protection System

7.12.1 The fire protection system for the proposed Cogeneration plant shall be consisting of:

- Hydrant System for all the areas of the plant.
- High velocity water spray system for Generator Transformers

- Automatic fire detection and alarm system
- Manual fire alarm system
- Portable fire Extinguishers

7.12.2 The components of the fire protection system, wherever applicable shall be approved by National Standards. The system shall be designed based on safety requirements and generally conforming to National Fire Protection Association of America (NFPA).

7.12.3 The fire detection and alarm system shall be designed according to National standards. The system shall consist of addressable type one loop fire alarm panel located at the control room, addressable type smoke detectors (ionization and optical), addressable type heat detectors, manual call points, electronic hooters, junction boxes and cables.

7.12.4 Portable type fire extinguishers of Dry Chemical Power (DCP) type shall be located in the TG building, control room, MCC rooms, fire pump house, etc.

7.13 Main Steam, Medium Pressure and Low Pressure Steam Systems

7.13.1 The outlet steam from each of the boiler will be conveyed through alloy steel main steam piping to each 24.9 MW Turbogenerator. Adequate number of stop valves, non-return valves & isolating valves shall be suitably placed in the piping. The piping system shall be complete with necessary hangers, supports & specialities. Steam flow meters shall be placed in the piping, from the boiler, to measure the boiler steam flow. Main steam from the boiler is conveyed to the turbogenerator and the piping shall be complete with stop valves, Instruments, Flow meters, hangers, supports & specialities. A tap off will be taken from the main steam piping to feed the main steam to

the Pressure Reducing & Desuperheating Stations for reducing the pressures, which is a standby arrangement for the turbine extractions for meeting the process steam requirement, Pegging PRDS and Auxiliary PRDS for meeting just the ejector and gland sealing steam requirements during start up.

- 7.13.2 All valves in the piping system shall be suitable for the service conditions i.e., flow, temperature and pressure under which they are required to operate and those performing similar duties shall be interchangeable with one another unless otherwise approved. All gate valves shall be of the full way type and when in the full open position the bore of the valve shall not be obstructed by any part of the gate. Globe valves shall have curved or spherical seating and the discs shall be free to revolve on the spindle. All non-return valves shall have an arrow cast or embossed on the side of the valve body to indicate the direction of the flow. For severe service conditions cushioned check valves are preferred to obviate valve clatter. In the case of swing-check valves the body seat shall be inclined at such an angle to the vertical as will facilitate closing and prevent chatter.
- 7.13.3 The insulating materials for the piping system or / and any component of the piping system shall not react chemically singly or in combination, with water or moisture to form substances which are more actively corrosive to the applied surface than water or moisture alone. The materials shall not offer sustenance to fungus or vermin and must not pose a health hazard. For mineral wool material the application density of insulation for temperature upto and including 400 Deg.C shall be 100 Kg/Cum. The application density for temperatures above 400 Deg.C shall be 125 Kg/Cum.
- 7.13.4 The sheeting material for all insulated piping and equipment shall be aluminium conforming to British Standards (BS) /ASTM codes.

7.13.5 The Drawing Nos.3-16083-800-0023 gives the scheme for plant steam system.

8.0 Plant and Machinery (Electrical) for Cogeneration Plant

8.1 Proposed System

8.1.1 The scheme of the electrical power generation for the cogeneration project will consist of two (2) nos. 11 kV, 50 Hz, 3 Phase, 0.8 PF Synchronous generators each having nominal capacity of 24.9 MW. The generators will operate in parallel with National grid. A portion of the power generated in the turbogenerators will meet the power requirements of the Co-generation plant auxiliary loads and the sugar plant loads through step down transformers. All the electrical equipment related to generation and power evacuation shall be designed to meet with the requirements of the National Grid Code.

8.1.2 After meeting the in-house requirements, the plant can export the net additional power to the grid by step-up to 132 kV using three (3) numbers 11/132kV, 30/40 MVA generator transformers, which will be located in the proposed outdoor switchyard. Enclosed protection, metering and control schematic Diagram (Drg.No.0-16083-900-0453) to this report gives the proposed electrical scheme for the cogeneration plant. Enclosed key single line diagram (Drg.No.0-16083-900-0454) gives the power generation & interconnection arrangement of co-generation plant with sugar plant.

8.2 Generator

8.2.1 The Generation voltage will be 11 kV, three phase, 50 Hz, at a rated power factor of 0.8 (lag). The generator is capable of operating at the power factor from 0.8 lag to 0.98 lead at rated power generation. The machine will run at 1500 rpm and will operate with the Voltage and Frequency variation of $\pm 10\%$ and $\pm 5\%$ respectively. The enclosure will be of dust, vermin and water proof. The generators will meet other requirements

as stipulated in IEC:60034. The generator will be complete with base frame, closed air circuit water cooled (CACW) cooling system, brushless exciter, automatic voltage regulator, neutral grounding cubicle, LAVT (lightning arrestor & surge capacitor and voltage transformer) panel, relay, metering, and control panels, load sharing panel, instrumentation control and safety devices and other accessories, spares and special tools that will be required for satisfactory erection and efficient operation of the station. The generator coupled to the steam turbine will be suitable in all aspects for operating in parallel with grid. The generator will match with the turbine in respect of speed, over speed, moment of inertia, overload capacities, coupling and other relevant requirements.

8.2.2 The stator and the rotor of the generator will have class 'F' insulation but the temperature rise will not exceed the limits specified for class 'B' insulation. The generator will be fitted with RTDs (min. 4 nos. per phase, for monitoring the temperatures), space heaters and temperature indicators.

8.2.3 The generator terminals will be suitable for connecting to switchgear panel through 11 kV phase segregated busduct. The current transformers for metering and protection will be housed in the 11 kV busduct and NGR cubicle. The protection, metering and control schematic Diagram (Drg.No.0-16083-900-0453) enclosed to this report gives the protection scheme for the generator.

8.3 Excitation System & Synchronizing Panels

8.3.1 The excitation system will be of brushless type and will be provided with the following features:

- a. Generator voltage control
- b. Excitation current control

- c. Excitation build up during start up and field suppression on shutdown
 - d. Limiter for the under excited range and delayed limiter for overexcited range
 - e. PT fuse failure detection and auto changeover
 - f. Auto power factor control
- 8.3.2 The system will have twin auto and manual channels, with bumpless changeover facilities. Alarms will be arranged for AVR fault, AVR automatic changeover to second auto channel / manual mode and for diode failure.
- 8.3.3 Swinging / trolley type synchronizing bracket complete with running and incoming voltmeters, running and incoming frequency meters, synchroscope, synchronizing check and guard relays, no volt relays, synchronizing cut off switch, lamps etc. will be provided. Automatic synchronizing with inputs to governor and AVR control will be made possible.
- 8.3.4 Load sharing panel with required number of load sharing modules and other auxiliary relays shall be provided in the panel to share the loads between the generators in equal or proper ratio, when both the generators are running in parallel with each other.
- 8.4 **Unit Control Panel**
- 8.4.1 The unit control panel will comprise of control and metering system, common synchronizing system, load sharing panels, protective relays, start / stop system, alarm / annunciation and temperature measurement system. The control panel will have provision for closing / synchronizing through the generator breakers, tie breakers, bus coupler breakers and LT Breakers. Dead bus closing arrangement will also be provided in the control panel. The panels may be split up into control panel, metering panel and relay panel for convenience.

8.4.2 Panels will have digital / electronic TVM, ammeters, voltmeters, frequency meter, power factor meter, kW and kVA meters. All meters will be hooked-up to DCS system through RS485 ports for data logging. The following minimum protections will be provided for the generators:

- Accidental energisation protection
- Over & Under voltage
- Under & over frequency
- Field failure
- Reverse power
- Low forward power
- Voltage restrained over current
- Generator differential
- Stator standby earth fault detection
- Local breaker back-up / struck-up
- Negative sequence
- Pole slipping
- Voltage balance / PT fuse failure
- Over fluxing Protection
- 100% stator earth fault relay
- Over all differential relay

8.4.3 Following additional stage of protections shall be used to trip tie CBs with grid interconnection:

- Over voltage
- Over frequency
- Under voltage
- Under frequency

8.5 LAVT and NGR Cubicles

8.5.1 The LAVT cubicle will house surge capacitors, potential transformers for protection (class 3P), metering (class 0.2) &

AVR sensing / excitation supply, lightning arrestors, cable box etc. The NGR cubicle will comprise of current transformers (class 0.2 and 5P20), neutral isolating switch and grounding resistor (punched grid type stainless steel grids). The enclosure for the panels will be of Cold Rolled Cold Annealed (CRCA) sheet of 3 mm thick for front and back and 2.5 mm thick for rest.

8.6 11 kV Switchgear Panel

8.6.1 The broad specification for the 11 kV switchgear panel will be as follows:

Rated Voltage	:	11 kV, 3 Phase, 50 Hz
Maximum Voltage	:	12 kV
Power frequency Voltage	:	28 kV rms
Impulse withstand voltage:		75 kV peak
System Fault level	:	750MVA(40kA for 3 sec)
Maximum bus bar Temp.	:	As per IEC
Operating Duty	:	O-0.3sec-CO-3min-CO
Control Voltage	:	110 V DC

8.6.2 A common 11 kV indoor switchgear board will be provided in the TG house, for power distribution and evacuation of both Turbo generators of cogeneration plant and a separate 11kV indoor type sugar switchgear board shall be provided for power distribution of sugar plant loads, which shall be located in the existing sugar plant. The board will be metal clad, free floor standing, totally enclosed, dust and vermin proof with draw out type vacuum circuit breakers. The switchgear will conform to IEC:298 and breakers will conform to IEC:62271. Each breaker will have distinct positions for service, test and isolation mode and will have independent earth switch or earthing trolley for earthing the cable side terminals and main bus bars. All panels will have earth switch with interlock or separate earthing trolleys. The panels will be suitable for bottom cable entry.

Details of incomer and outgoing feeders will be as indicated in the schematic diagram enclosed to this report. Current and Potential transformers will conform to IEC 60044-1 and IEC 60044-2, respectively.

8.6.3 The switchgear panels will be complete with necessary CTs and PTs for metering and protection which will be of cast resin type conforming to relevant IEC standards. The auxiliary transformer feeders & motor feeders will be provided with the necessary relays, meters and surge protection devices as shown in the enclosed protection scheme drawing. Energy management system will be provided in the plant DCS system by hooking-up all meters in PCCs and 11 kV / EHV systems, to ensure that data in any fashion on energy consumption / generation / export could be made available during operation.

8.6.4 Generator circuit breaker (GCB) shall be suitably selected for short time rating, making and breaking capacity (symmetrical as well as asymmetrical) depending upon the X_d'' of the generator and other system parameters.

8.7 Distribution System

8.7.1 Four (4) numbers of 4MVA, 11/0.415/0.415kV VSD transformers will be provided in the cogeneration plant for feeding to the auxiliary loads of cogeneration plant, as indicated in the enclosed protection, metering & control schematic diagram (Drg. No. 0-16083-900-0453).

8.7.2 Five (5) numbers of 2.5MVA, 11/0.415kV transformers shall be provided for interconnecting existing 415V g switch boards for feeding sugar plant loads, Three (3) numbers of 11/0.690/0.690kV VSD transformers shall be planned in the sugar plant for feeding mill loads of sugar plant. 11kV feeders for Shredder motors of two (2) numbers and cutter motors of

two(2) numbers shall be fed from 11kV sugar switchboard as indicated in the enclosed (Drg. No. 0-16083-900-0453).

- 8.7.3 Interconnection between the 11kV cogeneration switchboard and 11kV sugar switchboard have been planned for catering power to sugar plant loads, as shown in the enclosed (Drg. No. 0-16083-900-0453).

8.8 Plant Auxiliary Transformers and LT Panels

- 8.8.1 The following transformers conforming to IEC:60076 shall be provided for catering power to the cogeneration plant as well as sugar plant auxiliary loads, as per the following specification:

	Interconnection transformer for sugar plant loads	VSD transformer for cogeneration plant Auxiliary loads
Quantity	5 Nos	4 Nos
Rating in MVA	2.5MVA	4MVA
Cooling	ONAN/ONAF	ONAN
Ratio	11/0.415kV	11/0.415/0.415kV
Highest system Voltage	12	12 kV
Power frequency Voltage	28 kV rms	28 kV rms
Impulse Withstand Voltage	75 kV peak	75 kV peak
Taps and Range	Off-circuit, $\pm 7.5\%$ in steps of 2.5%	Off-circuit, $\pm 7.5\%$ in steps of 2.5%
Voltage Vector	Dyn11	Dyn11zn0
Neutral Earthing	Resistively Earthing	Solid Earthing

- 8.8.2 The transformers will be protected by over current and earth fault relays at HV side and Restricted Earth Fault (REF) relay at neutral end in addition to in-built protective devices like Buchholz relay, Magnetic Oil Level Gauge (MOG), Oil and Winding Temperature Indicators (OTI & WTI). Neutral

bushing CT before bifurcation of neutral will be provided for REF protection of secondary winding of the VSD transformers.

- 8.8.3 The LT distribution panels conforming to the latest revision of IEC:61439 will be of dust & vermin proof construction, sheet steel clad, totally enclosed, floor mounted, self-standing type. All panels will be of single bus bar type with bottom cable entries. The Motor Control Centres (MCCs) will be of compartmentalised design with cable alley at the sides. Power Control Centres (PCCs) will have the cable chambers at the rear. The busbars will be of electrolytic grade copper busbar, designed for 85°C end temperature with an ambient of 50°C. All panels will have neutral bus, sized to carry half the phase current. All panels will be designed for 50 kA for 1 sec.
- 8.8.4 The panels will have Air Circuit breakers for ratings 630A & above. All breakers will be of draw-out type with spring charged motor operated closing mechanism for incomer feeders and motor feeders and manual type for others feeders. For ratings less than 630A, MCCBs will be provided. MCC feeders will be of MCCB / MCCB + microprocessor based over load relays + contactor / MPCB + contactor, with ammeters of suppressed scale for rating 5.5kW and above. , indication lamps, suitable for remote operation.
- 8.8.5 LT Busduct of suitable rating will be used for interconnecting VSD transformers and PCC / VFD panels.
- 8.8.6 AC Variable Speed Drives (VSDs) will be provided for BFP motors, ID, FD and SA fan, MCW pumps, CT fans, ACW pumps, fuel feeders, and Air compressors. All the VFD drives will be fed from VSD transformers by equally distributing the loads on both the side of the transformers to minimise the harmonic injected at 11kV bus by the VSD loads.

- 8.8.7 All motors will be of squirrel cage type conforming to IEC:34, totally enclosed and fan cooled. Motors will be of energy efficient type (IE3). The windings will be insulated by class 'F' insulation material and maximum temperature rise will be limited to class 'B' insulation limit over an ambient of 50 Deg. C.
- 8.8.8 Motors of rating less than 50 HP will be provided with DOL starters in MCC. Higher sized motors may be provided with star / delta starter depending on application. Motor feeders will be complete with contactor, over load relay, MCCB/MPCBs.
- 8.9 **Plant Start-up & Emergency power requirement**
- Two (2) Nos. of 1250kVA DG sets will be considered for starting the cogeneration plant auxiliary loads. The DG set voltage rating shall be 415V.
- 8.10 **Earthing System**
- Neutral point of the VSD transformer and neutral grounding resistor of the TG set generators will be effectively connected to individual earth pits and will be interconnected, as per IEEE: 80 recommendations. Non-current carrying parts of all electrical equipment viz. motors, MCCs, PCCs, distribution boards, control panels, HT switchgears, generators and all lighting fittings will also be earthed rigidly, to ensure safety.
- 8.11 **Cables**
- 8.11.1 All cables will be selected to carry the load current under site conditions, with permissible voltage drop. In addition, high voltage cables will be sized to withstand the short circuit current. The following types of cables will be used:

- 8.11.1.1 Power cables for 11 kV system will be with single / three core aluminium conductor XLPE insulated, screened, armoured and overall PVC sheathed confirming to IEC:502.
- 8.11.1.2 The power cables of 1.0 kV grade will be of PVC insulated, copper conductor, inner sheath PVC taped strip / wire armoured with outer sheath of PVC compound conforming to latest version of IEC:227.
- 8.11.1.3 The control cables for control / protection / indication circuit of the various equipment will be of 1.0 kV grade, PVC insulated annealed high conductivity stranded copper conductor, inner sheath PVC taped, flat/round wire armoured with outer sheath of PVC compound conforming to latest version of IEC:227.
- 8.12 **DC supply system**
- 8.12.1 Two (2) Nos. of DC system each rated for 100% requirement of both the units consisting of battery banks, float cum boost charger and DC distribution board will be provided in common for the power house DC load requirements (viz. turbine emergency oil pumps, control & protection), switchyard loads and emergency lighting.
- 8.12.2 VRLA type batteries with 2V cells along with accessories will be provided.
- 8.12.3 The battery sizing of each set will be on the basis of the following type of loads of the both the plant/unit:
- Momentary load for 1 min.
 - Emergency load for 1 Hrs
 - Continuous load for 10 Hrs.

- 8.12.4 The battery charger will be of SCR controlled with dual float cum boost charging (FCBC) equipment housed in a free standing, floor mounting cubicle having hinged half doors made out of 14 SWG CRCA sheets.

8.13 **AC Auxiliary Supply**

AC supplies of single and three phase, needed for internal use for Illumination, Battery charging, UPS, Transformer tap changer drives, Excitation supply, Power supplies for communication equipment, Breakers / Disconnect switch motors, Space heaters in cubicles, generators and marshalling kiosks will be arranged from minimum two supply sources. For extremely critical AC loads, UPS supply system will be envisaged.

8.14 **Lighting System**

Good lighting in the cogeneration plant will be ensured to facilitate normal operation and maintenance activities and at the same time to ensure safety of the working personnel. Lux levels and glare index will be as per recommendations of IEC Standard. The lighting system would comprise of normal and emergency power supplies. Main lighting system will receive supply from reliable supply sources and the emergency lighting system will be supplied from battery units. Emergency lighting will be provided at strategic points in the power station, switchyard area and in control rooms.

8.15 **Lightning Protection**

Building lightning protection system will be provided as per IEC 62305 / IEEE-80 guidelines. The protections consisting of roof conductors, air terminals and down conductors will be provided for the power house structure and other taller structures of the plant.

8.16 Plant Communication system

All parts of the power plant, viz. boiler, bagasse & ash handling, water system, ESP and switchgear rooms will be linked to the plant control room through telephone communication system and Walkie-Talkies. In addition paging system will be installed for paging over public address system. The plant shall be effectively connected with NTDC (National Transmission and Dispatch Company) / DISCO (Distribution Companies-FESCO) load dispatch centre through a suitable telephonic system as per NTDC/DISCO(FESCO) requirement.

8.17 Suitability of power units to operate in parallel with grid

8.17.1 It is important that the co-generation plant is designed to operate satisfactorily in parallel with the grid under extremely high voltage and frequency fluctuation conditions, so as to export the maximum possible units to the grid. It is also extremely important to safeguard the system during major disturbances, like tripping / pulling-out of big generating stations and sudden overloading during falling of portion of the grid loads on the power plant in island mode, under fault / feeder tripping conditions.

8.17.2 The plant generators should be sized to operate at it's full capacity at extreme frequency levels of connected grid under all conditions. The hooking-up will be done at FESCO and 18 Hazari 132kV feeder through Loop in Loop Out Arrangement (LILO), which is a distance of 3km from the cogeneration plant. through transmission line. . In order to maintain voltage variations within limits for the plant loads, the generator transformers that will interconnect the grid (at 132kV) and the plant generators should be provided with sufficient on load tapplings changers on higher as well as lower ends to take care of grid voltage variations and transmission system voltage variations due to loading.

8.18 Proposed system

The Co-generation Project envisages a power export of 34,485 kW during season operation and about 45,067kW during off season of the plant generated from the two TG sets. With this, the switchyard electrical system will be designed for export of maximum 45,067kW of power, after in-house consumption by the co-generation plant loads and sugar plant loads. It is proposed to export this surplus power to FESCO grid by connecting the generated power to FESCO and 18 Hazari 132kV feeder through Loop in Loop Out Arrangement (LILO), which is a distance of 3km from the cogeneration plant. through transmission line on DC tower.

- 8.18.1 The exportable power from the plant shall be evacuated by stepping up the power from 11 kV to 132 kV through Three nos. of 11/132 kV, 30/40 MVA generator transformers located at each transformer bay. Though Two nos. Transformers are adequate for power export, additional one no. Is considered to meet N-1 condition of NTDC requirement. The switchyard in the plant will be provided with a three transformer bays including tariff metering, two line bays and one bus coupler bay with Bus-1 and Bus-2 bays.
- 8.18.2 Proposed 132kV switchyard in the plant premises will have Three generator transformers with control and protection equipment, CBs, CTs, PTs, isolators, lightning arrestors and TVM for FESCO measurement will be arranged as per the drawing 'Protection, metering & control schematic diagram' with Drg no. 0-16083-900-0453 enclosed to this report. The arrangement and layout of the equipment shall be as per the Switchyard layout drawing with Drg no.1-16083-900-0452 enclosed in this report.

- 8.18.3 Switchyard arrangement and other requirements will be in line with NTDC/FESCO specifications. Switchyard shall not have provision for extension in future.
- 8.18.4 Protection, metering & control panels for the switchyard and grid feeders will be accommodated in the plant's central control room/Switchyard control room. A hot line telephone communication system shall also be established between the sub-station and the power plant control room to enable better coordination.
- 8.18.5 DPLC/VSAT system as per NTDC specifications shall also be planned based on the availability of equipments available at respective FESCO substations.
- 8.18.6 Tariff metering shall be accommodated in separate tariff metering room near switchyard control building in the plant end switchyard as per NTDC/FESCO standards/ requirements. Dedicated tariff metering CTs and Tariff metering PTs have been considered for main and check tariff meters as per NTDC /FESCO requirements. The tariff meter shall register import as well as export parameters and shall be of digital type, with class of accuracy 0.2S as per IEC:687 / IEC:1036 an NTDC /FESCO specifications.
- 8.18.7 The bus bars will be formed with AAC Hawthorn conductor. The switchyard components will be designed to have a BIL value of 650 kVp. All equipment shall be selected for creepage distance suitable for very highly polluted category.
- 8.18.8 Transmission line between the plant end switchyard and the FESCO-18 Hazari 132kV feeder shall be of double circuit conductor of size Rail and shall be taken through steel lattice DC towers suitable for double circuit conductors and single earth wire. Foundations, civil works and execution of work shall

be in accordance with NTDC/FESCO Specifications & norms. The transmission system shall be complete with galvanized transmission towers, normal as well as extension arrangements, conductors, earth wires, strain / string insulators, hardwares & accessories for towers, gantries at termination points, etc.

8.19 Generator Transformer

8.19.1 Generator transformers will be used to step-up the generated exportable power at 11 kV into 132 kV, which will be housed in the switchyard, inside plant premises. The transformer conforming to IEC:60076 will be complete with the fitting & accessories like conservator, MOG, breather, Buchholz relay with contacts for alarm and trip, pressure relief devices, thermometer pockets, OTI & WTI, Valves, earthing terminals, cooling accessories, bi-directional flanged rollers with locking and bolting device for mounting on rails, air release devices, inspection cover, On Load Tap Changer (OLTC) with remote tap changer control (RTCC) panel, marshalling box, etc. Brief specification of each transformer will be as below:

Cooling	:	ONAN/ONAF
Rating	:	30 / 40 MVA
Ratio	:	11 / 132 kV
Highest system Voltage	:	145 kV
Power frequency Voltage	:	275 kV rms
Impulse Withstand Voltage	:	650 kV peak
Voltage Vector	:	YNd1
Impedance	:	12.5 %
Neutral Earthing	:	Solid Earthing

8.19.2 On load tap changer of generator transformer will meet the requirements of IEC:214.

8.20 Circuit breakers

8.20.1 Circuit breakers of Sulphur Hexafluoride (SF₆) gas type will be provided in switchyard. The circuit breaker and accessories will be in general conforming to IEC:62271.

8.20.2 The circuit breaker will be totally restrike free under all duty conditions and will be capable of breaking magnetizing current of transformer and capacitive current of unloaded overhead lines without causing over voltages of abnormal magnitudes.

8.20.3 The SF₆ gas will comply with IEC:376 and be suitable for use in the switchgear under the operating conditions. The high pressure cylinders in which the SF₆ gas is shipped and stored will comply with requirements of relevant IEC standards.

8.20.4 Closing coil will be suitable for operation at all values of voltages between 85% and 110% of the rated voltage. Shunt trip will operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

8.21 Protection, metering & control cubicles

8.21.1 Protection, metering & control schematic diagram with drg. No. O-16083-900-0453, enclosed to this report, gives the details of relays & meters to be provided for switchyard, feeder and unit protection.

8.21.2 The generator transformer will have the following minimum protections, in addition to the in-built protections (Buchholz relay, Oil & winding temperature relays, magnetic oil level gauge), to isolate the equipment during fault conditions:

8.21.3 Protective list for Generator Transformer (GT):

- i. Non directional IDMT over current relay on HV side (51-HV)
- ii. Non directional IDMT earth fault relay on HV side (51N-HV)
- iii. Non directional instantaneous over current relay on HV side (50-HV)
- iv. Non directional instantaneous earth fault relay on HV side (50N-HV)
- v. Local breaker back up protection (50LBB)
- vi. Directional over current relay on HV side (67-HV)
- vii. Directional earth fault relay on HV side (67N-HV)
- viii. Over flux relay (99)
- ix. Relays for transformer internal faults, alarms and trips (49x,63x,26x,71x)
- x. Transformer differential protection (87)
- xi. Transformer restricted earth fault relay (64)
- xii. Stand by earth fault relay (51G)
- xiii. Over voltage relay (59L)
- xiv. Under voltage (27L)
- xv. Under frequency relay (81 U/F)
- xvi. Over frequency relay (81 O/F)
- xvii. Rate of change of frequency relay (81 df/dt)
- xviii. Vector shift /jump relay (78)
- xix. Non directional IDMT over current relay on LV side (51LV)
- xx. Non directional instantaneous current relay on LV side (50LV)
- xxi. Neutral displacement relay for LV side
- xxii. Other auxiliary relays and timers shall be provided as per system requirement
- xxiii. Metering for the GT shall be provided as shown in the enclosed SLD.

8.21.4 Protective list for 132kV line panel:

- i. Non directional IDMT over current relay (51-L)
- ii. Non directional IDMT earth fault relay (51N-L)
- iii. Non directional instantaneous over current relay (50-L)
- iv. Non directional instantaneous earth fault relay (50N-L)
- v. Directional over current back up relay (67-L)
- vi. Directional E/F back up relay (67N-L)
- vii. Distance protection relay (21 and 50LBB)

8.21.5 Protective list for 132kV Buscoupler Panel:

- i. Non directional IDMT over current relay (51)
- ii. Non directional IDMT earth fault relay (51N)
- iii. Non directional instantaneous over current relay (50)
- iv. Non directional instantaneous earth fault relay (50N)

8.21.6 Protective list for 132kV line busbar protection panel:

- i. Bus bar protection replay (Central Unit) along with its CT supervision relays.

As decentralized schemes for busbar protection shall be considered as per NTDC requirements, differential relays (Peripheral Units) have been considered in each transformer, line and bus coupler bay relay panels. These bay differential relay shall be connected to the differential relay (central unit) provided in the busbar protection panel.

8.21.7 Other auxiliary relays and timers shall be provided as shown in the enclosed SLD

- 8.21.8 Metering for the line shall be provided as shown in the enclosed protection, metering & control schematic diagram (Drg. No. O-16083-900-0453).
- 8.21.9 SCADA (Supervisory Control and Data Acquisition system) with RTU (Remote Terminal Unit) and GPS (Global Positioning System) clock shall be planned with required software as per NTDC/FESCO requirement. All the requirement of NTDC/FESCO like real time power system monitoring, warning system etc. shall be met with.
- 8.21.10 As elaborated above, the feeders linking the plant substation will be protected with distance and directional over current & earth fault relays. Rate of change of frequency (dF/dt) relay with under frequency protection and vector surge protective relay will also be provided to isolate the generating system during grid disturbances / over loading conditions.
- 8.21.11 Meters for monitoring the electrical parameters, mimics, transducers, annunciators for fault signals, control switches will be provided in the control panels, as per the enclosed drawings. Interlocking between breakers / isolators / earth switches for safe operation of the system will also be ensured.
- 8.21.12 All the protection, metering & control cubicles and Remote Tap Changer Control (RTCC) panels will be housed in the plant common control room.
- 8.22 **Lightning Arrestors**
- 8.22.1 Lightning arrestors rated 120 kV, 10 kA will be provided for transformer / switchyard equipment protection and on terminating ends of the transmission lines. The lightning arrestor will be heavy duty station class type, discharge class III, conforming to IEC specification 99-4. Arrestors will be

complete with Insulating Base, self contained discharge counters and suitable milli ammeters.

8.23 Isolators & Insulators

8.23.1 Isolators complete with earth switch (wherever necessary), galvanised steel base provided with holes, solid core type post insulators with adequate creepage distance conforming to IEC, blades made up of non-rusting material, operating mechanism (gang operated, manual / motor charging mechanism). They will be of centre break type. The isolators will have interlocks with circuit breaker and earth switch.

8.23.2 Solid core type post insulators of adequate creepage distances (suitable for high pollution category) conforming to IEC will be provided for insulation and support in the switchyard.

8.24 Instrument transformers

8.24.1 The instrument transformers and accessories will conform to standards specified below:

- a. Current Transformers : IEC:60044-1
- b. Potential Transformers : IEC:60044-2

8.24.2 Instrument transformers will be mounted on 132 kV class, sealed porcelain bushings suitable for outdoor service and upright mounting on steel structures. Instrument transformers will be hermetically sealed units with in-built provision to dissipate any excessive pressure build up. Current Transformers will be of ring type with suitable construction at the bottom for bringing out secondary terminals.

8.25 Structures

8.25.1 The structures will be made up of hot-dip galvanized steel and designed to withstand forces during normal conditions (viz. wind loads & dead load of switchyard components) and abnormal conditions (viz. short circuit, earthquake etc.).

8.26 **Safety Earthing System for switchyard**

8.26.1 A safety earthing system consisting of a buried Copper bare conductor earthing grid will be provided for the switchyard. The earthing system will be formed to limit the grid resistance to below 1 ohm. In the switchyard area, the touch potential and step potential will be limited to the safe values. The earthing design will be as per IEEE:80 recommendations.

8.26.2 The buried earthing grid will be connected to earthing electrodes buried underground. Neutral point of generator transformer, non-current carrying parts of equipment, lightning arrestors, fence etc. will be earthed rigidly. The following factors will be considered for earthing system design:

- a. Magnitude of fault current
- b. Duration of fault
- c. Soil resistivity
- d. Resistivity of surface material
- e. Shock duration
- f. Material of Earth Conductor, and Earth mat grid geometry

9.0 Instrumentation and Control System

9.1 General

9.1.1 This Section of the Report gives the general philosophy of the Instrumentation and Control system for the new Cogeneration Power Plant.

9.1.2 The objectives of Instrumentation & Control system design are as follows.

- a. To ensure maximum availability of the plant
- b. To effectively monitor and control the plant to ensure desired efficiency levels.
- c. To ensure plant and personnel safety and reduce down time
- d. To provide necessary information to management personnel regarding overall plant performance
- e. To have self diagnostics & faster response time
- f. To be user friendly for operation and maintenance personnel

9.1.3 Centralized control and monitoring with provision for local intervention wherever necessary is the essence of the design philosophy.

9.1.4 Modular design concept will be adopted to ensure that single defective equipment will not disturb functioning of overall system.

9.1.5 The plant will be complete with the basic instrumentation and control system necessary for its safe and efficient operation.

9.1.6 Comprehensive instrumentation and control equipment will be provided for each major area of the plant i.e. Boilers,

Turbogenerators, etc. The Drawing No.3-16083-800-0026 gives the DCS System Architecture.

9.2 Design Criteria

9.2.1 The control system shall be based on the State-Of-The-Art Distributed Control System (DCS) technology with Data Acquisition and control of the entire plant operational parameters.

9.2.2 For critical automatic control loops, redundant transmitters will be provided with 2 out of 3 logic to improve reliability / availability. All other control loops shall be provided with 1 out of 2 logic.

9.2.3 System configuration will be such that any single point failure will not affect the continuous operation of the plant. Redundancy will be provided at appropriate levels to ensure maximum system availability.

9.3 Plant Control & Operation Philosophy

9.3.1 Microprocessor based Distributed Control System (DCS) is envisaged for the centralized control and monitoring of the co-generation power plant. DCS will be located in the central control room (CCR), in the Turbogenerator building.

9.3.2 The Cogeneration power plant will be mainly comprised of the following system.

9.3.2.1 Boiler and its Auxiliaries

- a. The control of the boiler operations like Start-up / Shut-down / Trip shall be realized directly from the DCS. All the signals required for controlling the boiler operation shall be processed by the DCS and necessary actuating signals for

the various final control elements shall be driven from the DCS.

- b. The major control of the boiler includes the following as a minimum:

- Deaerator level control
- Deaerator pressure control
- Drum level (3 element) control
- Combustion control
- Furnace Draft pressure control
- Superheated Steam Temperature Control
- Soot Blower Control
- PRDS control

- c. All the Boiler safety and protection interlocks shall be realized from DCS.

9.3.2.2 Steam Turbine and its Auxiliaries

- a. The closed loop controls of each of the Turbine such as Gland steam pressure control, hot well level and minimum re-circulation flow control shall be performed by the DCS as a minimum (except turbine governor control):
- b. The open loops and interlocks & protections will be implemented in the DCS as per control schemes provided by the STG vendor.
- c. Electronic Governor Control system required for STG will be supplied by STG vendor. It will perform the control of load, speed and inlet steam pressure of the turbine. Governor control system will be housed in the turbine control panel, which will be located in the central control room. It will communicate with DCS through RS 485 MODBUS

communication link. Trip signals of turbine from Woodward Governor will be hardwired to DCS.

- d. Turbo supervisory instrumentation (TSI) rack will also be supplied by STG vendor. The parameters such as turbine axial displacement, Turbine front & rear bearing vibrations, Gearbox front and rear bearing vibrations, Keyphasor etc will be monitored on the same. It will be connected to DCS through RS 485 MODBUS communication link.

9.3.2.3 Bagasse Handling System

The bagasse Handling Systems can be operated from DCS at central control room.

9.3.2.4 Ash Handling System

The Ash Handling System can be operated from DCS at central control room.

9.3.2.5 Water Treatment Plant

The WTP can be controlled manually through Local control panel. The important signals of WTP are connected to DCS through hardwired.

9.3.2.6 Cooling water system

The cooling water system shall be controlled from DCS.

9.3.2.7 ESP

Operation and control of ESP shall be through DCS at central control room.

9.3.2.8 Fire Protection system

Stand alone microprocessor based control system shall be provided for control of Fire Protection system at fire water pump house. The important parameter shall be connected to DCS through hardwired.

9.3.2.9 AC and Ventilation system

Stand-alone microprocessor based control system shall be provided for AC and Ventilation system. This system shall be interfaced with DCS for Monitoring through Hardwired.

9.3.2.10 Compressed Air System

The Control and Operation of compressed air system shall be from DCS at central control room.

9.3.2.11 Switchyard

All important parameters shall be connected to DCS through SCADA system.

9.3.2.12 Steam and Water Analysis System (SWAS)

- a. Steam and Water Analysis System shall be furnished for continuous monitoring of water and steam purity in the plant.
- b. The system shall comprise of all items like conductivity, pH, Silica and Hydrazine analysers, sample conditioning components and other accessories.
- c. The below table gives the parameters to be monitored for the various samples

Sample	Parameters
Feed Water	Conductivity, pH, Silica
Deaerator	DO2
Blow down water	Conductivity, pH
Saturated Steam	pH, Conductivity
Superheated Steam	pH, Conductivity, Silica
Condensate from condenser	Conductivity

- d. All the above signals can be hooked up to DCS through 4-20 mA signals.

9.3.2.13 Stack Monitoring System

- a. The following signals can be hooked up to DCS through 4-20 mA signals for monitoring

♦ SOX/NOX and SPM

- b. The following details on the **electrical signals** shall be processed / monitored by the DCS for interlock / data acquisition purpose:

- Safety Relay status
- Breaker status
- Generated Voltage, Current, KiloWatt, KVAR, Power factor, Frequency
- Line Voltage, Current, KiloWatt, KVAR, Power factor, Frequency
- Synchronization

- c. Various electrical inputs from the transducers and the digital signals from MCC panels shall be processed in the DCS system for achieving the necessary interlocks / controls.

- 9.3.3 The design of the total control system will be such that the following sub-system's functions will be handled by the respective equipment :
- 9.3.3.1 **Data acquisition, Display and logging** sub-system for monitoring, display, logging and printing of process parameters like flow, temperature, pressure, level, power, current, voltage, analytical and status will be performed by the operator station
- 9.3.3.2 **Start / Stop Sequence & Interlock** sub-systems consisting of the safety interlocks, sequence of starting and stopping of the power plant and alarm generation will be achieved by DCS.
- 9.3.3.3 **Closed loop control** sub-system consisting of the continuous monitoring of the operational parameters like Level, Pressure, Flow etc., and **controlling** of the same using the PID functions will be achieved by DCS system.
- 9.3.3.4 **Engineer / Operator interface** sub-system consisting of setting / changing the operational parameters based on the experience of the operator and as a reaction to emergency situations will be achieved by the computers used as the operator station.
- 9.3.3.5 **Communication sub-system** for interconnecting all the above systems.
- 9.3.3.6 **Data highway and network** for connecting the control and data acquisition sub-systems, **operator** interface sub-systems to a duplexed data highway such that there will be information exchange among each one of them.
- 9.3.3.7 **Auxiliary units** such as system cabinets, printer consoles, marshaling cabinets and power **supply** distribution cabinets.

9.3.4 The Distributed Control system is proposed for Control and Instrumentation system, keeping in view the safety, reliability and availability for comprehensive presentation of plant operation status, trends and essential operator interaction facility.

9.3.5 The DCS based plant control will have the following inherent advantages:

- Integration of information from different individual controls provides centralized data on plant operation.
- Increased reliability due to the use of Large Scale Integrated (LSI) components
- Increased flexibility for modification at any stage due to software configuration capability.
- Better availability due to provision of critical module redundancy coupled with Auto / Manual stations.
- Modular design concept provides easy expandability for future in hardware and software.
- Higher maintainability due to improved self-diagnostic and display features.

9.3.6 The major design aspects of the system will be as follows:

- Control will be of the type which normally relieves the operator of continual regulating duties and will be backed up by interlocks and safety systems that will take pre-planned action in cases where unsafe trends and/or conditions develop faster than the operator's ability to respond.

- Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.
- All the closed loop analog signals shall be processed by the DCS. All the safety and interlock signals and digital signals shall be processed by a redundant DCS system.
- Redundancy will be provided in the Central Processing unit, power supply (both at the CPU & I/O), I/O modules and Communication modules (both between the controller & the operator station and between the I/O modules and the controller)
- Redundancy will also be provided for the communication cables.
- Power supply used for interrogation with field devices shall also be redundant.
- The Input/Output modules will be provided with noise filter and galvanic / upto isolation from external control source.
- The Inputs/Outputs modules will also be provided with protection against reversal of polarity of supply voltage.
- The inputs modules shall be suitable for processing the field signals. The outputs will be short circuit proof and protected by fuses.
- The memory will be non-volatile or battery backed up as required.
- On-line replacement of modules shall be possible without

affecting the process.

- Auto boot up facility for the DCS shall be within 2 minutes.
- Display response time shall be less than 2 Sec.
- Data communication net work response time shall be less than 100 m Sec.
- Closed loop control task execution (Control response time) shall be done within 250 msec.
- Sequence control / Interlocks scan time should be within 100 msec.
- Display update time shall be less than 1 sec.
- The system shall be designed so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.
- All equipment/systems located in the field shall be suitable for continuous operation without loss of function, departure from the specific function or damage at the ambient temperature and humidity conditions.
- The control system software shall have all the essential capabilities to perform advanced control algorithms as a minimum. It shall be user friendly, easily programmable and have excellent Data acquisition, Graphic display and logging capabilities.

9.3.7 The field instruments that are primarily responsible for measuring the process parameters will be having the following major design features:

- All the field instruments/equipment that are used shall be of the same make for ensuring the smooth & optimal maintenance including efficient spare parts management.
- All field instruments used for sensing transmission and measuring shall be of electronic smart type with signal transmission in current mode of 4-20 mA.
- All control valves and control damper drives will be of pneumatic type because of their fast response and ease of maintenance.
- Appropriate de-rating of electronic components and parts.
- Important plant parameters that are required to assess the plant efficiency, must be serially communicated to the operator station for the purpose of display / logging.
- All solid state systems/equipment shall be able to withstand the electrical noise and surge as encountered in actual service conditions and inherent in a power plant, and shall meet the specification requirements of surge protection.
- All solid state electronic system/equipment furnished shall meet the requirements of Burn-in and Elevated temperature test.
- All the instrumentation cables shall be flame retardant low smoke type.

- The instrumentation cables and wires shall function without breakdown for surges experienced in the control system. Voltage class and insulation level shall be compatible with the signals they convey.

9.3.8 The turbine shall be provided with an electro-hydraulic governing system. The system shall be designed such that the governing of the turbine shall be automatic and provides for safe operation.

9.3.9 Apart from the above integrated control system, local gauges will be provided near the equipment / pipelines at essential parts of the plant for the purpose of operator guidance.

10.0 Civil Engineering Requirements

10.1 General

This section of the report covers the basic requirements of civil work to be executed for the Bagasse Based Cogeneration Power Project. More detailed specifications are to be drawn at the time of Project engineering depending upon the nature of soil, based on the soil investigations.

10.2 Geo-technical investigation

The Geo-technical investigation shall cover the entire Power plant area. Required and adequate field tests in the form of test boring including drilling through rocks (if required), direct load tests, trial pits, tests for dynamic properties, electrical resistivity tests, etc. and necessary laboratory tests shall be conducted to determine soil and sub-soil characteristics required for site preparation and foundation design. Soil Investigation tests shall be conducted at all major structure / foundation / building locations within the battery limits of the new cogeneration power plant. A comprehensive report on soil investigations shall be prepared incorporating all the data collected and firm recommendations with regard to the type of foundations shall be given supported by calculations. The contour mapping of the cogeneration plant area has to be done during the implementation stage.

10.3 Equipment Foundations

10.3.1 Turbogenerator foundation

10.3.1.1 The Turbogenerator Foundation is a cast-in-situ reinforced concrete Frame foundation which consists of top deck slab, beams, columns and base raft. The base raft shall be extended

to a depth, which conforms to the allowable bearing pressure of the soil.

- 10.3.1.2 The foundation design will take into considerations all the loads from the machine including dynamic loads as per the Turbogenerator manufacturer's loading data. The design and construction will be done as per provisions laid down in British / European / American Standards. The Grade of concrete for the complete foundation including the top deck shall be atleast M-25 (specified characteristic compressive strength of 25 N / sq.mm for a 150 mm test cube at 28 days). The high strength deformed reinforcement steel bars used for reinforcement concrete shall conform to British / European / American Standards.
- 10.3.1.3 Detailed static and dynamic analysis shall be done for the turbogenerator foundation. The static analysis shall include all the operating condition loads as well as abnormal loads like short circuit loads, loss of blade unbalance loads and seismic loads. A fatigue factor of atleast 2 shall be considered for all dynamic loads. The mass of the foundation block shall be not less than three times the mass of the machine.
- 10.3.1.4 Dynamic analysis shall be carried out to calculate the natural frequency and mode shapes and to evaluate the dynamic response of the foundations to the applied dynamic loads. Unbalance loads for the normal operating conditions as given by the manufacturer or VDI 2060 (German standard), whichever is more conservative, shall be used for calculating the dynamic response. Transient dynamic analysis shall be carried out for the short circuit condition with an appropriate forcing function.
- 10.3.1.5 The detailed design and vibration analysis shall be carried out to:
- The determination of the natural frequencies of the

system, to ensure that atleast 20% frequency separation exists.

- Ensure the suppression of vibration amplitudes to acceptable limits.
- The provision for adequate foundation bearing capacity and settlement, limited to acceptable amounts.

10.3.1.6 The reinforcements shall be designed to the working stress methods for the worst load combinations of static and dynamic loads.

10.3.1.7 All necessary provisions by way of cut-outs, embedments, foundation bolt assemblies shall be incorporated into the foundation block to meet the functional requirements.

10.3.1.8 Steam turbine generator foundation shall be isolated from adjoining parts of buildings and other foundations for vibration control. Joints at floor / grade shall be suitably sealed.

10.3.1.9 For foundations supporting minor equipment, weighing less than One Tonne or if the mass of the rotating parts is less than one-hundredth of the mass of the foundations, no dynamic analysis need be done. However if such minor equipment is to be supported on buildings, structures etc., suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolations system shall be designed suitably.

10.3.2 Static Equipment Foundations

10.3.2.1 All the static equipment foundations shall be constructed with cast-in-situ reinforced concrete. All foundations shall be extended to a depth, which conforms to the allowable bearing pressure of the soil.

- 10.3.2.2 The design of foundations will take into account all the loads from the equipment as per the equipment manufacturer's loading data. The design and construction will be done as per provisions laid down in British / European / American Standards. The grade of concrete shall be atleast M-20 (specified characteristic compressive strength of 20 N / sq.mm for a 150 mm test cube at 28 days). The high strength deformed reinforcement steel bars used for reinforcement concrete shall conform to British / European / American Standards.
- 10.3.2.3 The design of foundations shall be carried out by Limit State Method.
- 10.3.2.4 All necessary provisions by way of cut-outs, embedment, and foundation bolts assemblies shall be incorporated into the foundation block to meet the functional requirements.
- 10.3.2.5 The foundations will be isolated from building foundations and superstructures.
- 10.4 **Buildings**
- 10.4.1 **General**
- 10.4.1.1 All buildings, the loads coming on the various floors of the building, the earthquake loads, etc. will be designed and constructed as per applicable Pakistan / British / European / American Standards and codes. However the buildings shall mandatorily comply with the requirements of the Local building codes for Industrial Plants. The analysis and design of structures shall be carried out by Limit state method and by using standard computer programs as per technical specifications and using reinforced concrete (Grade of concrete M-20) & High Yield Strength Deformed (HYSD)

reinforcement steel bars. The buildings shall be designed to suit the climatic conditions of the region. Roofs of all the buildings shall be weatherproof and leak-proof under all conditions. Proper drainage arrangement will be made and these are connected to main storm water drains. All buildings shall be provided with suitable approach roads connecting to main plant roads. The buildings will be properly ventilated and illuminated to meet their functional requirements.

10.4.2 Power House Building

10.4.2.1 This building in general accommodates turbogenerator, all the auxiliaries of the turbogenerator, EOT crane, maintenance area, switchgears, control room, battery room, ventilation and air conditioning room, offices & toilets etc. Pressure reducing stations, etc. could be supported on the roof of the control room.

10.4.2.2 The sub structure of the building will be with concrete shallow foundations and superstructure with Structural steel framework or RCC Frame work, with concrete cast in situ floor slabs. The machine room will be with steel roof truss, Galvalume steel sheet cladding. The building will be cladded with Galvalume sheet steel or with brick. The building frame shall support the overhead Electrical Overhead Travelling (EOT) crane moving on gantries.

10.4.2.3 The control room, DCS room and battery charger room shall be fully air conditioned. Offices will be provided with window air conditioners as per the requirement. Lift may be provided in the power house area for easy access. Staircases will be provided as per the requirement at suitable locations.

10.4.2.4 All doors shall be of steel in steel frames and shall be of fire, explosion and noise proof. Adequate windows / ventilators with

anodized aluminium / steel frame with 6.0 mm thick glass shall be provided.

- 10.4.2.5 Around the buildings a 1.0 m wide smooth finished concrete walkway and necessary steps and ramps shall be provided.

10.4.3 **Floor Finishes**

10.4.3.1 Turbogenerator Room floors

The floor shall be finished with granolithic concrete with a surface hardener. Skirting shall be plastered and painted.

10.4.3.2 Switchgear room, AC & Ventilation machine room

The floor shall be finished with granolithic concrete with a surface hardener. Skirting shall be plastered and painted.

10.4.3.3 Control Room

The control room shall have false flooring to accommodate the cables. The control room should also have false roofing and suitable light fitting recess.

10.4.3.4 Office & Passages

Mosaic Tiles

10.4.3.5 Toilets

Ceramic Tiles

10.4.3.6 Battery Room

The floor and wall shall be finished in tiles resistant to electrolyte/acid and set in electrolyte/acid resistant mortar.

Similar provision shall apply in case of other rooms containing inflammable or corrosive liquids.

10.4.3.7 Ceiling Finishes

Room / Area	Ceiling
Switchgear room, Office, AC & Ventilation room	Plastered & Oil Bounded Distemper painted
Control Room	Suspended Thermal insulation/ Acoustic tiles
Battery Room	Acid Resistant paint
Toilet	Plastered oil painted
Entry, Corridor	Plastered oil painted

10.4.4 Non-Plant Buildings

10.4.4.1 Non-Plant Buildings like, Lab building, MCC Rooms, Pump house etc. will be of concrete shallow foundations and superstructure with reinforced concrete / Structural steel frame work, reinforced concrete cast in situ / Plastic Coated Steel sheeting roof. External walls shall be of 230 mm thick brick masonry and internal walls will be of 115 mm thick brick masonry depending upon the functional requirement of the buildings.

10.4.4.2 Exterior and interior walls, ceiling shall be plastered and painted with approved colour painting. Doors and rolling

shutters with steel frame and adequate windows / ventilators with steel frame with 6.0 mm thick glass shall be provided.

10.4.4.3 Around the buildings a 1.0 m wide smooth finished concrete walkway and necessary steps and ramps shall be provided.

10.4.5 Switchyard

10.4.5.1 Transformers, breakers etc., shall be supported on reinforced concrete (Grade of concrete atleast M-20) pedestals and foundations. The foundations shall be extended to a depth, which conforms to the allowable bearing pressure of the soil. Necessary embedment, guide rails shall be provided for installation and easy manoeuvrability of the transformers. In addition accessibility for mobile crane / fork lift shall be provided for the maintenance work for the transformers.

10.4.5.2 An oil drainage pit filled with broken stones shall be provided around each transformer from which oil shall be drained to a common tank (soak pit) and shall have capacity equal to 100% of the volume of the largest transformer.

10.4.5.3 Brick, blast / fire wall (if required) shall be provided to prevent the spread of fire or explosion from one transformer to another transformer. The height of the blast / fire wall shall be extended 0.5 m above highest point of the transformer. The blast / fire walls will be provided on all three sides transformers. Fencing and gate shall be provided all around the switchyard with proper approach roads. Gravel spreading will be done inside the switchyard.

10.4.5.4 Cable Trenches will be constructed as per the requirement and as described in cable trenches.

10.4.6 Cooling Tower

- 10.4.6.1 The basin underneath the cooling tower for the collection of the cold water shall be of grade M-25 concrete. The raft slab shall be checked for uplift forces considering empty condition of the basin with ground water table at the maximum level. A minimum factor of safety of 1.2 shall be ensured for the condition that the basin walls are constructed upto finish ground level and there is no water in the basin and superstructure columns are not constructed and the ground water table is at the maximum level. The basin shall be water tightness, to prevent mixing of the ground water with the cooling water in the basin.
- 10.4.6.2 Water proofing admixture (plasticizer cum water proofing compound), shall be added to the concrete for basin, channels, drain pits, etc.
- 10.4.7 Cable / Pipe Trenches
- Cable trench walls and base slab will be of cast in situ reinforced concrete (Grade of Concrete M-20) & HYSD reinforcement steel bars. Trenches shall be covered with pre-cast RCC cover slabs of standard design. Suitable slope in the longitudinal direction shall be provided and to be connected to nearby plant drainage system. Necessary embedment and edge protection angles shall be provided as per functional requirements.
- 10.4.8 Pipe Racks
- 10.4.8.1 Pipe rack supporting structure will be of structural steel columns with interconnecting longitudinal & transverse beams, properly braced with vertical & horizontal bracings. All structural steel members will be painted suitably. Width and tier of the rack shall be as per the system requirements. Access ladders at suitable places will be provided.

- 10.4.8.2 The steel columns will be resting on RCC pedestals/footings (grade M20). The analysis and design of structures and foundations will be done as per provisions those laid down in the codes.
- 10.4.9 Roads and Pavement
- 10.4.9.1 All roads within the plant shall be either double lane roads with 6.0 m black topping and 2.5 wide shoulders on either side of the roads or shall be single lane roads with 4.0 m black topping and one meter wide shoulders on either side of the road. Roads geometry and construction shall be in accordance with British / European / American Standards. All the roads shall be designed to withstand the largest expected loads. Minimum longitudinal slope of the road shall be 1 in 200 where there are curbs on each side. Without curbs the roads may be laid flat. Slope from crown to edge should be 1 in 50 generally on straight stretches. Super elevation shall be provided on curves.
- 10.4.9.2 The sub-grade shall be compacted to the levels, falls, widths and cambers as per the grade requirements. Sub-base will be laid on a prepared sub grade. Base and final road surfacing shall be of bitumen macadam. Seal coat will also be provided. Pre-cast RC kerbs on both sides of road shall be provided. The rainwater shall be collected in road side gullies and let into the plant surface drainage system.
- 10.4.9.3 Paving areas shall be properly graded and compacted to required grade and slopes before providing the base layer. Reinforced concrete paving (grade M20) shall be done in alternate panels not exceeding 3.0 m x 3.0 m in size. Construction joints shall be filled with sealing compound. Around equipment foundations / columns isolation joint shall be provided upto full depth of the pavement. Expansion joints shall be provided at a maximum spacing of 15.0 m.

- 10.4.9.4 Top surface of the pavement shall be provided with adequate slopes as required for the surface drainage.
- 10.4.10 Surface Drainage
- 10.4.10.1 All the paved and unpaved areas shall be adequately drained. The surface drainage system shall be designed for surface washings and/or rain/fire water as the case may be.
- 10.4.10.2 Contaminated area surface drainage shall be collected and discharged through catch pits. The catch pits shall be of RCC construction and shall be covered with Cast Iron (CI) gratings. Uncontaminated areas surface drainage shall be done through rectangular RCC drains to be connected to open storm water drains.
- 10.4.10.3 The catch pits, interconnecting pipes and rectangular / trapezoidal drains shall be sized for carrying the design discharge when running full. Adequate bottom slope shall be provided to maintain minimum velocity.
- 10.4.10.4 The paved areas shall be sloped towards the catch pits drains.
- 10.4.10.5 At the road and other crossings suitable pipe / open RCC culverts shall be provided.
- 10.5 **Plumbing and Sanitary System**
- 10.5.1 Plumbing and sanitary system shall serve all toilets, showers, bathrooms, kitchens and laundry room. Wherever possible, all discharge pipes shall be fully vented. The design, installation, testing and maintenance of all plumbing systems & sanitary appliances shall comply with latest applicable National Standards.

10.5.2 Toilets shall have Western style water closets, complying with the local building code requirements. All piping shall be concealed. Floor drains shall be designed in such a way that their taps are always filled with water to guard against odours as well as insect and rodent infiltration.

10.5.3 All wash basins shall be equipped with pop up drain stops. All sinks shall have water taps.

All urinals and water closets shall have flush valves. The minimum acceptable mounting height of a shower head shall be 1.8 m from the finished shower floor.

10.6 Sewerage Treatment plant & Drainage System

10.6.1 The cogeneration power plant will be provided with sewerage treatment plant. The sewerage drainage system consists of connecting the sanitary waste disposal from different buildings to the Septic tank through necessary pipeline. All the pipes shall be of RCC material. Minimum size of pipe at a service connection shall be 100 mm and the minimum size of pipe for sewers shall be 200 mm. Minimum slope in service connections shall be 1 in 40 and in sewers 1 in 400. All sewers shall be located along with roadways or public open spaces. Manholes shall be provided at the head of each sewer, at all changes in slope, direction or pipe size or at junctions of sewers. The maximum distance between manholes shall be 50 m.

10.7 Site Clearance

10.7.1 All the materials and equipment employed for construction purpose shall be taken away from the site. All the rubbish and unwanted plant material shall be cleared and dumped away from the site. All areas within and outside the site which have been used during the construction shall be cleared and the ground surface shall be left in a safe and aesthetically good condition.

10.8 Fencing / Compound Wall

- 10.8.1 The fencing shall be provided for the switchyard area, transformer area and fuel storage area. The fencing shall be for a height of 2.7 M and steel gates shall be provided for approach / maintenance. Compound wall shall be provided wherever necessary and for isolation of specific plant areas.

11.0 Operation and Maintenance Requirements

11.1 General

11.1.1 This section of the report outlines the operation and maintenance philosophy to be adopted for the new Bagasse Based Cogeneration Power Plant. These broad outlines given here will provide useful guidelines for the basic and detailed engineering of the plant, so that all the requirements of the operation and maintenance of the Cogeneration Power plant are met and provided for in the engineering stage itself.

11.1.2 The production of power from steam involves the interaction of several major components and subsystems. The steam supply system includes fuel handling and preparation equipment, the boiler system and emissions control equipment. To generate electrical power, a prime mover, such as a turbine generator is required to convert the thermal energy of steam into mechanical and ultimately electrical power. The water cooled condenser and cooling tower reject unused energy to the environment while minimizing back pressure on the steam turbine. The turbogenerator generates power and part of the power is fed to the plant, the additional being exported to the grid. In addition to the in-plant distribution, the power plant should operate in parallel with the electricity grid.

11.2 System Design Philosophy

11.2.1 The main O&M objective is the high availability and reliability of the plant. In order to achieve the main objective, the following principles would be adopted.

- Optimum margins on the operating parameters of all important equipment and auxiliaries and systems to ensure operation of the plant at rated capacity under all

modes of operation.

- Providing redundant and standby capacity for all critical equipment.
- Use of Equipment and systems with proven design, performance and have a high availability track record under similar service conditions.
- Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.
- Strict compliance with the approved and proven quality assurance norms and procedures during the different phases of the project.

11.2.2 The basic and detailed engineering of the plant will aim at achieving high standards of operational performance especially with respect to the following key parameters.

- Optimum efficiency of the equipment.
- Low Auxiliary power consumption.
- Low make up water consumption.

11.2.3 The plant Instrumentation and control system should be designed to ensure high availability and reliability of the plant to assist the operators in the safe and efficient operation of the plant. It should also provide for the analysis of the historical data and help in the plant maintenance people to take up the plant and equipment on preventive maintenance.

11.3 **Operation Requirements**

11.3.1 The operation of the plant starts with the Commissioning. In broad terms commissioning can be defined as setting up of the plant to work safely and on program. It is necessary to ensure

that all equipment is completely erected before operations begin. Although this may be considered difficult, the other extreme of operating a plant with insufficient instrumentation, controls and alarms is very dangerous. Although some compromise can be made with regard to plant completion, the commissioning procedures should never compromise personnel and the system safety.

11.3.2 A proper checklist must be drawn up, which shall include all the sections of the plant and shall take into account, the contractual responsibilities, the technological relationship between the various sections, pre-commissioning, cleaning requirements, etc. The checklists procedure helps in the following:

- a) To ensure that the necessary checks are carried out on each item of the plant before it is put into commercial service.
- b) To indicate a contractor's commissioning requirements from the client or from other contractors.
- c) To ensure that energy is supplied to any equipment or a plant when it is safe to do so.
- d) To facilitate the recording of the progress on the various commissioning activities.
- e) To provide a basis for the plant history.

11.3.3 The Operation of the power plant unit interconnected to the grid is an activity that must be properly coordinated, within the plant as well as with sub-station to which the plant feeds power. Operation in parallel with the grid eventually makes the Power plant a part of the utility system and hence the Power plant must assume some of the same responsibilities of the national grid. With this, the electricity company's local dispatch centre will need to monitor the incoming power from the power plant on a continuous basis.

11.3.4 The operation of a modern high pressure and high temperature unit demands closely controlled operating conditions. The unit start-ups, shut-downs and even load variations must strictly follow the carefully laid down procedures given in the operational Manuals. Generally, the plant shall be sufficiently instrumented to permit close checks on such operating parameters as boiler tube and drum metal temperatures, furnace gas temperatures, turbine expansions, casing metal temperatures, condenser vacuum, etc.

11.3.5 An important feature of the modern power generating plant is the automatic safety lock-out devices. While sufficient thought goes into it at the design stage, it remains the responsibility of the operating staff to ensure that the safety devices are set correctly and kept in operation.

While safety of the plant and personnel is the foremost importance in the operation, the efficient operation of the plant cannot be ignored. While operating, it is important to check the essential parameters of the plant and equipment to ensure that the plant performance is at the optimum level. Any variations in the operating parameters or any deviations from normal performance of the equipment or plant shall have to be analysed immediately to diagnose the problem and to take remedial measures to bring back the plant and equipment to its original parameters.

11.3.6 The detailed treatise on the operation of the Power plant is beyond the scope of this report. However, three important areas are highlighted.

11.3.6.1 Water Chemistry

With the rapid increase in the operating levels of the steam temperatures and pressures of the modern boilers, ensuring good quality of water has assumed greater importance. The

high pressure boilers to be installed at the Power Plant will generate steam at a high pressure and warrants strict maintenance of water quality, both feed water and boiler water within limits for proper operation of the boiler and avoiding scale or deposit formation in turbogenerators. In a Cogeneration system operating in synchronization with the sugar mill, one of the major sources of concern, with regard to the water chemistry, is the possibility of contamination of the condensate returning from the sugar mill. The contamination in the condensate, mostly from the juice can create problems in the boiler and the turbine. As we go higher in the operating pressure, this contamination issue becomes more serious. As HPPL is going in for a very high pressure system and considering the fact that the operating experience available in Pakistan is not much, it is proposed to have built in safeties to eliminate the possibility of contamination. With due consideration to the above, proper instruments are available for online monitoring. Another area of concern could be the condenser leakage where the condensate gets contaminated by the cooling water. A routine check-up of the feed water quality during the start-up of the plant and also periodic check-ups result in the elimination of any serious problem due to the water quality. Similarly, the monitoring of water treatment plant and the water quality at Water Treatment plant outlet, the water quality at the inlet of the Water treatment plant and cooling tower is of utmost importance.

11.3.6.2 Instrumentation

The modern day power generating system like the one envisaged for the specific Power plant cannot be effectively operated without proper instrumentation and control system. An effectively designed instrumentation and control system performs the following functions:

- Provides operators with the indication or record of the

instantaneous, averaged or integrated value or condition of the various operating parameters such as temperatures, pressures, flows, levels, position of valves, switches, currents, voltages, power, etc.

- It also provides at convenient locations either local, remote or automatic control system to control the above operating parameters and gives alarms and even ensures automatic trip outs, when operating parameters reach beyond the normal range to the unsafe or undesirable range.

Instrumentation is increasingly taking over many functions of the operator. Its response to changing and transient conditions, its ability to anticipate, detect and discriminate faulty conditions and act accordingly is quicker and for more accurate if well designed. With the ability of the microprocessor based systems to include data acquisition and processing capabilities, the systems' ability, to log and process periodically the plant data, is also far superior and permits more timely corrective actions. Presently some of the responsibilities of the operation section are taken over by good instrumentation. The most difficult thing to be encountered in the initial stages of plant operation is the necessity to develop in the operation staff a faith in the instrumentation. Many times the operators' first response to a meter reading too high or too low is to disbelieve it on the ground that it may be reading incorrectly. If instruments are not checked and calibrated frequently an operator will delay taking corrective actions.

The plant operator should follow the guidelines given below:

- Frequent checking and calibration of instruments
- Developing a habit of cross checking instrument indications with each other to determine whether the

instrument is faulty or there is an abnormal operating condition; and

- Developing a habit of analysing indicated data to determine accurately what could be wrong.

11.3.6.3 Evacuation of additional power:

It is important to recognise that;

- Generation voltage of 11 kV at the Power plant has to be stepped up to 132 kV to the grid voltage at the point of interconnection.
- The Power plant has to operate in parallel with the grid system which is a very vast power carrier. The Power plant has to protect its equipment against possible faults or other disturbances from the grid.

11.4 Maintenance Requirements

11.4.1 The main objectives of the maintenance section are to keep the plant running reliably and efficiently as long as possible. Reliability is impaired when a plant is thrown to forced and unforeseen outages. This aspect assumes greater significance in a power plant exporting power to State grid under contractual commitments. It is imperative that any planned maintenance is undertaken with closer coordination with the sub-station.

11.4.2 Efficient operation implies close control not only over the cost of production but also over the cost of maintenance. There are two components in maintenance cost, one is the direct cost of maintenance i.e., the material and labour and the other is the cost of production loss.

11.4.3 There are two categories of maintenance work. One is the irksome breakdown maintenance, which is expensive. Much as it

is desirable to avoid or minimize this, its existence must be accepted. Secondly, it is the preventive maintenance with proper planning and execution of plant and equipment overhauls. This maintenance activity should be clearly planned with regard to the availability of material and labour. It is also essential to develop proper inspection procedures with non-destructive testing methods. Such inspections, by trained personnel reveal defects not necessarily detected by mere visual inspection.

11.4.4 The following help in reducing the breakdown maintenance and also help in planning for preventive maintenance.

- Careful logging of operation data/historical information from the DCS and periodically processing it to determine abnormal or slowly deteriorating conditions. Walk down checks of the plant.
- Careful control and supervision of operating conditions. Wide and rapid variations in load and frequency conditions do contribute to increased maintenance particularly on the high temperature and high pressure units. The turbine throttle steam pressure and temperature conditions must also be kept steady at the rated value.
- Regulate routine maintenance work such as keeping equipment clean, cleaning heat exchangers, filters, effectively executed lubrication program, effective operating supervision over bearings, commutators or slip ring brushes, gland and flange leakage, etc.
- Correct operating procedures.
- Frequent testing of plant equipment to determine internal condition of equipment such as plant cycle efficiency tests, enthalpy drop tests, heat exchanger and

pump performance tests, generator and turbine shaft vibration tests, turbine lube oil testing, etc.

- Close coordination with the manufacturers to effect improvements in plant layouts and design, use of better material, introduction of such facilities as cathodic protection, use of better protective paints, etc.
- Multi task load management systems that have recently been developed and marketed also enable continuous monitoring of different electrical parameters enabling timely corrective measures to be undertaken.

11.4.5 It is extremely important that proper records are maintained not merely for the maintenance work done but also of the material used and actual man hours spent, etc. Some sort of a card system shall have to be introduced to keep records that are most useful in future planning of outages and providing for effective control.

11.4.6 Another important requirement of a good maintenance program is to ensure that spares are ordered in time and good stocks of the frequently required spares are maintained.

12.0 Manpower and Training

12.1 General

12.1.1 It is essential that the manpower requirement for the Power plant is well planned and a proper program of recruitment and training is thought of. The Power Plant operation and maintenance personnel must be trained and available before the plant commissioning commences and therefore, it is essential that appointments are made well before the programmed plant commissioning date. The staffing and the organizational structure should be decided based on and considering the specific requirements of the man power preferably with a power plant background.

12.1.2 The recruitment of the personnel required must be based on the rational assessment of the following factors:

- a) The nature of the plant and machinery i.e. travelling grate bagasse fired boiler, Distributed Control System (DCS) based control system for the complete plant, electrostatic precipitator, fuel storage and feeding system, extraction cum condensing turbogenerator, paralleling with the grid and working in conjunction with National grid, fuel and ash handling plant, cooling water system, Water treatment plant, 132 kV switchyard etc.
- b) Socio economic conditions.
- c) Availability of personnel, with the right background and experience.
- d) Company's policy regarding recruiting permanent employees and contract labour.

12.1.3 Once the staffing is finalized and agreed, a suitable training scheme shall be programmed and implemented. The objective of the training program must be to equip each individual to carry out his particular function with skill and confidence. The training program shall be based on the classification of the main functions as Operation and Maintenance, and within this main classification, designed to cater to engineers, supervisors, skilled workers, technicians, etc.

12.2 Operation and Maintenance Organization

12.2.1 The table enclosed to this section gives the proposed operation and maintenance organization set up proposed for the 2 x 24.9 MW Power plant. It is possible that some of the existing plant personnel in the HSMPL's sugar mill, can be fitted in some positions and recruitment could be made for the other positions.

12.2.2 The organization proposed assumes that the cogeneration Power Plant will be an independent project with the Power Plant Manager, holding the full charge of the Power plant, reporting directly to the General Manager of the complex. The staffing recommended here takes care of the operation, maintenance and record keeping for the Power plant. The Drawing No.4-13276-800-0025 gives the proposed organization chart for the Cogeneration plant. It is also possible that HPPL will go for an Operation and Maintenance Contractor for taking care of the complete O&M functions. Under such a condition, the proposed organization shall be reviewed taking into account the strength of the O&M contractor's staff.

12.2.3 The Table-12.1 shows the suggested qualification and specific experience desired for the various positions of the Power plant organization. This will only be a guideline to be followed for the recruitment of the personnel. Position numbers have been given for each of the function indicated in the organization chart.

The title against the position numbers are only indicative and can be altered to suit the companies' practices and to meet the individual recruit's aspirations.

- 12.2.4 All the personnel indicated in the organization chart should be provided with housing in the company's premises or they should be located very near the power plant complex. It is considered that these personnel will be available for regular operation of the plant and also to meet with any emergency conditions.
- 12.2.5 The cogeneration Power Plant's O & M organization will be headed by a Power Plant Manager. The Power Plant Manager will be in-charge for both technical and administrative functions. The organization under the Plant Manager of power plant shall be divided into operation group, maintenance group, administration, performance department and laboratory. There is a separate Performance department with a Performance engineer reporting to the Manager Power Plant. The Performance engineer will also be in-charge of documentation for the project.
- 12.2.6 The cogeneration Power Plant envisages high level of automation with Distributed Control System (DCS) to minimize the manpower required and optimize on the performance of the equipment. Hence, there will be one position for a Senior Engineer Instrumentation reporting to the Manager Power Plant, who will have adequate experience with handling similar instrumentation.
- 12.2.7 The plant operation team will work in three shifts per day. Each shift will be controlled by a shift charge engineer. There will be one additional shift charge engineer who will function as a reliever. The shift charge engineer will be located at the control room and will be in full charge of the plant operation during the shift. The following personnel will assist him for the operation during the shift

- a) Instrument Technician (1)
- b) Control Room Engineer (2)
- c) Electrical Supervisor (1)
- d) Shift chemist (1)
- e) Boiler operator (2)
- f) Fuel / Ash handling supervisor (1)

- 12.2.8 The boiler operator and the fuel / ash handling supervisor report to the control room engineer and in turn reports to the shift charge engineer.
- 12.2.9 The maintenance organization of the Power plant is divided as Electrical Maintenance and Mechanical Maintenance. Each of the Maintenance Department is headed by a Senior Engineer Maintenance. It is suggested that the power plant maintenance group is an independent group and the sugar plant maintenance organisation could be different in order to ensure accountability. However, the facilities of workshop, electrical repair shop, instruments, tools, etc. could be common between HSMPL's sugar plant maintenance and HPPL's power plant maintenance group.
- 12.2.10 The shift electrical supervisors report to the shift charge engineer during the plant operation, but they are administratively responsible to the senior engineer electrical maintenance. The electrical equipment repair shop, if it is independent for the power plant will be under the control of senior engineer-electrical maintenance.
- 12.2.11 The senior engineer mechanical maintenance is responsible for overall maintenance and the functioning of the mechanical workshop. The power plant maintenance group is divided into turbine maintenance group and boiler maintenance group. Each of these groups are staffed with adequate mechanics and fitters.

The documentation of the engineering office is the responsibility of the performance engineer reporting to the Power Plant Manager. In addition to evaluating and reporting daily performance and generation data, he will be responsible for maintaining the master copies of all the technical documentation of the power plant.

12.2.12 A few labour contractors could be registered with a Company for meeting the surge load requirements of the operating and maintenance group to handle major break down / maintenance work.

12.2.13 The Performance department is an important section, which serves both the operating and maintenance sections by providing useful feed back to the operating staff and valuable information to the maintenance staff on the performance and the healthiness of the various equipment. The major responsibilities of this department are :

- a) To collect the daily operating data from the DCS system in the control room.
- b) To analyse daily plant performance data to detect departures from normal expected performance and to keep track of trends indicating gradual deterioration.
- c) To establish from the design and plant acceptance test data, as well as after-overhaul test data norms against which day-to-day performance can be checked.
- d) To carry out frequent tests on the plant and individual equipment to determine their internal conditions to help maintenance scheduling.
- e) To investigate special problems as and when they arise.

The analysis and the data provided by the efficiency cell, enables plant operation and maintenance personnel to take suitable corrective actions promptly and with proper priorities.

12.2.14 Safety and fire department will be part of power plant organisation, which will assure the fire & safety for the entire complex.

12.2.15 In addition to the above, sufficient number of contract labourers may be required for assistance in ash disposal, bagasse back feeding, cleanliness operation, etc.

12.2.16 The power plant manager will also be assisted by office assistants and an administrative officer to take care of accounts, transport, coordination with Electric transmission company, etc. The administrative section will also take care of the time office functions, legal and personnel requirements, etc.

12.3 Training

12.3.1 The major objectives of the operational training shall be to acquaint the operators of the following:

- a) The nature, purpose and limitations of all plant and equipment.
- b) The detailed operating instructions on each section and equipment of the plant.
- c) Normal start up and shutdown program for the unit.
- d) The emergency procedures.

12.3.2 The basis, for the training shall be the Plant's operating and Maintenance Manual Particulars Book, which is compiled from the manufacturers' instructions, the contract documents and the drawings. In addition, the information gathered from the

visits to the other operating plants and to the manufacturers works shall also be included in the training. Supervision and co-ordination of the training program requires full time attention of a senior executive of the plant, and also the consultant's assistance may be taken. The training program shall include lectures, expositions by experienced plant operators and maintenance personnel, informal discussions and visits to operating plants and manufacturer's works and exposure to the courses conducted by Institutions like Power Plant Training Institute or any other Institution to be given to the operating & maintenance staff.

- 12.3.3 The maintenance training program should be based on the requirements of the individual maintenance functions, like mechanical, electrical, instrumentation etc. The Engineers and the Technicians should be sent to the manufacturers' works to witness the production and be associated with the erection of plant and equipment.
- 12.3.4 The Power plant should be equipped with proper measuring/testing instrument for periodic cross checking of parameters shown in the control room and power plant area local gauges. Logging of data and periodic review of the plant operation, review of failures, break downs, etc. should be done to improve the availability of the plant. The proposed DCS based control system takes care of almost all the above requirements.

Table 12.1 Suggested Qualification and Specific Experience for the O&M staff.

P. No	Designation	Engg. Graduate	Diploma	Technical Training	Science Graduate	Experience (Yrs) / Additional Qualification	Total
1	Power Plant Manager	Mechanical /Electrical	-	-	-	15-20 years in Cogen. Plant / CPP (project & O&M experience preferred)	1
2	Sr. Engineer - Instrumentation	Electronics/Instrumentation	-	-	-	10-12 years in power plant with DCS	1
3	Shift Charge Engineer	Mechanical / Electrical with BOE	-	-	-	10-12 years in Cogeneration / CPP	4
4	Sr.Engineer	Electrical	-	-	-	10-12 years in Cogeneration / CPP	1
5	Control Room Engineer	Mechanical / Electrical	-	-	-	8-10 years in Cogeneration / CPP Control Room	7
6	Efficiency Engineer	Mechanical	-	-	-	8-10 years in Power Plant	1
7	Sr.Engineer - Maintenance	Mechanical	-	-	-	8-10 years in cogeneration / CPP maintenance	1
8	Boiler Operators	-	Mechanical (BOE)	-	-	BOE, 8-10 years Boiler Operation	7
9	Shift Chemist	-	-	-	Chemistry	5-10 years in power plant	4

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P. No	Designation	Engg. Graduate	Diploma	Technical Training	Science Graduate	Experience (Yrs) / Additional Qualification	Total
10	Electrical Supervisor	-	-	Electrical A-Grade	-	5-10 years in power plant - A-Grade Certificate	4
11	Mechanics / Fitters	-	-	Mechanical	-	5-10 years in Power Plant	7
12	Supervisors	-	-	Mechanical	-	Less than 5 years in sugar plant	4
13	Instrumentation Technicians	-	-	Instrumentation	-	Less than 5 years in power plant	4
14	Fire & Safety Officer	Mechanical with Diploma on fire and Safety	-			5-10 years in Power Plant	1
15	Fire and Safety Attendants	-	-	A - Grade		Less than 5 years in power plant	4
16	Draughtsman	-	Mechanical	-		Less than 5 years in power plant	1
	TOTAL						52

13.0 Environment Protection and Waste Management

13.1 General

13.1.1 Environmental protection and the control of solid, liquid and gaseous effluents or emissions are key elements in the design of all steam and power generating systems. The emissions from combustion systems are tightly regulated by Governments regulations and specific rules and requirements are constantly changing. At present, the most significant of these emissions are sulfur dioxide (SO₂), oxides of Nitrogen (NO_x) and fine airborne particulate. All of these require specialized equipment for control.

13.1.2 Environmental control is primarily driven by Government legislation and the resulting regulations at the local and National levels. These have evolved out of a public consensus that the real costs of environmental protection are worth the tangible and intangible benefits now and in the future.

13.1.3 One major redeeming factor about HPPL's Bagasse based Cogeneration power plant is that, for a substantial period in a year, the dust or the green house gases released into the atmosphere are no more than what would have been produced by alternative methods of bagasse disposal. The bagasse that is being burnt in the existing low pressure boilers is the same quantity that is being used in the new high pressure cogeneration boiler. Hence, there is no net addition of pollutants to the atmosphere. Also this power plant, feeding the additional power to the National Electricity grid, indirectly prevents a pro-rata quantum of pollutants being let into the atmosphere from the utility plant, from where otherwise the equal quantum of power would have been generated. This power plant thus being environment friendly deserves encouragement. Also it is a fact that bagasse being a bio-mass renewable fuel

does not add any net Carbon-di-Oxide to the atmosphere, because of the carbon recycling during the growth of cane.

13.1.4 Atmospheric emissions arise primarily from the by-products of the combustion process. When the fuel is burnt in the boiler combustor, SO₂, NO_x, particulate fly ash, volatile organic compounds (VOC) and some trace quantities of other materials and are exhausted from the stack. A second source of particulate emission is fugitive dust emissions from Fuel piles and fuel handling system and equipment. A final source of air emissions is the cooling tower and the associated thermal rise plume which contains heat and some trace materials along with the water vapour.

13.1.5 Aqueous discharges arise from a number of sources. These include cooling tower blow down, sluice water from the bottom ash handling system, boiler chemical cleaning solutions, boiler gas side water washing waste solutions, as well as a variety of low volume wastes including ion exchange regeneration solutions from the Demineralised Water Plants, boiler blowdown, sewerage system discharges from buildings and plant floor drains.

13.2 **Particulate matter and gases**

13.2.1 The elements polluting the air that are discharged from the proposed Power unit are,

- Dust particulate from fly ash in flue gas
- Nitrogen oxide in flue gas
- Sulphur-di-Oxide in the flue gas.

13.2.2 Electrostatic precipitators are proposed for the Power plant steam generator, to contain the dust emissions from the plant to a level of 50 Mg/N.cu.m during bagasse firing. The chimney will be common for both the boilers and the height of the

chimney, which disburses the pollutants over a larger area, has been worked out as at 98 meters, based on the dispersion of the sulphur-di-oxide and the dust emissions.

13.2.3 There is very marginal presence of Sulphur in bagasse and the power plant will burn mostly bagasse, during the season and a few days in the off-season, for the steam generation. Because of the negligible Sulphur presence in the bagasse, SO_x emissions will not be a matter of concern from boilers during bagasse firing.

13.2.4 The temperatures encountered in the steam generator while burning, high moisture bagasse is low enough not to produce nitrogen-oxides. Hence, no separate measures are taken to contain the nitrogen oxide emissions.

13.3 **Dry fly Ash and Furnace Bottom Ash**

Fly ash collected from the ESP hoppers, the air-heater hoppers and the ash collected from the furnace bottom hoppers can be used in the cane fields, when bagasse will be the main and only fuel for the operation. The ash content in bagasse is around 1.55 %. The total fly ash collected during bagasse firing could be used for field applications. The Potash content in the bagasse ash makes the ash good manure. The filter press mud from the sugar plant also has a good field nutrient value. It is possible to mix the bagasse ash with press mud and distribute it to the farmers for use in the cane fields.

13.4 **Water Pollution**

13.4.1 **Effluent from water treatment plant**

Hydrochloric acid and sodium hydroxide will be used as regenerants in the proposed Demineralised water plant in the Water Treatment Plant. The acid and Alkali effluents

generated during the regeneration process of the ion-exchange resin columns would be drained into an epoxy lined underground neutralizing pit. Generally, these effluents are self-neutralizing. However, provision will be made such that the effluents will be neutralized by addition of either acid or alkali to achieve the required pH of about 7.0. These effluents are slightly high in TDS (depending on the inlet raw water TDS, the effluent and without any COD or BOD content) will then be pumped into the effluent treatment ponds, which are part of the sugar plant for disposal or can be used for gardening.

13.4.2 Chlorine in cooling water

In the condenser cooling water, residual chlorine of about 0.2 ppm is maintained at the cooling tower outlet. This comes out of the sodium hypochlorite or chlorine di-oxide dosing given to the cooling water. This chlorine dosing is done mainly to prevent biological growth, like algae, in the cooling tower system. This small level of chlorine in water would not result in any chemical pollution of water.

13.4.3 Steam generator blow down

The salient characteristics of blow down water from the point of view of pollution are, the pH and temperature of water since suspended solids are negligible. The pH would be in the range of 9.8 to 10.3 and the temperature of blow down water will be 100 Deg.C. The quantity of blow down, on an average, is only about 1% of the boiler steam generation capacity and it is proposed to put the blow down from IBD tank into the trench and take it to the effluent ponds. Before draining the water to the trench, the blowdown water temperature will be tempered with cooling water to bring the outlet temperature to about 50 Deg.C.

13.4.4 Sewage from various buildings in the plant

Sewage from various buildings in the power plant area will be conveyed through separate drains to the septic tank and then treated in the sewage treatment plant.

13.5 Thermal Pollution

A close circuit cooling water system with cooling towers has been proposed. This eliminates the letting out of high temperature water into the canals and prevents thermal pollution. Blow down from the cooling tower will be trenched out and ultimately conveyed to the effluent treatment ponds. Hence, there is no separate pollution on account of blow down from cooling water system.

13.6 Noise Pollution

The rotating equipment in the Power plant will be designed to operate with a total noise level of not exceeding 85 to 90 db(A) as per the requirement of Occupational Safety and Health Administration (OSHA) Standards. The rotating equipment are provided with silencers wherever required to meet the noise pollution. The frequently blowing safety valves will also be provided with silencers to meet with the norms for the noise levels.

13.7 Monitoring of Effluents

The characteristics of the effluents from the proposed plant will be maintained so as to meet the requirements of Pollution Control Board and the minimum national standards for allowable effluent discharges from thermal power plants. Air quality monitoring will also be undertaken to ensure that the particulate emission level is within limits.

13.7.1 Air Quality Monitoring Programme

The purpose of air quality monitoring is the acquisition of data for comparison against the prescribed minimum standards and thereby, assures that the air quality is maintained within the prescribed levels.

The following will be monitored from the stack emissions.

- Suspended Particulate Matter.
- Sulfur-Di-Oxide.

The Laboratory attached to the Power plant will be equipped with the necessary instruments for carrying out air quality monitoring. It is also proposed to have an online monitoring of particulate emission in the Chimney to keep a continuous check on the performance of the ESP. Adequate sampling openings will be provided in the Chimney.

13.8 Impact of the Pollution on the Environment

As all the necessary pollution control measures to maintain the emission levels of dust, SO_x & NO_x are taken and other effluents will be treated in the sugar mill's effluent treatment plant, there will be no adverse impact on either the air or water quality in around the proposed Cogeneration Power plant site.

13.9 Quantity & Quality of the effluents from the 2 x 24.9 MW Cogeneration Plant

The figures given below are for the normal operation of the plant during the seasonal with bagasse as the fuel.

13.9.1 Gaseous Effluents from the Cogeneration Plant

Flue Gases from the stack from: 561657 kg/Hr
Both the boilers

Temperature of the gases : 160 Deg.C (max)
leaving the stack

SO₂ Emission : NIL

NO_x Emission : Less than 80 ppm.

Particulate Emission through : 50 mg/NCu.M
flue gases : 0.023 MT/Hr

13.9.2 Solid Wastes from the Plant

Dry Fly ash : 1.09 MT/Hr.

Wet bottom ash from Grate : 0.47 MT/Hr.

13.9.3 Liquid Effluents

a) Boiler Blowdown Water : 4.87 TPH

Total Dissolved Solids : 130 ppm (max)

pH @ 25 Deg.C : 9.8 to 10.3

b) Cooling Tower Blowdown : 103 Cu.M/Hr

Total Dissolved solids : 1960 ppm

pH @ 25 Deg.C : 8 to 9

Chlorine : 0.2 ppm

- c) Waste Water from : 34TPH (average)
Neutralizing Pit
- Total Dissolved solids : 1585 ppm
- pH @ 25 Deg.C : 7

The figures given below are for the normal operation of the plant during the off-season operation.

13.9.4 Gaseous Effluents from the Cogeneration Plant during bagasse firing.

- Flue Gases from the stack : 390,153 kg/Hr,
from both the boilers
- Temperature of the gases : 160 Deg.C (max)
leaving the stack
- SO₂ Emission : NIL
- NO_x Emission : Less than 80 ppm.
- Particulate Emission through : 50 mg/NCu.M
flue gases : 0.015 MT/Hr

13.9.5 Solid Wastes from the Plant during bagasse firing

- Dry Fly ash : 0.84MT/Hr.
- Wet bottom ash from Grate : 0.36 MT/Hr.

13.9.6 Liquid Effluents

- a) Boiler Blowdown Water : 3.28 TPH
 - Total Dissolved Solids : 130 ppm (max)
 - pH @ 25 Deg.C : 9.8 to 10.3
- b) Cooling Tower Blowdown : 255 Cu.M/Hr
 - Total Dissolved solids : 1960 ppm
 - pH @ 25 Deg.C : 8 to 9
 - Chlorine : 0.2 ppm
- c) Waste Water from Neutralizing pit : 55 TPH (average)
 - Total Dissolved solids : 1790 ppm
 - pH @ 25 Deg.C : 7

14.0 Site Features and Plant Layout

14.1 Location and Features of the Plant Site

14.1.1 The proposed Cogeneration plant at HPPL, will be located adjacent to the HSMPL's sugar plant complex. This complex presently consists of only the sugar plant. The Drg. No.O-16083-600-0004 gives the Plot Plan of the proposed Cogeneration Plant.

14.1.2 The following specific features of the site have been discussed in this section of the report.

- Availability of adequate space for locating the Cogeneration plant, bagasse storage and adequate space for the construction activities.
- Suitability of the site from topographical and geological considerations.
- Availability of road connections for material movements.
- Availability of adequate quantity of water for meeting the plant's water requirements.
- Availability of adequate fuel and its transport.
- Interconnection with Grid.
- Ecological Impact.

14.1.3 Space Availability

14.1.3.1 Adequate land is available adjacent to the sugar plant premises for locating the Cogeneration plant. Logistically the Cogeneration plant has to be located close to the sugar plant as the steam for the processing of sugar has to be supplied from the turbine extractions, the power for the sugar plant operations has to be supplied from the HT panels of the Cogeneration plant, and the bagasse from the sugar plant has to be supplied to the Cogeneration plant. Keeping the plant away

from the sugar plant will result in more capital cost towards the piping, cables and bagasse conveyors. However, in HPPL cogeneration project, the plant is located slightly away from the sugar plant due to the non-availability of space near the existing sugar plant.

14.1.3.2 In the area identified for the Cogeneration plant, adequate space is available for the construction activities during the installation period of the plant and there will not be any hindrance to the operation of the sugar plant during the construction period. Allocation of construction space will be based on the requirements to be given by the Contractors. However, detailed topographical survey will be made during the detailed engineering stage.

14.1.4 Topographical and Geological Aspects

14.1.4.1 The area identified for the Cogeneration plant is almost flat and does not much of levelling. The level difference between the existing sugar plant and cogeneration area, if any, will be taken care of appropriately in the detailed engineering stage.

14.1.4.2 The soil cannot be termed as good as the Soil bearing capacity is just about 10 Metric Tonnes per Sq.M at a depth of about 1.5 meters depth. However a detailed investigation has to be carried out to arrive at the correct value at various locations of the power plant for taking the final decision on the foundations.

14.1.5 Rail and Road Facilities

14.1.5.1 All plant and machinery has to be transported only by road. All the imported equipment have to be brought to the port of Karachi and then transported by road. The Plant is located on the Layyah Road. Road connectivity to the plant is very good. In addition the nearest Railway station is Jhang city. Also, the nearest airport from HPPL's plant is Faisalabad.

14.1.6 Water Availability

14.1.6.1 The raw water for the Cogeneration plant is required for meeting the following requirements.

- Make up water to the Steam Generator.
- Make up water to the Cooling Tower.
- Ash disposal.
- Other Plant services

14.1.6.2 The water availability is through the bore wells in the plant. Presently the requirements of the sugar mill are being met only from this bore wells.

14.1.7 Availability of Fuel

The proposed Cogeneration plant operation will be based on the in house generation of Bagasse in the sugar plant. Bagasse is generated in-house from the cane received at the sugar mill.

14.1.8 Interconnection with Grid

It is proposed to step up the generation voltage of 11 kV to 132 kV and to parallel with the National grid at 132 kV level. The 132 kV transmission lines from the Cogeneration plant's switchyard will be connected to the Electricity Transmission Company's 132 kV Sub-station at Hazari through LILO connection.

14.1.9 Ecological Impact

A thermal power plant, that too the one based on a renewable energy source as the fuel for majority of the days, does not affect the ecology, provided a few precautions are taken in the design of the plant. All the necessary measures are planned to

be taken in the plant design for minimizing the impact on the ecology of the environment. A separate Section on this specific topic gives more details on this subject.

14.2 Site Layout

14.2.1 The proposed Cogeneration Plant will be located adjacent to the sugar plant complex. The entire Cogenerating plant will be located on the North Western side of the sugar factory. The Boilers and the TG Building are located in West - East direction with chimney on western side. The switchyard of the Cogeneration plant is located on the North Western side of the cogeneration boiler. The closed bagasse yard will be used to store the bagasse saved in the season operation and the same is located on the western side of the Mill House and Southern side of the cogeneration plant. The raw water tank will be located on the Northern side of the Boilers and the Water treatment plant will be located on the western side of the Raw water tank. The Cooling Towers are located on Eastern side of the TG building. The Cogeneration plot plan drawing gives the details of the various plant locations.

14.2.2 The basic criteria for the selection of the site is that the plant and equipment are located in such a manner that the HT cables, high pressure steam piping, and bagasse conveyor routings are optimized. The predominant wind direction at the site is West to East.

14.2.3 Another important point to be considered in finalizing the layout is that the Cogeneration plant construction activities pose minimum disturbance for the operation of the sugar plant. **The construction activities in the proposed location in no way hamper the sugar plant operation.**

14.2.4 As the sugar mill is an already operating plant adequate road and access facilities are available so that the plant and

machinery could be easily brought to the site. However adequate road work within the plant is considered for accessing the maintenance bay of the proposed new TG building, movement for chemicals, etc.

- 14.2.5 Adequate construction space is available for the storage of materials of the contractor and for them to carry out prefabrication work. Specific areas to be identified at the time of start of the site activities.

14.3 **Layout of the Steam Generating Unit**

- 14.3.1 The steam generators are laid out, along the East to West direction, with the steam generator front facing the East. The steam generator is of semi-outdoor design, with a canopy over the furnace area and the bagasse storage silo. The Deaerator, bagasse storage silos along with the feeders, chutes and the distributors are kept in front of the steam generator. The steam generator feeder operating floor level will be approximately at 8.5 meters.
- 14.3.2 The economizer and the air pre-heater are arranged in a single vertical pass behind the steam generator. The air pre-heater is laid out such that the tube replacement is done easily. The fans and Electro Static Precipitator shall be arranged as shown in the layout drawing. Adequate platforms and stairways, as required for the operation and maintenance of the steam generator shall be provided.
- 14.3.3 The steam generator feed water pumps shall be located on the ground floor below the deaerator structure. The deaerator will be located on the front side of the steam generator in between the TG building and the steam generator. The feed water control station shall be located on the steam generator operating floor.

- 14.3.4 A RCC Chimney is located downstream of the Electrostatic Precipitator, on to the Western side. Concrete paving will be provided in the steam generator area with necessary drains and trenches for cables and pipes.
- 14.3.5 The steam generator gets its fuel mainly from the sugar plant's milling section. The bagasse from the sugar plants existing system of conveyors will be tapped off and fed through a system of belt and slat chain conveyors and the surplus bagasse will be taken back to the storage yard through a set of conveyors. Belt conveyors are used for stacking the bagasse into the covered storage yard and also for reclaiming the bagasse from the storage yard to the boiler.
- 14.4 **Turbogenerator Building Layout**
- 14.4.1 The turbogenerator building, located on the Eastern side of the steam generator will be of size 84 m x 25.5 m, and will be sized to accommodate the Turbogenerator and its main auxiliary equipment. The turbogenerator operating floor shall be at 10 m elevation. The building superstructure will be of steel /RCC structure framing with Galvalume sheet steel / brick cladding and RCC floor slabs. The building roof will be of steel trusses and Galvalume steel sheets. The transformers & DG sets are located on the Western side of the TG building.
- 14.4.2 The turbine and generator foundation will be of reinforced concrete, isolated from the building foundation and the superstructure. The turbogenerator will be laid out with its axis in the North-South direction perpendicular to the steam generator axis, at the 10 m elevation. The oil system console and other auxiliaries will be located within the building.
- 14.4.3 One Electric Overhead Travelling (EOT) crane, with a span of 13.5 m, capable of serving the entire length of the building shall be provided in the turbogenerator building. An opening of 15 m

x 8 m provided on the turbine operating floor which serves to take out the turbogenerator components for maintenance. Road access is provided for this maintenance bay for the easy transportation of the material and equipment into the TG building or from the TG building.

14.4.4 The steam inlet piping and the extraction steam piping will be run below the operating floor, and a bay is reserved for routing of all these pipes.

14.4.5 Adequate staircases will be provided for accessing the building. The drawing nos.1-16083-600-0012 to 0015 gives the equipment layouts for the TG hall at various levels.

14.5 **Control and Electrical Rooms**

14.5.1 The Ten and half meter wide bay on Western side of the TG bay (B-C) houses the electrical panels & control room for the complete cogeneration plant. The electrical panel room will be located on the Western side of the TG building at 3.5 M elevation. Control room for the entire plant will be located on the Western side of the TG at 10 M level. There will be false flooring for the control room, to facilitate cable routing to the various panels and the DCS systems.

14.6 **Water systems**

14.6.1 The raw water storage tank (Service water storage tank) is located on the Northern side of the TG Building. The Cogeneration cooling towers shall be located adjacent Eastern side of the TG building. The cooling water pumps shall be located near the cooling tower.

14.6.2 The Water treatment plant building will be located on the Western side of the raw water tank and the Northern side of the Boiler. This building will house only the UF/ RO/EDI

systems. DM water storage tank and make up water tanks shall be located in this area. The acid bulk storage tanks required for storing the chemicals required for the cooling tower treatment system will be located close to the cooling tower.

14.7 Ash Handling

14.7.1 The Ash handling system consisting of two different sets of handling systems. One is for the furnace bottom ash collection and handling and another is for the fly ash collection and handling. The furnace bottom ash is collected by water impounded scrapper conveyers, and as the quantity of ash discharge is less, the same is collected in trolleys parked near the scraper conveyor.

14.7.2 The fly ash from the air heater hoppers and the ESP hoppers will be transported using dense phase system, to a storage silo and will be evacuated from this silo once in a shift.

14.8 Distribution Transformers

The distribution transformers, required for meeting the Cogeneration plant's auxiliary power requirements, are located on the Western side of the TG building.

14.9 Switch Yard

The 132 kV switch yard is located on the North - Western side of the boiler. The area required for accommodating the power transformer, insulators and the structures, circuit breakers, isolators, etc., is indicated in the drawing.

15.0 Project Implementation and Schedule

15.1 General

15.1.1 The most essential aspect in the implementation of this Bagasse based Cogeneration Power Project is to ensure the project completion within the schedule, spanning for twenty (20) months from the date of ordering of the Boiler & Turbogenerators. The time schedule is important mainly because of the synchronization required with the sugar mill operation and to match with the modifications planned in the sugar mill. While the financial closure, permits and statutory authority clearances are being processed, tender documents could be floated for the Boilers, Turbogenerators and Major BOP items. Planning such parallel activities will save the overall time for the implementation of the project. Getting approvals from the regulator and getting all statutory clearances should precede all activities.

15.1.2 The layout of the plant and machinery has been so chosen that the installation of the equipment for the Power plant could be carried out in an independent area near the sugar plant. This is very important as the sugar mill will continue to crush during the construction period of the Cogeneration project and the construction activities should not pose any limitation on the sugar mill operation.

15.1.3 A good planning, scheduling and monitoring program is imperative to complete the Power project on time and without cost overruns.

15.1.4 Consents and Permits

Government of Pakistan's new policy on Cogeneration simplifies the procedures for setting up the Power plant. The salient

points of the policy are enumerated elsewhere in this report. However the project shall obtain applicable permits and consents from GOP institutions, including but not limited to the following.

- Private Power and Infrastructural Board (PIIB)
- State Bank of Pakistan
- Federal Board of Revenue
- Security and Exchange commission of Pakistan
- Ministry of Ports and Shipping For Import of Plant and Machinery
- Ministry of commerce and Export promotion Board
- Pakistan Environmental Protection Authority
- Government of Punjab, Pakistan

HPPL will obtain any other approvals, consents or permits as applicable at the time project implementation.

15.2 **Project Team**

15.2.1 The successful and timely implementation of the project and the avoidance of overspending and consequent frustration depend on the performance of the project team. This project team shall be formed within the company and will be assisted by the consultancy organisation. This project team shall be directed by a Project Manager, who has experience in the implementation of similar projects. The engineers from this group should be involved from the early stages of the execution of the project, right from the engineering and procurement stages of the project. This would give them ample opportunity to familiarize themselves with the equipment and the systems being procured.

15.2.2 Subsequently, at the time of installation at the site, these personnel should be involved with the critical phases of installation and commissioning. These engineers shall be trained

at the machinery manufacturer's works and at similar plants operating elsewhere. After the plant has been commissioned, these engineers would occupy key positions in the organizational structure for the operation and maintenance of the plant. This approach ensures a smooth transition from engineering and procurement to erection and commissioning and finally to operation and maintenance.

15.2.3 The responsibilities of this project team shall be:

- a) Plan and program all the work and resources required for the project completion.
- b) Project engineering and co-ordination involving the Design of the plant, plant support systems.
- c) Co-ordination with Equipment supplier and the sugar plant and furnishing data for interfacing at terminal points.
- d) Inspection of the major items and expediting.
- e) Organize the construction and commissioning of the plant by progressively integrating individual systems.
- f) Monitor and control the project progress with regular interactions and co-ordination.

15.3 Contract Strategy

15.3.1 The first step to be taken in the execution of the project is the constitution of an appropriate project organization, as discussed above, which would be responsible for the execution of the project. The development and the size of the project organization must be based on the tasks that need to be performed in the project. For a Power project the following are the identified important phases. These phases are not mutually exclusive and some degree of overlapping is envisaged.

- Appraisal of the Report by Financial Institution.
- Financial Closure.
- Planning.

- Procurement including Inspection and Expediting.
- Project management.
- Construction Phase.
- Commissioning and performance testing.

15.3.2 The plant should form an effective Project management group within their organization for the project execution involving the above mentioned phases of the project. The consultancy organization will technically assist the project team in all the activities.

15.3.3 The nature of the project calls for the division of the project into recognizably discrete plant areas with specific terminal points that can stand alone for engineering and contract purposes. An appropriate contract strategy involves, the decision on the number and the type of contracts to be let, vendor evaluation, formulation of contract agreement defining respective obligations, the basis for discharging them and remedies for default.

The major points to be considered in packaging are:

- The packages proposed are compatible, which ensures adequate competition in bidding and consequent procurement at optimum cost either within the country or from overseas vendors.
- The packages include such combination of equipment and services that can be advantageously engineered for the preparation of specifications for bidding and subsequent design including manufacture/construction.
- The packages formed are mutually exclusive as well as collectively exhaustive.
- The number of packages and their sizes are optimum for effective implementation.

- The terminal points of each of the packages are clearly defined and proper tie-ups of these points between the packages are ensured.

The following gives the tentative list of contract packages for this project. Each package is an EPC package, wherein, the responsibility of engineering, procurement and construction is left to the vendor with guarantees for each package clearly defined. The package route also gives an advantage in choosing the vendor considering the availability of after sale service, spare parts, HPPL's preferences and technical support from the vendor.

- Steam generator and Auxiliaries
- Turbogenerator and Auxiliaries.
- Fuel & grate bottom ash Handling system.
- Cooling Tower
- Water treatment plant and other associated systems
- Air compressor and dryer
- Air conditioning & ventilation system
- Centrifugal Pumps and Drives.
- Dense Phase ash handling system
- EOT crane
- Piping and appurtenances.
- Electrical distribution, MCC, PCC, cables, lighting, Transformers, switchyard and installation package
- DCS and Balance Of Plant (BOP) Instrumentation Package
- Fire Fighting System
- Civil works package

15.3.4 Preparation of the Tender Specification, obtaining offers from qualified bidders, technical and commercial evaluation of offers, finalization of the vendor, formulation of the contract agreement, contract reviews, vendor drawing review and approval etc. are the major activities for each of the packages.

The scope of the package vendors will be the design and engineering, procurement, manufacturing, inspection, testing, transportation to the site, installation and commissioning & performance guarantee of the respective packages.

15.3.5 The specifications for major equipment like the boiler, turbogenerator, cooling towers, switchyard equipment etc., the technical information of which, is essential to the development of the plant design and in particular to the civil design, shall be drawn up at an early stage of the project. Program of design information submission from the mechanical and electrical contractors that satisfies the overall project schedule shall be drawn up. The most important among such information are the location of the individual plants, floor loading, support requirements etc. which are required for the civil design.

15.3.6 Since the project execution calls for closer coordination among the contractors, consultants and HPPL's team, proper contract co-ordination and monitoring procedures shall be formulated. Detailed bar charts or networks shall be made to plan and monitor the project progress. Contract drawings and documents requiring approval from statutory authorities shall be clearly identified and scheduled so that the procedural formalities do not affect the project progress.

15.3.7 Procurement

15.3.7.1 Procurement is an important function in the implementation of the Project. The procurement of the systems equipment and services will be through a series of suitably packaged contracts as outlined earlier. The Project team with the consultants floats the enquiries with the appropriate commercial conditions, delivery requirements, guarantees etc. to renowned suppliers. The specifications for the procurement of the equipment and systems will be provided by the consultants.

- 15.3.7.2 Evaluation of the offers is done by the consultants, with coordination from other related members of the project team, based on the evaluation criteria stipulated in the tender documents. After evaluation and taking a decision on placement of the order, the contract agreement with commercial terms and conditions, delivery schedule and guarantees etc. are drafted and purchase order placed on the selected bidder. Once the purchase order is placed, the consultants project team follows up regularly to ensure smooth and timely execution of the contract and for obtaining technical information for the inter-package engineering. The procurement activity includes the review of the vendor drawings by the consultant/HPPL's project team, expediting, stage and final pre-delivery inspection, supervision of installation and commissioning.
- 15.3.7.3 When the contract for the packages are awarded, detailed program in the form of network are tied up with the contractor to clearly indicate Purchaser's obligations and the supplier's responsibilities. HPPL's inputs are in terms of land availability, construction power and water availability, civil fronts, etc. while that of the contractors are in terms of drawing submission, manufacture, supply, transportation, erection and commissioning. The progress for each work package against the schedules drawn up is evaluated regularly. Such evaluation indicates the causes for the delay, if any, in meeting the schedules and identifies actions to be taken for the rectifying the delays.
- 15.3.7.4 To expedite supplies from the contractors, regular visits to the supplier's works will have to undertaken by the consultants. The manufacturing program and the quality plans finalized at the time of contract award are utilized by the engineers for the monitoring of the manufacturing and quality status. Regular reports shall be prepared indicating the schedule variations, if

any, their likely impact on the delivery schedule and the recommendations to meet with the schedules.

15.3.8 The Construction Phase

15.3.8.1 This is the critical phase of the project where work progresses in almost all the fronts. The erection and commissioning phase of all the contracts proceed simultaneously and it is important to ensure that the various contractors have adequate facilities and are established on the site in time to meet their programmed commitments. Adequate power and water shall be made available for the construction.

15.3.8.2 While the construction manager from the Purchaser's plant side will be in-charge of the site, Consultant project manager will take the full responsibility for overseeing the construction activities. The construction team's key task is to continuously monitor the site progress against the agreed program and to initiate whatever corrective action is necessary to maintain satisfactory site progress. During the execution stage of the project at site, quite a few of the various contracts progressing simultaneously are interrelated and hence, the delay in the activities of one contractor will invariably affect the progress of the other contractors and ultimately the project progress.

15.3.8.3 This aspect emphasizes the importance of progress review, project monitoring and timely remedial measures, for the smooth and 'within the budget' execution of the project.

15.3.8.4 Certain basic responsibilities of the construction management are:

- a) The contractor shall be encouraged to give the earliest possible warning of actual or potential difficulties.

- b) Ensure that the senior management in the contractors' organisation are made aware of the serious problems at an early date.
- c) Provide a focus for early discussion of any potential problem and possible remedial measures, while clearly maintaining the contractor's responsibility for recovering delays.
- d) Help to foster a climate among all concerned that no extension of site deliveries and erection schedule are allowable.

15.3.8.5 A fortnightly progress review meeting will be held with each contractor, where formal reports are tabled, giving an agreed progress statement. From these agreed progress statements, an accurate prediction of the state of the project is available which helps the construction team to adjust, if necessary, the activities of the particular contractor, and also the activities of any affected contractor.

15.3.8.6 Major problems such as non-availability of drawings, clarifications, documents from various disciplines of engineering group, non-receipt of required materials from the various contractors, reasons for the default, remedial measures initiated, impact of such delays on the project progress will be taken up and resolved in the progress review meetings.

15.3.9 Plant Commissioning

15.3.9.1 The commissioning phase in a project is the one where the design, manufacturing, erection and quality assurance expertise are put to test. The commissioning team for each plant will consist of representatives from the contractor, consultant and the power plant. As discussed earlier, it is essential to associate the staff identified to operate the plant in the commissioning stage itself.

15.3.9.2 When construction work is complete, the checklists, designed to ensure that the plant has been properly installed and appropriate safety measures have been taken are gone through and all the documentation pertaining to the statutory inspections and approvals are presented, the commissioning team shall take over. The commissioning team will follow scrupulously the commissioning and operating instructions laid down by the plant & equipment manufacturer/supplier, to prove that the plant/equipment is in every respect, fit for service. The plant shall be subjected to a performance test, after the stipulated trial operation and the reliability run. After the successful completion of the performance test the plant will be taken over by the purchaser.

15.4 The Responsibilities of HPPL & HSMPL

15.4.1 Since the Power project is coming up adjacent to the sugar plant, it is important that the area identified for the Power plant is cleared for the early start of the civil work. The soil investigation and site grading shall be taken up in the very beginning so that the civil work can proceed without any hindrance. The site development shall include the levelling of site, clearing the site for construction of the power house, identifying or constructing adequate storage space, providing lighting, water connection, construction power in the work area, etc.

15.4.2 It is essential that before the Zero Date of the project all the clearances from Government & statutory authorities are obtained. It is also essential that uninterrupted fund flow is ensured for the successful execution of the project on schedule.

15.5 Project Schedule

- 15.5.1 The Fig.15.1 gives the overall project schedule in the form of a bar chart. This schedule envisages the project commissioning and synchronization in Twenty (20) months from the date of ordering of the boilers and turbogenerators. The proposed COD date is 31st July 2018. With the completion of the detailed project report by 15th September 2016, the preparation of the procurement specifications for the boilers, turbogenerators & other balance of plant packages will be taken up. It is expected that the tendering, evaluation and order finalization will take about two to two & half months time and Boilers & the Turbogenerators could be ordered by 1st December 2016.
- 15.5.2 For the major packages, the schedule includes the following applicable activities. The time period requirement for these activities has been included in the periods shown against each package.
- a) Basic Study
 - b) Tendering
 - c) Receipt of offers, evaluation, discussions and Purchase order placement.
 - d) Manufacturing and delivery
 - e) Erection and other work at site
 - f) Commissioning, trial run and testing
- 15.5.3 In the proposed Cogeneration plant the boiler and the turbogenerator are the long lead items and the planning of the schedule for the project implementation should provide adequate time period for the installation of these equipment.
- 15.5.4 Once the project gets started, it is essential that a more detailed bar or network chart is prepared incorporating all the contract activities, so that the planning and the monitoring is effectively carried out.

16.0 Works Cost Estimate

16.1 Methodology of the EPC Cost estimate

16.1.1 This section of the Report gives the project cost estimate for the proposed Cogeneration power plant at HPPL. It is assumed that the project will be executed through the package route with an Engineering Procurement And Construction Management (EPCM) consultants carrying out the Engineering, Procurement and Construction Management activities. The EPCM consultants make the basic design of the plant, divide the project into logical and manageable packages, prepares the procurement specifications and assists HPPL in the procurement of the packages. Once the packages are ordered, the EPCM consultant expedites with the contractors, reviews drawings, co-ordinates all the activities between the contractors and manages the implementation of the project. The complete Cogeneration plant civil works will be executed by a separate contractor. Based on the overall project guarantees, individual package guarantees are arrived at and specified in the contracts of the individual packages.

16.1.2 Due to the current economic conditions in most of the countries, the prices of engineering goods have not registered any appreciable increase and this probably may be the best time for capital investments. Another major advantage today is that the most of equipment suppliers do not have comfortable order book positions and consequently we can expect a shorter delivery of the equipment. While the commodity prices have come down slightly the cost of other input like energy and manpower had been continuously on the uptrend. Avant-Garde has vast experience in the implementation of these bagasse based Cogeneration projects both in India and in other countries. They are already implemented three bagasse based cogeneration projects in Pakistan and implementation of few

more projects are in planning stage. Because of their long and continuous involvement in these types of projects they are aware of the current price levels of the equipment and materials in the international markets. For the estimation of the project cost, Avant-Garde had gone about completing the preliminary basic engineering and estimating the cost based on the information available with them in their data bank and based on the recent orders finalized by them for their various projects including the projects currently implemented / under implementation in Pakistan.

- 16.1.3 Based on the discussions with HPPL/HSMPPL and the visit to the sugar plant and the proposed plant site, the scheme for the Cogeneration plant and the location of the Cogeneration plant were finalized. Preliminary sizing of the major equipment and the auxiliary equipment were finalized and the Cogeneration plant plot plan was prepared. All the interfacing points with the sugar mill were finalized and the routing of the fuel conveyors, Piping routing and the cable routing were finalized and incorporated in the layout drawing. As the layout of the plant is one major factor affecting the cost of the balance of plant equipment, a detailed layout was prepared for the Cogeneration plant. The cost estimate of all interconnections like piping, cabling, conveyors etc., were made with this layout. The layout of the Cogeneration plant and the interfacing of the various packages of the Cogeneration plant are elaborately dealt with in other sections of this report.

16.2 Civil Works

- 16.2.1 The civil works for the Cogeneration plant constitute approximately about 12 to 15% of the total works cost and include execution of all foundations, plant buildings, storage tanks, roads and drains, pipe racks etc. Also included in the civil work scope are the cooling tower's basin and a 98 m tall RCC Chimney common for both the boilers. As the soil is sandy the

bearing capacity should be quite good and hence no piling has been envisaged and all the foundations are designed with footings. However a final decision on the type of foundation will have to be taken after a detailed soil investigation during the contract stage. Surveying and soil investigation are not part of the civil works and will be done by HPPL through other contractors and the cost of these studies shall be part of the pre-operative expenses for the project.

16.2.2 The civil works' scope does not include any non-plant buildings like a new administration office, temporary site offices and staff quarters, vehicle parking sheds etc. No separate mechanical workshop or a store is considered as the existing facilities at the sugar mill will be hired/used for the Cogeneration plant also.

16.2.3 The following are included in the civil scope of work for the Cogeneration plant:

- Site Grading and Levelling
- Foundations for all equipment, structural columns, pipe racks etc.
- Turbogenerator Building
- Water cooled condenser Foundations
- Bagasse storage yard including closed storage area for bagasse.
- RCC Chimney including foundation
- Cooling Tower basin and superstructure
- Water treatment plant building
- All tank foundations
- Cable trenches with cover slabs
- Plant Roads, Drainage, Storm Water Drains and Fencing
- Switchyard Equipment foundation Works and fencing
- Paving of boiler area, power house area, water treatment plant area, etc.

- Electrical and Instrumentation Workshop & Stores in TG building
- Supplying of all grouting cement and applying the grouting cement for all the equipment supplied.

16.3 Mechanical and Electrical works

The mechanical and the electrical works of the Cogeneration plant include, but not limited to the following. The listing below does not in any way represent the number of packages for procurement for the project, but is a general listing giving all the major mechanical and electrical equipment and systems in the plant.

16.3.1 Mechanical Works

- Two (2 Nos.) of Steam Generators with spreader stoker with travelling grate and with all its accessories including an Electro Static Precipitator. The capacity of the boilers will be 135 TPH each with the outlet steam parameters of 110 bar(a) and 540 Deg.C.
- Two (2 nos.) of extraction condensing Turbogenerators with all its accessories. The capacity of each of the Turbogenerators will be 24.9 MW. The turbogenerator will be complete with the complete water cooled condenser system.
- Complete bagasse handling system from existing bagasse yard to cogeneration boiler, surplus bagasse to storage yard and back feeding of bagasse from storage yard to boiler.
- Wet ash handing system for Boiler Travelling grate ash.
- Dense phase ash handling system for all Fly Ash generation points including air compressors for pneumatic conveying and ash silo.

- Complete Water Treatment Plant with all its accessories and laboratory equipments and chemicals including waste water treatment plant.
- Complete Cooling Tower with all its accessories
- E.O.T. Crane for the power house
- Complete set of centrifugal pumps with its accessories for the Cogeneration plant
- High Pressure Feed Water Heater(s)
- Complete Cogeneration plant Piping and its associated auxiliaries including pipe rack
- All pressure reducing and de-superheating stations as required.
- Air Compressor, Air dryer and Air receiver with all its accessories.
- Complete Thermal Insulation and refractory for boiler, turbine, equipment, piping etc.
- Circulating water chemical treatment system and gas chlorination system
- Fire fighting system for the entire Cogeneration power plant.
- Air conditioning system and ventilation system for the Cogeneration plant.
- One no. Industrial elevator common for both the boilers

16.3.2 Electrical:

- Synchronous generators, along with coolers and accessories, PMG, brushless exciter, AVR, NGR and LAVT panel
- Generator transformers, distribution transformers and converter transformers required for co-generation plant and interconnection transformers for sugar plant , along with 10% extra oil in non-returnable containers along with NGR panels
- Plant end Switchyard equipment including main and check tariff metering & associated equipment as per SLD and layout drawings enclosed. The scope includes required GI lattice structures, bus bar materials, support insulators, wave traps and coupling capacitors, circuit breakers, isolators, instrument transformers, Lightning arrestors, cabling, earthing, lightning protections, junction boxes, necessary hardware, clamps and connectors, safety appliances and cable race ways to meet the requirement as per drawings and specification
- 11 kV switchgears for the co-generation plant and sugar plant, as indicated.
- Protection, control, metering and synchronisation panels for the complete systems in scope including generators, generator transformers, and line and bus coupler bays at plant end substation.
- DPLC system along with its panels & Equipments, its battery and battery chargers. Required cabling between field equipment and protection schemes for line protection shall also be included in the scope.
- 11kV segregated phase bus ducts (SPBD) and other bus ducts along with accessories for the Cogeneration plant, as furnished in the detailed specifications and the drawings.

- 400V PCCs, MCCs, distribution boards for the complete cogeneration plant.
- DC system completes with battery bank, battery charger, DC starter for EOP motor and DC distribution board.
- AC Variable frequency (ACVF) drives panels along with stand-by drives, as specified in the enclosed drawings and specification
- Drive motors for the complete equipment in scope
- UPS system
- Complete SCADA system for the 132kV Switchyard
- Power (HT & LT), Control and Signal cables along with termination kits, termination accessories, cable trays & accessories, support arrangements, etc. for the complete plant including sugar plant equipment in scope.
- Plant earthing system
- Lightning protection for the complete plant
- Illumination system (main AC and emergency DC) complete with lighting transformer, switchgears, lighting fittings, lamps, poles, towers, support structures / materials, cabling, etc, for the entire plant.
- 415V Black start Diesel Generating Sets and accessories, as indicated
- Local push button stations, receptacles, welding sockets etc. for the complete plant

- Communication system for the complete plant
- Mimic for the complete electrical system from 132 kV level to motor levels. Energy management system from 132 kV system to PCC and VFD outgoing levels.
- Safety Appliances for the complete cogeneration plant.

16.3.3 Instrumentation & Control System

- All hardware and software necessary to meet the specified functional requirements, as per the control system architecture of the Distributed Control System (DCS).
- Measurement, Monitoring, Alarm, Logging and Control of the instrumentation requirements of the Boiler, Turbine and its associated auxiliaries and other balance of Plant equipment.
- Monitoring the status of the individually controlled sub-systems such as Bagasse Handling, Ash Handling, Air Compressor, Water treatment, Fire fighting and Protection, Turbovisory and Governing.
- All field instruments for sensing, transmission, and all the associated accessories such as Isolation valves, Impulse piping, tubing fittings and accessories for the connection of instruments and control equipment to the process etc., that are required for the safe and continuous operation .
- All interconnecting cables between the field instruments and the DCS control panel, branch cables between the field instrument and junction box, inter-panel wiring and internal wiring of the panels.
- Necessary earthing / grounding arrangements for all the instruments.

- 16.4 Some of the Salient Points on the various equipment and systems:**
- 16.4.1 Electrostatic precipitators have been included as the dust collection equipment to control the particulate emission level from the boilers to 50 mg/N.Cu.m. The complete Electrostatic precipitator system is included in the Boiler scope.
- 16.4.2 Included in the scope of the boiler package, other than the ESP, are the auxiliary systems like the fans, boiler feed water pumps, deaerator, dosing system, desuperheating system, pressure reducing and desuperheating stations (PRDS) for meeting with the process steam requirement (in case the turbine operating at low loads under grid out conditions), piping, instrumentation for the complete boiler package, dense phase ash handling system for both the boilers etc.
- 16.4.3 The scope of the turbogenerator includes the auxiliary systems like the condensing system, lube oil system including the emergency lube oil system, governing system, turbovisory system, governing system, turbine and generator control system, generator protections, 11 kV switchgear panels with incomer from the generator and outgoing feeders for the various transformers and spares feeders, neutral grounding resistors, CTs, PTs etc.
- 16.4.4 With high pressure Cogeneration systems, the supply of treated good quality water to the boiler becomes a very important factor for the reliable operation of the plant. This calls for a suitable water treatment plant which will supply the treated water to the boilers to the required quality. The water treatment plant proposed for the plant is based on the proven membrane technology which is called the Ultra Filtration & Reverse Osmosis (RO) system. As the source of raw water is the deep borewells, it is proposed to include a Multigrade filter,

and other pre-treatment systems to the RO plant. The RO permeate water will be further treated in an EDI downstream of the RO plant, to make the water suitable for feeding to the high pressure boiler.

- 16.4.5 The fuel handling system package will include the bagasse handling from the sugar mill take off point to the Cogeneration plant, surplus bagasse carrying conveyors from the Cogeneration plant to the storage yard and the bagasse back feeding conveyors. Also included in this package is the wet bottom ash handling system to handle the ash from the grate discharge hoppers.
- 16.4.6 Induced draft cooling tower meeting with the requirements of the condensers and of the turbogenerator auxiliary equipments and this will be a separate package. The tower will be of counter flow type and shall be of RCC construction.
- 16.4.7 All pumps, not part of the main packages will be ordered separately, as a package. They will be ordered along with the drive motors.
- 16.4.8 All the interconnecting piping between packages and between the Cogeneration plant and the sugar mill will be a separate package along with all the piping appurtenances and supports. Some of the tanks and vessels not forming part of any major package will be included in the piping package.
- 16.4.9 The equipment and systems like the Air-conditioning and ventilation system, fire protection system, compressed air system for providing the service and instrumentation air for the Cogeneration plant, will be ordered out as separate packages.
- 16.4.10 Electrically operated over head travelling crane for the maintenance of the turbogenerator etc.

- 16.4.11 The power generation is at 11 kV level. The generated power will be stepped up to 132 kV in the plant switchyard. The Electrical scope includes power transformer, switchyard equipment, cabling, protection system, etc. at the plant switchyard. The internal power distribution for the Cogeneration plant including the distribution and converter transformers, Power control centres (PCC), Motor Control Centres (MCC) and Variable Frequency Drives (VFD) for meeting the internal power requirements of the Cogeneration plant. Judicious use of the VFDs has been made to reduce the internal power consumption of the Cogeneration power plant. As far as the power supply to the sugar mill from the new Cogeneration plant is considered, the additional transformers required for stepping down the Voltage to 400 V level will be provided.
- 16.4.12 The cost of the transmission lines from the plant switchyard to the FESCO's Grid sub-station at grid to 18 Hazari 132kV Feeder through a loop in loop out (LILO) arrangement is are included.
- 16.4.13 The plant operation and control is envisaged through a well designed Distributed Control System (DCS). The complete DCS system, all the field instrumentation and junction boxes, the complete signal and power cabling, the I/O racks etc., are included in the scope of the contract.
- 16.5 **Works Cost**
- 16.5.1 Table 16.1 gives the details of the estimated costs for the civil, mechanical and electrical works. These estimates are based on the actual ordering of identical/similar equipment for various other projects. These costs included in the Table cover the complete civil, mechanical and electrical works of the complete Cogeneration plant. The costs include the equipment design,

procurement, manufacturing, supply and the erection and commissioning of the complete plant. No taxes and duties are included in the above costs.

The estimated cost of Civil works is :US\$ 4,600,000.00

The estimated Cost of Mechanical works is :US\$ 40,240,000.00

The estimated cost of electrical & Instrumentation works is :US\$ 10,820,000.00

Total Works Cost : US\$ 55,660,000.00

16.6 Land Cost

16.6.1 The Cogeneration project is proposed to be implemented in an area adjacent to the sugar mill, which already belongs to Hunza Sugar Mills Private Limited. Hence no cost is included under this head. The section on the Plant Layout details the location and the layout of the plant.

16.7 Contingency

16.7.1 The methodology of cost estimation is discussed earlier. The equipment costs are based on similar/identical orders placed in the recent past. To get a price estimate which is reasonably accurate for the interconnections a detailed layout had been made to make an estimate of the quantities and the recently ordered prices of piping, cables etc., in Pakistan had been used to arrive at the estimate. At the time of project implementation, detailed contract specifications will be prepared to get the detailed final offers from the contractors. As all these activities will take time and in the meantime, with the reviving economy world over, the prices will start moving up.

This report optimistically assumes that the project implementation will start by Last Quarter of 2016.

- 16.7.2 The implementation of the project through the package route is expected to take about Twenty (20) months from the date of issue of the LOI for the boiler and TG packages, which is likely in December 2016. The other package ordering will follow subsequently. The project completion, tentatively, is estimated to be in July 2018 and the commercial operation could start in August 2018. With the ordering of the boiler and TG almost two months away and with the project schedule of Twenty (20) months, the prices now estimated could undergo some upward revision. So it is necessary that a provision is made for some contingency expenses and generally a provision of 5% is made as contingency, towards meeting the possible escalation in the prices.

Table 16.1 -Works Cost Estimate

All Amount in Million USD					
S No	Description	Unit	Quantity	Rate	Amount
A. CIVIL WORKS					
	This cost includes construction TG building, boiler foundation, Water Treatment Plant building, Raw water tank, various equipment foundation in the cogeneration plant, switchyard, pipe rack, roads, drains and chimney				4.6
	TOTAL FOR CIVIL WORKS				4.60

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2 x 24.9 MW COGENERATION PROJECT

All Amount in Million USD

S. No.	Description	Unit	Quantity	Rate	Amount
B. MECHANICAL WORKS					
1.	2 x 135 TPH steam generator including ESP, field instrumentation, fans, pumps, valves specialties, piping, PRDS & auxiliaries	Nos.	2		19.4
2.	2 x 24.9 MW extraction cum condensing turbogenerator unit including all auxiliaries, piping, governor, turbovisory, control & instrumentation and electrical incl. HP heater	Nos.	2		9.2
3.	Bagasse handling, conveyor components, structurals, hoods etc.	LS			2.6
4.	Ash handling system for the boiler consisting of submerged scrapper conveyors, for wet ash and dense phase handling system for fly ash	LS			0.8
5.	Induced draft cooling tower (RCC work to be included in civil)	LS			1.10
6.	Pumps with base frames and electric motor drives (pumps not included in boiler & TG scope)	LS			0.50

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2 x 24.9 MW COGENERATION PROJECT

All Amount in Million USD

S. No	Description	Unit	Quantity	Rate	Amount
7.	Steam, water piping and valves & supports	LS			2.6
8.	Reverse Osmosis based water treatment plant (borewell water)	LS			1.40
9.	Tanks and Vessels	LS			0.45
10.	EOT Crane for TG Building	LS			0.45
11.	Air conditions system & ventilation system for TG building etc.	LS			0.70
12.	Air Compressors	LS			0.09
13.	Fire Protection Systems (including bagasse yard)	LS			0.95
	TOTAL FOR MECHANICAL WORKS				40.24
C. ELECTRICAL WORKS					
1.	24.9 MW Generators & all generator accessories including relay, metering and control panels, AVR, NGR & LAVT Panels of each TG set.	Nos.	2		Incl. in turbine

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2 x 24.9 MW COGENERATION PROJECT

All Amount in Million USD

S. No	Description	Unit	Quantity	Rate	Amount
	11 kV Panels, Common synchronizing panel and load sharing panel				
2.	Switchyard				
2.1	Power Transformer (11 kV / 132 kV)	Nos.	3		1.15
2.2	Plant End Switchyard (132 kV)	LS			2.70
3.	Auxiliary Transformers				
3.1	Converter Transformers	Nos.	4		0.27
3.2	Interconnection Transformer 11 / 0.415 kV	Nos.	5		0.45
4.	LT Package	LS			0.90
5.	VFD Package	LS			0.90
6.	Cables Package	LS			0.80
7.	Contracts Package (Cable Tray, LT bus duct, lighting & Misc items)	LS			1.10
8.	DG Set Package - 1250 kVA	Nos.	2		0.75
9.	Distributed Control Systems	LS			1.8

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2 x 24.9 MW COGENERATION PROJECT

All Amount in Million USD

S No	Description	Unit	Quantity	Rate	Amount
	& Misc. Instrumentation other than that covered by packages & UPS				
	TOTAL FOR ELECTRICAL WORKS				10.82
	TOTAL WORKS COST				53.66

Note: This cost includes interconnection transformer for the sugar plant and excludes Transmission line & Substation end switchyard.