BAHAWALPUR ENERGY LIMITED

GENERATION LICENSE APPLICATION

BAHAWALPUR ENERGY LIMITED

Ref: BWEL/12/2016/016
Dated: 21/12/2016

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Office Building,
Sector G-5/1,
Ataturk Avenue (East),
Islamabad

Subject: Application for a Generation License

I, Ch. Khan Muhammad Ashraf, Chief Executive of *Bahawalpur Energy Limited (BWEL)* by virtue of Resolution of Board of Directors dated 15-12-2016, hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to Bahawalpur Energy Limited (BWEL) 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 terms and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

A Bank Draft No. 17168009 dated 17-12-2016 drawn on Habib Bank Limited (HBL), in the sum of Rupees Two hundred ninety four thousand three hundred and eighty four rupees only PKR (294,384/-), 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.

Yours faithfully

Ch. Khan Muhammad Ashraf
Chief Executive

BAHAWALPUR ENERGY LTD.

RESOLUTION OF BOARD OF DIRECTORS

BAHAWALPUR ENERGY LIMITED

EXTRACT OF THE RESOLUTION OF BOARD OF DIRECTORS OF BAHAWALPUR ENERGY LIMITED PASSED IN THEIR MEETING HELD ON 15/12/2016 AT 128 – Tufail Road, LAHORE

The Board of Directors of BWEL a public company duly formed and registered in the Islamic Republic of Pakistan having incorporation No. **0103439 (The BAHAWALPUR ENERGY LIMITED)** and having its registered office at 128 - Tufail Road, Lahore, in their meeting held on 15/12/2016, 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 board of directors decided to authorize Mr. Ch. Khan Muhammad Ashraf, Chief Executive, Mr. Tahir Sattar GM (Power Project) and Mr. Aurangzeb Mohsin, Company Secretary, of the Company be and are hereby 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 extract of this resolution be provided to the NEPRA with the seal/stamp duly affixed thereon.

Mr. Aurangzeb Mohsin

Company Secretary

15/12/2016

Mr. Ch. Khan Muhammad Ashraf

Chief Executive

Head Office: Upper Mall Lahore, Pakistan
Registered Office : 128 Tufail Road ,Lahore
Contact: +92-42-35718333-555 Fax: +92-42-35716999

A024261

SECP

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. 0103439

I hereby certify that **BAHAWALPUR ENERGY LIMITED** is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is **Limited by Shares.**

Given under my hand at **Lahore** this **Eighth** day of **November,** Two **Thousand** and **Sixteen.**

Fee Rs.420,500/-

(LIAQAT ALI DOLLA)
Additional Registrar

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES

No.ARL/ 8607 **DATED: 08-11-2016**

PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, MANAGING AGENT, SECRETARY, CHIEF ACCOUNTANT, AUDITORS AND LEGAL ADVISERS, OR OF ANY CHANGE THEREIN

THE COMPANIES ORDINANCE, 1984 FORM 29

[SECTION 205]

1. Incorporation Number
2. Name of Company: BAHAWALPUR ENERGY LIMITED
3. Fee Paid (Rs.): 500.0 Name and Branch of Bank: LAHORE, MCB - Main Market Gulberg [0183]
4. Receipt No.: E-2016-503956 Date: 08/11/2016
5. Mode of Payment (Indicate): Bank Challan
6. Particulars*:

6.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointment / change / any other remarks (i)
Chaudhry Khan M Ashraf	31202-1302899-3	S/O Muhammad Zaka Ashraf	H No 19, Zafar Road, Lahore Punjab Pakistan	Director	Pakistan	Business	Since Incorporation.	
Fiza Ahsraf	31202-6738953-6	D/O Muhammad Zaka Ashraf	H No 19, Zafar Road, Lahore Punjab Pakistan	Director	Pakistan	Business	Since Incorporation.	
Ubeda Ashraf	35201-6933192-0	W/O Usman Akram	H No 19 Zafar Road Lahore Punjab Pakistan	Director	Pakistan	Business	Since Incorporation.	

6.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES

6.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

Name of Signatory	Chaudhry Khan M Ashraf	Designation	Director
Signature of Chief Executive/Secretary		Date (DD/MM/YYYY)	08/11/2016

[illegible]
[illegible]
[illegible]

PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, MANAGING AGENT, SECRETARY, CHIEF ACCOUNTANT, AUDITORS AND LEGAL ADVISERS, OR OF ANY CHANGE THEREIN

THE COMPANIES ORDINANCE, 1984 FORM 29

[SECTION 205]

1. Incorporation Number: 0103439
2. Name of Company: BAHAWALPUR ENERGY LIMITED
3. Fee Paid (Rs.): 500.0 Name and Branch of Bank: LAHORE, MCB - Cavallary Ground [1508]
4. Receipt No.: E-2016-513031 Date: 14/11/2016
5. Mode of Payment (Indicate): Bank Challan
6. Particulars*:

6.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)
Chaudhry Khan M Ashraf	31202-1302899-3	Muhammad Zaka Ashraf	H No 19, Zafar Road, Lahore	Chief Executive	Pakistan	Business	14/11/2016	Appointed

6.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

6.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

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JOINT REGISTRAR OF COMPANIES

Name of Signatory	Ghaudhry Khan M Ashraf	Designation	Director
Signature of Chief Executive/Secretary		Date (DD/MM/YYYY)	14/11/2016

[illegible]

PARTICULARS OF DIRECTORS AND OFFICERS, INCLUDING THE CHIEF EXECUTIVE, MANAGING AGENT, SECRETARY, CHIEF ACCOUNTANT, AUDITORS AND LEGAL ADVISERS, OR OF ANY CHANGE THEREIN

THE COMPANIES ORDINANCE, 2016 FORM 29

[SECTION 197]

1. Incorporation Number	0103439
2. Name of Company	BAHAWALPUR ENERGY LIMITED
3. Fee Paid (Rs.)	500.0
Name and Branch of Bank	LAHORE, MCB - Main Market Gulberg [0183]
4. Receipt No.	E-2016-526134
Date (DD-MM-YYYY)	07/12/2016
5. Mode of Payment (Indicate)	Bank Challan

6. Particulars*:

6.1. New Appointment/Election

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)
KPMG Taseer Hadi and Co Chartered Accountants	NA	NA	2nd Floor, Servis House, 2-Main Gulberg, Jail Road, Lahore	Auditor	Pakistan	Chartered Accountants	07/12/2016	Appointed
SBK and Co Advocate and Corporate Legal Consultants	NA	NA	179/180-A, Scotch Corner, Upper Mall, Lahore	Legal Adviser	Pakistan	Legal Advisor	07/12/2016	Appointed
Aurangzeb Mohsin Khan	35201-1448267-3	Agha Iftikhar ud Din (Late)	11 Uper Mall, Lahore	Secretary	Pakistan	Service	07/12/2016	Appointed

6.2. Ceasing of Officer/Retirement/Resignation

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality** (f)	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

15/12/2016

JOINT REGISTRAR OF COMPANIES

6.3. Any other change in particulars relating to columns (a) to (g) above

Present Name in Full (a)	NIC No. or Passport No. in case of Foreign National (b)	Father / Husband Name (c)	Usual Residential Address (d)	Designation (e)	Nationality**	Business Occupation *** (if any) (g)	Date of Present Appointment or Change (h)	Mode of Appointement / change / any other remarks (i)

Name of Signatory	Ubeda Ashraf	Designation	Director
Signature of Chief Executive/Secretary		Date (DD/MM/YYYY)	07/12/2016

[illegible] the case of a firm the full name, address and above mentioned particulars of each partner and the date on which each became a partner

[illegible] the nationality is not the nationality of origin, provide the nationality of origin as well

[illegible] provide particulars of other directorships or offices held, if any

CERTIFIED TRUE COPY OF MEMORANDUM OF ASSOCIATION

THE COMPANIES ORDINANCE, 1984

(Company Limited by Shares)

MEMORANDUM OF ASSOCIATION

OF

BAHAWALPUR ENERGY LIMITED

I. NAME:

The name of the Company is "**BAHAWALPUR ENERGY LIMITED**".

II. REGISTERED OFFICE:

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

III. OBJECTS:

The objects, for which the Company is established, are all or any of the following:

1. To design, develop, build, establish, own, operate, maintain and manage electric power generation plants for the generation of electric power through different methods, including but not limited to power generation from bagasse/biomass and sale, supply and transmission of the electric power so generated subject to prior permission from NEPRA and/or other relevant Authorities, if required.

2. To carry on all or any of the business of producers, manufacturers, generators, suppliers, distributors, transformers, converters, transmitters, processors, developers, storers, procurers, carriers and dealers in electricity, all form of energy and any such products and by-products derived from such business including without limitation, steam, fuels, ash, conversion of ash into bricks and any products derived from or connected with any other form of energy, including, without limitation to conventional sources such as heat, thermal, hydel and/or from non-conventional sources such as bagasse, tidalwave, wind, solar, geothermal, biological, biogas and coal bed methane subject to prior permission from NEPRA and/or other relevant Authorities, if required.

3. To carry on the business of power generation and in relation thereto, to generate, accumulate, transmit, distribute and sell electric power anywhere in Pakistan, to the public sector, including but not limited to, Central Power Purchasing Agency (G) (CCPA-g)., National Transmission and Dispatch Company, Government and Government bodies, as well as the private sector including but not limited to sugar mills subject to any permission required under the law.

4. To manufacture, purchase, import or otherwise acquire, construct, own, process, operate and maintain buildings, apparatus, fixtures, fittings, plants, machinery, materials, and all things as may be necessary and/or incidental to in connection with power generating plants for the generation of electric power and/or in connection with supply, transmission and distribution of electric power subject to prior permission from NEPRA and/or other relevant Authorities, if required.

5. To carry on business as manufacturers, buyers, sellers, importers, exporters, repairers, assemblers, designers, developers, installer, testers, stockists, distributors, indenters, agents, representatives or dealers of solar and other power systems, panels, appliances, equipment

and accessories of all kind and descriptions and all accessories of kinds of said the aforementioned items and to undertake all such activities as are connected, linked or associated therewith and own or acquire all requisite facilities and seek necessary approvals, registrations, affiliations and recognitions and for that purpose to do all such acts, deeds or things as would be required for effective discharge of these objects subject to any permission as required under the law.

6. To own, promote, set up, establish, develop, maintain, run, operate and manage the business of transmission of electricity, including wheeling of electricity, of every kind and description [whether on a BOO (Build, Own, Operate) basis or BOOT (Build, Own, Operate and Transfer) basis or otherwise] for electricity purchased or generated from any source, whether conventional or non-conventional, from a generating station to another generating station or a sub-station, together with any step-up and step-down transformers, switch-gear and other works necessary to and used for the control of such cables or overhead lines, and such buildings or part thereof as may be required to accommodate such transformers, switch-gear and other works subject to the permission of relevant authority.

7. To carry on business as manufacturers, assemblers, buyers, sellers, importers, exporters, erectors, installers, repairers, renovators, over haulers, suppliers, distributors, indenters, stockists, agents, representative or dealers of electric transformers, feeders, grid stations, distribution and transmission system equipment, towers, pools, jigs, tools, fixtures, fittings, spares and accessories of all kinds and descriptions and for that purpose to own or acquire all requisite facilities and to do all such acts, deeds or things which would be required for effective discharge of these functions.

8. To render, undertake and execute civil, mechanical, electrical, electronic, communicational and general engineering services, works and projects of all kinds and descriptions and to own or acquire all requisite facilities and do all such acts, deeds or things as would be required for effective discharge of the said objects.

9. To enter into any agreement or agreements with Government or any other authority, supreme, municipal, local or otherwise, that may seem conducive to all or any of the objects of the Company and/or to obtain from such Government or authority, including State Bank of Pakistan, National Electric Power Regulatory Authority, any rights, concessions or privileges, licenses, which the Company may think desirable to obtain and to carry out, exercise and comply with any such arrangement, rights, privileges, concessions and licenses.

10. To manufacture and deal in all apparatuses and things required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity, including in the term electricity all power that may be incidentally hereafter discovered in dealing with electricity and also to deal in sale of spares parts and equipments required for the above purposes whether as manufacturer, importer and/or as indenter/trader.

11. To provide consultancy services and to enter into and perform any plant/power plant operation and maintenance agreements as contractors or subcontractors or any other engineering, construction, erection, and supervision contracts with regard to the plants/power plants.

12. To enter in negotiation and agreements with Governments, authorities, agencies, semi government bodies or any other private associations, persons, corporations and companies for the sale of fuel supply or other inputs, sale of electricity in any mode.

13. To carry on and undertake trading business of all sorts and to act as indenters, importers, exporters, traders, suppliers and commission agents of products, commodities and materials in any form or shape manufactured or supplied by any company, firm, association of persons,

body, whether incorporated or not, individuals, Government (Federal, Provincial, or Local), semi-Government/autonomous agencies, departments, authorities, bodies (corporate or statutory), corporations subject to such permission as required under the law.

14. To carry on inside or outside Pakistan the business of manufacturing, importers, exporters, indenters, transporters, dealers in all articles and commodities akin to or connected with any of the business of the Company capable of being conveniently carried on or necessary for the promotion of the objects herein contained, as permissible under the law.

15. To enter into joint venture and partnership arrangements with other entities as the Company shall deem fit and appropriate in furtherance of its objects.

16. To construct, build, rent, own, repair, purchase, lease warehouses, storage facilities, whether covered or uncovered, and to undertake the custody and warehousing of merchandise, goods, and materials and to provide special storage facilities such as secure storage, cold storage, data storage and the like.

17. In pursuance of the main objects, the Company is hereby authorized to undertake any and/or all of the following:

a. Acquisition and Disposal of Property: To acquire, purchase, lease, rent, hire, exchange, gift, sell, transfer, convey to or otherwise dispose of any movable or immovable property, rights, and privileges on such terms and conditions as the Company may think necessary or convenient for the furtherance of its objects but not to act as property developer.

b. Advertising: To adopt such means of making known the Company as may seem expedient and in particular by advertising in the media, by circulars, by purchase and exhibition of works of art or interests, by publication of books and periodicals and by granting prizes, rewards and donations.

c. Agents and Consultants: To appoint agents, sub-agents, attorneys, consultants, brokers and contractors in connection with the objects but not to act as managing agents.

d. Amalgamation/Merger: To amalgamate or merge with any other company having objects altogether similar or in part similar to those of the Company.

e. Shares: To issue shares of more than one kind so that each of such kind may have different classes of shares.

f. Articles of Association: To make, amend and modify Articles of Association and rules and regulations not inconsistent with this Memorandum of Association to provide for all matters for which provision is necessary or expedient for giving effect to the provisions of this Memorandum of Association and the efficient conduct of its objects.

g. Bank Accounts: To open, close and operate bank accounts of the Company with any bank or banks, financial institutions or co-operative societies and to draw, make, accept, endorse, discount, execute and issue promissory notes, bills of exchange, bills of lading, warrants, debentures and other negotiable or transferable instruments, but not to act as a finance or banking company.

h. Borrowing: To borrow or raise money in such manner as the Company shall think fit in pursuance of its objects, and in particular by the issue of debentures, or debenture stock (perpetual or otherwise), Participation Term Certificates, Term Finance Certificates or otherwise and by issue of all securities including securities not based on interest for raising redeemable capital, resource funds from banks or financial institutions and by issue of shares in lieu of standing balance of any loan and by issue of securities as required by the rules and regulations of the banks, financial institutions and loan giving agencies and to secure the repayment of any money borrowed, raised or owing by mortgage, charge or lien upon all or any of the property or assets of the Company (both present and future), and also by a similar mortgage, charge or lien to secure and guarantee the performance by the Company or any other person or company of any obligation undertaken by the Company or any other person or company as the case may be, but not to act as a finance or banking company.

i. Charity: To subscribe or contribute or otherwise to assist or to guarantee money to charitable, benevolent, religious, literary, scientific, technical, national, public or any other institutions or for any exhibition.

j. Companies: To promote, constitute, incorporate, form, register and operate any company or companies or other legal entities anywhere for any purpose which may seem directly or indirectly to benefit the Company and to cause the Company to be registered and recognised in any foreign country.

k. Contracts: To enter into agreement(s) with any individual, firm, co-operative or other society, company, corporate body, Government or local authority or other legal entity necessary or expedient for the purpose of carrying on its objects.

l. Employees' Fund: To establish and maintain or procure the establishment and maintenance of any contributory or non-contributory pension, superannuation funds for the benefit of, and give or procure the giving of donations, gratuities, pensions, allowances or emoluments to any person who are or were at any time in the employment or service of the Company, or who are or were at any time Directors or officers of the Company and the wives, widows, families and dependents of any such persons, and also to establish and subsidize and subscribe to any institutions, associations, clubs or funds calculated to be for the benefit of or to advance the interest and well-being of the Company.

m. Employment: To employ and remunerate managers and other officers, employees and servants of the Company or any person or firm or company rendering services to the Company upon such terms as the Company may determine.

n. Expenses: To pay out of the funds of the Company all expenses of and incidental to the formation, registration, advertisement of the Company and the issue and subscription of the share or loan capital including brokerage and/or commission for obtaining applications for or placing or guaranteeing the placing of shares or any debentures, debenture-stock and other securities of the Company and also all expenses relating to the issue of any circular or notice and the printing, stamping, circulating of proxies and forms to be filled up by the members of the Company.

o. Foreign Branches: To open branches, register the Company and to undertake all or any of the business of the Company, in any part of the world and to become a member of various associations and trade bodies whether in Pakistan or abroad.

p. Government Approvals and Consents: To apply for and obtain necessary consents, permissions, and licenses, rights, privileges and concessions from any Government, State, Municipal, Local and other authorities or persons for enabling the Company to carry on its objects and to oppose any proceeding or application which may seem directly or indirectly to prejudice the interests of the Company.

q. Import and Export: To import, export, sell, exchange, barter, pledge or otherwise deal in all goods, articles, merchandize, raw materials and products necessary for the business of the Company.

r. Insurance: To insure the property, assets, and employees of the Company in any manner deemed fit by the Company, and to create any reserve funds, sinking fund, insurance fund or any other special fund whether for depreciation or for repairing, insuring, improving, extending or maintaining any of the property of the Company or for any other purpose conducive to its objects but not to act as an insurance company.

s. Investment: To subscribe for, take or otherwise acquire and hold shares, debentures or securities of any other company having objects altogether or in part similar to those of the Company or carrying on any business capable of being conducted so as directly or indirectly to benefit the Company and to invest the moneys not immediately required for the business of the Company in, and to hold, sell and deal with the stocks, shares, bonds, debentures, debenture stocks, PTCs, TFCs, mutual fund certificates, NIT units, Modaraba certificates or certificates of investment obligations, notes and securities of any Government, Province, company, Corporation, Municipal or Local or other Body or Authority and to deal with the monies of the Company not immediately required for such purposes conducive to the interest of the Company and to vary investments from time to time but not to act as an investment company, or a brokerage house or managing agency.

t. Joint Venture/Partnership: To enter into a joint venture or a partnership or cooperation with any person or company or other legal entity, local or foreign, or otherwise assist any such person or company or legal entity in furtherance of its objects.

u. Lending: To advance money facilities to such persons or companies and on such terms as may seem expedient, and in particular to customers and others having dealings with the Company, and to guarantee the performance of any contract or obligation and the payment of money of or by any such persons or companies, and generally to give guarantees and indemnities but not to act as a finance or banking company.

v. Machinery: To import, rent, lease, buy, own, install machinery, goods, equipment, materials and spare parts or any other items required for or in connection with the business of the Company.

w. Other Business: To carry on any other business, whether agricultural, industrial, commercial, manufacturing, trading, marketing or distribution which may seem to the Company capable of being conveniently carried on in connection with the objects of the Company, calculated directly or indirectly to enhance the value of or render profitable any of the Company's property or rights and to acquire and undertake the whole or any part of the business, property and liabilities of any person or company carrying on or proposing to carry on any business which the Company is authorized to carry on, or possessed of property suitable for the purposes of the Company, or which can be carried on in conjunction therewith or which is capable of being conducted so as to directly or indirectly benefit the Company.

x. Patents/Trademarks: To apply for, purchase, protect, prolong, renew, or otherwise acquire any patents, brevetted invention (trademarks, designs), licenses, concessions, and the like, conferring any exclusive or non-exclusive or limited right to their use in furtherance of its objects.

y. Profits: To receive, declare and distribute profits and to capitalize such portion of the profits of the Company as are not distributed among shareholders of the Company in the form of dividends, and as the Directors of the Company may think fit, and to issue bonus shares, as fully paid up, in favour of the shareholders of the Company.

z. Registration/Fees: To file or register any document required to be filed or registered under law, and to pay any fees, charges, expenses, rents, taxes, duties and other dues payable in connection with its objects.

aa. Sale and Purchase: To accept, buy, sell, market, supply, distribute, transfer (including transfer of actionable claims) or deliver any and every kind of moveable property including commercial products and items for such price and subject to such terms, conditions and warranties as the Company may think fit.

bb. Sale of Company Assets: To sell, improve, manage, develop, exchange, lease, mortgage, enfranchise, dispose of or otherwise deal with, all or any part of the property, assets or undertaking of the Company for such consideration as the Company may think fit.

cc. Security: To accept or give security, including but not limited to promissory notes, indemnity bonds, guarantees, assignments, receipts, bailment, pledges, hypothecations, liens, mortgages and charges, against the credit extended or moneys borrowed in connection with its objects.

dd. Settlement of Disputes: To settle disputes by negotiation, mediation, conciliation, arbitration, litigation or other means and to enter into compromise with creditors, members and any other persons in respect of any difference or dispute with them.

ee. Technology/Know-How: To develop and/or transfer technology and to acquire or pass on technical know-how incidental or conducive to the attainment of its objects and to conduct research and development.

ff. Training: To train personnel and workers, both in Pakistan and abroad to obtain technical proficiency in various specialties connected with its objects.

gg. Trust: To undertake and execute any trust or trusts which the Company may deem to be desirable, expedient or necessary for its employees and to act as trustees of any deeds constituting or securing any debentures, debenture stock, or other securities or obligations and to undertake and execute any other trust and also to undertake the office of executor, administrator and to keep for any company, Government, authority or body, any register relating to any stocks, funds, shares or securities, to undertake any duties in relation to the registration of transfers, the issue of certificates or otherwise.

hh. General Power: To do all such other lawful things as may be deemed incidental or conducive to the attainment of the main objects or any of them in any part of the world, and as principals, agents, contractors, trustees or otherwise, and by or through trustees, agents or otherwise and either alone or in conjunction with others.

18. It is hereby declared that:-

a) The objects specified in each of the paragraph of this clause shall be regarded as independent objects, and accordingly shall in no way be limited or restricted (except where otherwise expressed in such paragraphs) by reference to or inference from the terms of any other paragraph or the name of the Company, but may be carried out in as full and ample a manner and construed in as wide a sense as if each of the said paragraphs defined the objects of a separate and distinct company;

b) Notwithstanding anything contained in the foregoing object clauses of this Memorandum of Association, nothing herein shall be construed as empowering the Company to undertake or indulge in the business of banking, finance, investment or insurance, managing agency, brokerage house, directly or indirectly, as restricted under law or any unlawful operations.

c) Notwithstanding anything stated in any object clause, the Company shall obtain such other approval or license from the competent authority, as may be required by any law.

IV. LIABILITY

The liability of the members is limited.

V. CAPITAL

The authorized share capital of the Company is Rs. 100,000,000 (Rupees One Hundred Million Only) divided into 10,000,000 ordinary shares of Rs. 10/- (Rupees Ten) each with the power to increase or reduce the capital, to divide the shares for time being into several classes and subject to Section 90 of the Ordinance, to attach thereto such rights, privileges and conditions in such manner as many, for the time being provided by the Articles of Association of the Company. The Company further reserves to itself the right to increase authorized capital in accordance with the regulations for the time being in force, and in accordance with law.

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

Name and Surname in Full	Father's/ Husband name in Full	Nationality	Occupation	CNIC Number	Residential address in full	No. of Shares	Signature
Chaudhry Khan M. Ashraf	Muhammad Zaka Ashraf	Pakistani	Business	31202-1302899-3	H. No. 19 Zafar Road Lahore Cantt	2,300,000	
Ubeda Ashraf	Usman Akram	Pakistani	Business	35201-6939192-0	H. No. 19 Zafar Road Lahore Cantt	500,000	
Fiza Ashraf	Muhammad Zaka Ashraf	Pakistani	Business	31202-6738953-6	H. No. 19 Zafar Road Lahore Cantt	500,000	
Chaudhry Muhammad Zaka Ashraf	Chaudhry Muhammad Ashraf	Pakistani	Business	31202-8858092-9	H. No. 19 Zafar Road Lahore Cantt	600,000	
Naushaba Zaka Ashraf	Ch Muhammad Zaka Ashraf	Pakistani	Business	31202-7764863-4	H. No. 19 Zafar Road Lahore Cantt	600,000	
Zunaira Atif	Atif Yaseen	Pakistani	Business	33100-2714321-2	H. No. 03, Civil Lines, Race Course Road, Faisalabad	250,000	
Sana Ashraf	Muhammad Ameer Sultan	Pakistani	Business	31202-1245633-2	H. No. 17 Zafar Road Lahore Cantt	250,000	

Total Shares Taken: 5,000,000 (Five Million)

Dated this **03 November 2016**

Witness to the above Signatures:

Signature: ____________________

Full Name: National Institutional Facilitation Technologies (Pvt) Ltd

Occupation: NIFT

Full Address: 5th Floor, AWT Plaza, I.I. Chundrigar Road, Karachi.

CERTIFIED TO BE TRUE COPY

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE

CERTIFIED TRUE COPY OF ARTICLES OF ASSOCIATION

THE COMPANIES ORDINANCE, 1984

(Company Limited by Shares)

ARTICLES OF ASSOCIATION

OF

BAHAWALPUR ENERGY LIMITED

PRELIMINARY

1. **TABLE "A" NOT TO APPLY**

The regulations in Table 'A' in the First Schedule to the Companies Ordinance, 1984 shall not apply to the Company except so far as the same are reproduced herein.

2. **DEFINITIONS**

Unless the context or the subject matter otherwise requires, the terms used in these articles shall have the meanings set out below:

(a) **"Articles"** mean these Articles of Association as originally framed or as from time to time altered by special resolution.

(b) **"Board"** means the group of directors in a meeting duly called and constituted or, as the case may be, the directors assembled at a Board.

(c) **"Book and paper"**, "book or paper" or "books of account" mean accounts, deeds, vouchers, writings and documents, maintained on paper or computer network, floppy, diskette, magnetic cartridge tape, CD-Rom or any other computer readable media;

(d) **"Chairman"** means the Chairman of the Board of Directors of the Company;

(e) **"Chief Executive"** means an individual who subject to the control and directions of the Directors, is entrusted with the whole, or substantially the whole, of the powers of the management of the affairs of the Company and includes a Director or any other person occupying the position of a Chief Executive, by whatever name called, and whether under a contract of service or otherwise."

(f) **"Company"** means **Bahawalpur Energy Limited.**

(g) **"Commission"** means the Securities and Exchange Commission of Pakistan established under Section 3 of the Securities and Exchange Commission of Pakistan Act, 1997.

(h) **"Directors"** mean the directors of the Company including alternate directors appointed and elected from time pursuant to Companies Ordinance, 1984.

(i) **"Dividend"** includes cash dividend, dividend in species and bonus shares.

(j) **"In Person"** includes attendance and/or voting at a meeting, personally or by video or telephone-conference or other facility whereby all the participants of the meeting can hear and / or see each other unless expressly stated otherwise by the directors.

(k) **"Member"** means a person whose name is for the time being entered in the register of members by virtue of his holding by allotment or otherwise any share, scrip or other security which gives him a voting right in the company including an accountholder of central depository.

(l) **"Memorandum"** means the Memorandum of Association of the Company as originally framed or as from time to time altered in accordance with the Companies Ordinance, 1984.

(m) **"Month"** means calendar month according to the English calendar.

(n) **"Office"** means the registered office for the time being of the company.

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

(p) **"Ordinary Resolution"** means a resolution passed at a general meeting when the votes cast (whether on a show of hands or on poll, as the case may be) in favour of the resolution by members present in person or by proxy exceeds the votes if any cast against the resolution.

(q) **"Proxy"** includes an attorney duly constituted under a power of attorney.

(r) **"Record"** includes, in addition to a written or printed form, any disc, tape, sound-track, film or other device in which sounds and / or other data is embodied so as to be capable (with or without the aid of some other instrument or machine) of being reproduced there from in audible, legible or visual form.

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

(t) **"Registrar"** means a Registrar, defined in Section 2 (1) (31) of the Ordinance performing the duty of registration of companies under the Ordinance.

(u) **"Regulations"** mean the rules of governance of the Company made by the board from time to time.

(v) **"Seal"** means the common or official seal of the Company.

(w) **"Section"** means Section of the Ordinance.

(x) **"Share"** means share in the share capital of the company.

(y) **"Sign" and "Signature"** unless otherwise provided in these articles, include respectively lithography, printing facsimile, "advanced electronic signature" which is capable of establishing the authenticity and integrity of an electronic document, as defined by Section 2(e) of the Electronic Transactions Ordinance, and names impressed with a rubber or other kind of stamp.

(z) **"Special Resolution"** means the special resolution of the Company as defined in Section 2 (1) (36) of the Ordinance.

INTERPRETATION

3. In these articles, unless the context otherwise requires:

(a) the singular includes the plural and vice versa and words denoting any gender shall include all genders;

(b) references to any Act, Ordinance, Legislation, Rules or regulations or any provision of the same shall be a reference to that Act, Ordinance, Legislation, rules or regulations or provisions, as amended, re-promulgated or superseded from time to time;

(c) the terms "include" or "Including" shall mean include or including without limitation;

(d) expression referring to writing shall, unless the contrary intention appears, be construed as including references to printing, lithography, photography, and other modes of representing or reproducing words in a visible form, including but not limited to, electronic transmission such as facsimile, and electronic mail or any other electronic process, as prescribed by section 3 of the Electronic Transactions Ordinance.;

(e) words importing persons shall include bodies corporate; and

(f) words importing singular number include the plural number or vice versa;

(g) words and expressions contained in these articles shall bear the same meaning as in the Ordinance.

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

PUBLIC LIMITED COMPANY

4. The Company is a public limited company within the meanings of Section 2 (1) (30) of the Companies Ordinance, 1984. The minimum subscription upon which the Directors may proceed to allotment as defined in Section 68 of the Ordinance is fixed at Rs. 50,000,000/-

BUSINESS

5. DIRECTORS MAY UNDERTAKE ANY BUSINESS

The business of the Company shall include the several objects expressed in its Memorandum of Association or any of them. All branches or kind of business which the Company is either expressly or by implication authorised to undertake may be undertaken by the directors at such time or times as they shall think fit, and further may be allowed by them to be in abeyance, whether such branch or kind of business may have been actually commenced or not, so long as the directors may deem it expedient not to commence or proceed with such branch or kind of business.

SHARES

7. POWER TO ISSUE SHARES OF DIFFERENT CLASSES AND KINDS

Subject to Section 90 of the Ordinance and Rules framed there under and without prejudice to any special rights previously conferred on the holders of any existing shares or class of shares, any share in the Company may be issued with different rights, restrictions and privileges, including but not limited to the following as may be approved by the Company by special resolution

(1) different voting rights; voting rights disproportionate to the paid-up value of share held; voting rights for specific purposes only; or no voting rights at all;

(2) different rights for entitlement of dividend, right shares or bonus shares or entitlement to receive the notices and to attend the general meetings;

(3) rights and privileges for indefinite period, for a limited specified period or for such periods as may from time to time be determined by the Company; and

(4) different manner and mode of redemption, including redemption in accordance with the provisions of these articles, including but not limited to, by way of conversion into shares with such rights and privileges as determined by the Company in the manner and mode provided in these articles.

8. **POWER TO ISSUE REDEEMABLE CAPITAL**

Subject to the provisions of the Ordinance and any rules in that regard made under the Ordinance, the Company may issue shares which are to be redeemed or any other redeemable security, on such terms and in such manner as may be provided in the Ordinance and rules.

9. **POWER TO ISSUE SHARES AT PAR, PREMIUM OR DISCOUNT**

Subject to provisions of the Ordinance and these Articles, the shares in the share capital of the Company may be issued and allotted as the directors shall determine and at such times and in such manner as the directors think fit, either at par or at a premium or subject to Section 84 of the Ordinance at a discount.

10. **ONLY FULLY PAID SHARES TO BE ISSUED**

The shares in the capital of the Company shall always be issued as fully paid shares and no shares shall be issued as partly paid shares.

11. **ISSUE OF SHARES FOR CONSIDERATION OTHERWISE THAN IN CASH**

The directors may allot and issue shares in the capital of the Company as payment or part payment for any asset or property sold or transferred, or for services rendered, to the Company in the ordinary course of its business, and shares so allotted shall be issued as and shall be deemed to be fully paid shares subject to the fulfilment of requirement of Section 73 of the Ordinance and applicable rules.

12. **ALLOTMENT OF SHARES**

The board shall, as regards any allotment of shares, duly comply with such provisions of the Ordinance and rules as may be applicable.

13. **PURCHASE OF COMPANY'S SHARES**

Except as permitted by the Ordinance or any other rules in that regard made under the Ordinance, no part of the funds of the Company shall be employed in the purchase of its own shares or in giving, whether directly or indirectly and whether by means of a loan, guarantee, security or otherwise, any financial assistance for the purpose of or in connection with a purchase made or to be made by any person of any shares in the Company.

14. **TRUST NOT TO BE RECOGNIZED**

Save as herein otherwise provided or as permitted by law, the Company shall be entitled to treat the registered holder of any share as the absolute owner thereof and accordingly shall not, except as ordered by a court of competent jurisdiction or as required by statute, be bound by or be compelled in any way to recognize (even when having notice thereof) any *benami*, equitable, contingent, future, partial or other claim or right to or interest in such share on the part of any other person.

15. WHO MAY BE REGISTERED AS MEMBER

Shares may be registered in the name of individuals, any limited company or other corporate body but not in the name of minors. Not more than four (4) persons shall be registered as joint-holders of any share.

16. JOINT MEMBERS

If any share or shares stand in the name of two or more persons, the person first named in the register shall, as regards receipt of dividend or bonus or service of notices and all or any other matters connected with the Company except voting at the meeting and the transfer of shares, be deemed the sole holder of such shares.

17. COMMISSION FOR PLACING SHARES, ETC.

The Company may at any time pay a commission to any person for subscribing or agreeing to subscribe (whether absolutely or conditionally) for any shares or debentures or redeemable capital of the Company or producing or agreeing to procure subscriptions (whether absolute or conditional) for any shares or debentures or redeemable capital of the Company. In case any commission shall be paid the Company shall comply with the provisions of Section 82 of the Ordinance. The Company may also pay expenses on any issue of shares or debentures or redeemable capital.

CERTIFICATES

18. SHARE CERTIFICATES TO BE ISSUED UNDER SIGNATURES AND SEAL

The Certificates of title to shares and duplicate thereof shall be issued under the seal of the Company and signed by two of the directors or by one such director and the secretary provided that such signatures may if necessary be printed lithographed or stamped subject to the approval of the directors.

19. TIME FOR ISSUE OF SHARES CERTIFICATES

The Company shall within ninety days after the allotment of any shares, debentures or debenture stock and within forty-five days after receipt by the Company of the application for transfer of any such shares, debentures or debenture stock complete and have ready for delivery the certificate of all shares, the debentures and the certificate of all debenture stock allotted or transferred, and unless sent by post or delivered to the person entitled thereto within the period aforesaid the Company shall immediately thereafter give notice to that person in the manner prescribed in these articles for the giving of notices to members that the certificate is ready for delivery.

20. ISSUE OF DUPLICATE SHARE CERTIFICATES

If a certificate of shares, debenture or debenture stock is proved to the satisfaction of the Company to have been lost or destroyed or, being defaced or mutilated or torn, is surrendered to the Company, and the Company is requested to issue a new certificate in replacement thereof, the Company shall, after making such enquiry as it may deem fit, advise the applicant within thirty days from the date of application the terms and conditions (as to indemnity and otherwise and as to payment of the actual expenses incurred on such enquiry as may be determined by the Board of Directors) on which the Company is prepared to issue a new certificate and a time for compliance therewith or of the reasons why the Company is unable to issue a new certificate, as the case may be, and in the former case if the applicant shall within the time allowed comply with the terms and conditions specified, the Company shall issue a new certificate to the applicant within forty five days from the date of application.

21. ISSUE OF CERTIFICATES TO JOINT HOLDERS

The Company shall not be bound to issue more than one certificate in respect of a share or shares held jointly by two or more persons and delivery of a certificate for a share to any one of joint holders shall be sufficient delivery to all.

TRANSFER AND TRANSMISSION

22. DIRECTORS MAY DECLINE TO REGISTER TRANSFER OF SHARES

The directors shall not refuse to register the transfer of fully paid shares unless the Instrument of Transfer is defective or invalid or is not duly stamped or accompanied by the certificate of the share(s) to which it relates or otherwise there are specific restrictions on the transferability of the shares imposed by the Commission or any Court. The directors may also decline to register the instrument of transfer if it is not accompanied by a certified copy of the computerized national identity card of the transferee. If the directors refuse to register a transfer of any shares they shall, within thirty (30) days from the date on which the Instrument of Transfer was lodged with the company, send to the transferee and the transferor the notice of refusal indicating the defect or invalidity; provided that the transferee shall be entitled, after removal of such defect or invalidity, to re-lodge the Instrument of Transfer with the Company.

23. FORM OF TRANSFER

The Instrument of Transfer of any share shall be in writing in the usual common form, or in the following form, or as near thereto as circumstances will admit:

"I/We .... of .... son/daughter/wife of being a national(s) of in consideration of the sum of Rupees .... only (Rs. ....) paid to me/us by ------------ of .... son/daughter/wife of being a national(s) of (hereinafter called the 'said transferee(s)') do hereby transfer to the said transferee(s) share(s) numbered standing in my/our name(s) in the books of **BAHAWALPUR ENERGY LIMITED**, to hold unto the said transferee(s) his/her/their executors, administrators and as signs, subject to the several conditions on which I/we hold the same at the time of execution hereof, and I/we the said transferee(s) do hereby agree to take the said share(s) subject to the conditions aforesaid.

As witness our hands the .... day of ....thousand and ....

Signed by the said transferor in the presence of	Transferor's signature .... Transferor's occupation ....
Witness	Witness ....
Occupation	Occupation ....
Address	Address ....
CNIC #............	CNIC #............
Signed by the said transferee in the presence of	Transferee's signature .... Transferee's occupation ....
Witness	Witness ....
Occupation	Occupation ....
Address	Address ....
CNIC #............	CNIC #............

24. INSTRUMENT OF TRANSFERS TO BE PRESERVED

All registered instruments of transfers shall be retained by the Company for a period of not less than 10 years, but any Instrument of Transfer which the directors may decline to register shall be returned to the person depositing the same.

25. TRANSFEROR TO REMAIN HOLDER OF SHARE(S)

The Instrument of Transfer of any share in the Company shall be duly stamped and executed both by the transferor and transferee, and the transferor shall be deemed to remain holder of the share(s) until the name of the transferee is entered in the register in respect thereof.

26. CLOSURE OF REGISTER(S)

On giving seven days previous notice by advertisement in some newspaper circulating in the areas specified in Section 151 of the Ordinance or as per requirement of the stock exchange(s) where the shares of the Company are listed, the transfer books and register(s) may be closed during such time as the directors think fit, not exceeding in the whole forty-five (45) days in each year, but not exceeding thirty days (30) at a time.

27. NOMINATION

Any Member may make and deposit with the Company a nomination in writing specifying one or more eligible person who or each of whom, in the event of death of the Member, may be entered in the Register as the holder of such number of shares specified in the nomination for such nominee or each such nominee of which the Member remains the registered holder at the date of his death. A person shall be eligible for nomination for the purposes of this Article only if he is a spouse, parent, brother, sister, or child of the Member nominating him and applicable relationship shall be specified in the nomination in respect of each nominee. A Member may at any time by notice in writing cancel, or by making and depositing with the Company another nomination before his death vary, any nomination already made by him pursuant to this Article. In the event of the death of a Member any person nominated by him in accordance with this Article may, on written application accompanied by the relative share certificates and evidence establishing the death of the Member, request the Company to register himself in place of the deceased Member as the holder of the number of shares for which the nomination in his favour had been made and deposited with the Company and if it shall appear to the Directors that it is proper so to do, the Directors may register the nominee as the holder of those shares in place of the deceased Member.

28. PERSONS ENTITLED ON DEATH OF MEMBER

In the case of the death of a Member who was a joint holder of shares, the survivor or survivors shall be the only person recognised by the Company as having any title to his interest in the shares. If the deceased Member was a sole holder of shares, the nomine or nominees of the deceased where a nomination is effective and legal personal representatives of the deceased where no such nomination has been made and deposited with the Company, shall be the only persons recognised by the Company as having any title to his interest in the shares.

29. PERSON ENTITLED ON DEATH OR INSOLVENCY MAY ELECT TO BE REGISTERED OR TO TRANSFER

Any person becoming entitled to a share in consequence of the death or insolvency of a Member may upon such evidence being produce as may from time to time properly be required by the Directors and subject as hereinafter provided, elect either to be registered himself as the holder of the share or instead of being registered himself to make such transfer of the shares as the deceased or insolvent person could have made, but the Directors shall, in either case, have the same right to decline or suspend registration as they would have had in the case of a transfer of the shares by that Member before his death or insolvency as the case may be.

30. EFFECT OF ELECTION

If the person so becoming entitled shall elect to be registered himself, he shall deliver or send to the company a notice in writing signed by him stating that he so elects. If he shall elect to have another person registered he shall testify his election by executing to that a person a transfer of the share. All the limitations, restrictions and provisions of these Articles relating to the right to transfer and the registration of transfers of shares shall be applicable to any such notice or transfer as aforesaid as if the death or insolvency of the Member had not occurred and the notice or transfer were a notice or transfer signed by that Member.

31. RIGHT OF PERSON ENTITLED BY TRANSMISSION

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

CAPITAL

32. INCREASE, CONSOLIDATION, SUB-DIVISION AND CANCELLATION

The Company may by ordinary resolution and subject to compliance with the requirements of Section 92 of the Ordinance

(a) increase the authorized share capital by such sum, to be divided into shares of such amount, as the resolution shall prescribe.

(b) consolidate and divide its share capital into shares of larger amount than its existing shares;

(c) by sub-division of its existing shares or any of them, divide the whole or any part of its share capital into shares of smaller amount than is fixed by the Memorandum of Association;

(d) cancel any shares which, at the date of the passing of the resolution, have not been taken or agreed to be taken by any person.

33. FURTHER ISSUE OF CAPITAL

The directors may from time to time increase the issued share capital by such sum as they think fit. Except as otherwise permitted by Section 86 of the Ordinance, and subject to any special rights or privileges for the time being attached to any issued shares, all shares intended to be issued by the directors shall, before issue, be offered to the members strictly in proportion to the amount of the issued shares held by each member (Irrespective of class); provided that fractional shares shall not be offered and all fractions less than a share shall be consolidated and disposed of by the Company and the proceeds from such disposition shall be paid to such of the entitled members as may have accepted such offer. Such offer shall be made by notice specifying the number of shares offered, and limiting a time within which the offer, if not accepted, will be deemed to be declined, and after the expiration of that time, or on the receipt of an intimation from the person to whom the offer is made that he declines to accept the shares offered, the directors may dispose of the same in such manner as they think fit. In respect of each such offer of shares the directors shall comply with the provisions of Section 86 of the Ordinance.

34. **NEW SHARES TO RANK WITH EXISTING CAPITAL**

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

35. **REDUCTION OF CAPITAL**

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

36. **SHARE PREMIUM ACCOUNT**

The share premium account maintained pursuant to section 83(1) of the Ordinance may, be applied by the company:

(a) in writing off the preliminary expenses of the company;

(b) in writing off the expenses of, or the commission paid or discount allowed on, any issue of shares or debentures of the company;

(c) in providing for the premium payable on the redemption to any redeemable preference shares or debentures of the company; or

(d) in paying up un-issued shares of the company to be issued as fully paid bonus shares.

VARIATION OF SHAREHOLDERS RIGHTS

37. **MODIFICATION OF RIGHTS OF DIFFERENT CLASSES OF SHARES**

Whenever the capital is divided into different classes of shares, all or any of the rights and privileges attached to each class may, subject to the provisions of section 108 of the Ordinance, be modified, commuted, affected, abrogated or dealt with by agreement between the Company and any person purporting to contract on behalf of that class provided such agreement is (a) ratified in writing by the holders of at least three-fourths in nominal value of the issued shares of the class or (b) confirmed by a special resolution passed at an extraordinary general meeting of the holders of shares of that class and all the provisions hereinafter contained as to general meetings, shall, mutatis mutandis, apply to every such meeting.

MEETINGS

38. **ANNUAL GENERAL MEETING**

Except as may be allowed under Section 158(1) of the Ordinance, the Company shall hold a general meeting once at least in every calendar year within a period of four months following the close of its financial year at such time as may be determined by the directors, provided that no greater interval than fifteen months shall be allowed to elapse between two such general meetings. The Company may, for any special reason and with permission of the Commission, extend the time within which any annual general meeting, not being the first such meeting, shall be held.

39. **WHERE TO HOLD ANNUAL GENERAL MEETING**

The Company shall hold its annual general meeting in the town in which the registered office is situate; provided that, it may, for any special reason and with permission of the Commission, hold the said meeting at any other place. Save as aforesaid, the Company may hold its general meeting at two (2) or more venues using any technology that gives the members as a whole a reasonable opportunity to participate in the meetings.

40. EXTRAORDINAY GENERAL MEETINGS

All general meetings of the Company, other than annual general meeting, shall be called extraordinary general meetings.

41. CONVENING OF EXTRAORDINARY GENERAL MEETINGS

The directors may, whenever they think fit, and they shall, on the requisition of the holders of not less than one-tenth of the issued capital of the Company, forthwith proceed to convene an extraordinary general meeting of the Company. If at any time there are not within Pakistan sufficient directors capable of acting to form a quorum, any director of the Company may call an extraordinary general meeting in the same manner as nearly as possible as that in which meetings may be called by the directors, and in the case of such requisition the following provisions shall have effect:

(i) The requisition must state the objects of the meeting and must be signed by the requisitionists and deposited at the office and may consist of several documents in like form each signed by one or more requisitionists.

(ii) If the directors do not proceed within twenty-one days from the date of the requisition being so deposited to cause a meeting to be called, the requisitionists or a majority of them in value may themselves convene the meeting, but any meeting so convened shall not be held after three months from the date of the deposit.

(iii) Any meeting convened under this article by the requisitionists shall be convened in the same manner as nearly as possible as that in which meetings are to be convened by the directors but shall be held at the office.

(iv) A requisition by joint-holders of shares must be signed by all such holders.

42. NOTICE OF MEETINGS

(1) Notice of a general meeting shall be sent in the manner hereinafter mentioned at least twenty one (21) days before the date on which the meeting is to be convened to all such persons as are under these articles or the Ordinance entitled to receive such notices from the Company and shall specify the place and the day and hour of the meeting and the nature of the business to be transacted thereat.

(2) In the case of an emergency affecting the business of the Company, an extraordinary general meeting may be convened by such shorter notice than that specified above as the Registrar may authorise.

(1) Where any special business, that is to say, business other than consideration of the accounts, balance sheet and the reports of the directors and auditors, the declaration of dividend, the appointment and fixation of the remuneration of auditors and, where the notice convening the meeting provides for the election of directors, the election of directors (all such matters being herein referred to as ordinary business) is to be transacted at a general meeting, there shall be annexed to the notice of such meeting a statement setting out all such facts as may be material for the consideration of such business including the nature and extent of the interest (whether direct or indirect) of any director, and where the item of business involves approval of any document, the time and place appointed for inspection thereof, and to the extent applicable such

a statement shall be annexed to the notice also in the case of ordinary business to be transacted at the meeting.

(2) Where a resolution is intended to be proposed for consideration at a general meeting in some special or particular form, a copy thereof shall be annexed to the notice convening such meeting.

(3) If a special resolution is intended to be passed at a general meeting, the notice convening that meeting shall specify the intention to propose the resolution as a special resolution.

(4) A notice for a general meeting at which an election of directors is to take place shall state the number of directors to be elected at that meeting and the names of the retiring directors.

(5) The notice of every general meeting shall prominently specify that a proxy may be appointed who shall have the right to attend, demand or join in demanding a poll and vote on a poll and speak at the meeting in the place of the member appointing him and shall be accompanied by a form of proxy acceptable to the Company.

(8) The Company shall comply with the provisions of section 160(1) and section 50 of the Ordinance with regard to giving notices of general meetings.

43. ACCIDENTAL OMISSION TO GIVE NOTICE

The accidental omission to give any such notice to or the non-receipt of notice by, any of the members shall not invalidate the proceedings at any such meeting.

PROCEEDINGS AT GENERAL MEETINGS

44. QUORUM

No business shall be transacted at any general meeting unless a quorum of members is present at the time when the meeting proceeds to business. Not less than two (2) members present in person representing at least twenty five percent (25%) of the total voting power either of their own account or as proxies shall be a quorum.

45. CHAIRMAN OF GENERAL MEETINGS

The Chairman of the board of directors shall preside as Chairman at every general meeting of the Company, or if there is no such Chairman, or if he shall not be present in person within fifteen minutes after the time appointed for the holding of the meeting or is unwilling to act, the Chief Executive shall preside as Chairman of the meeting, or if the Chief Executive is absent or unwilling to act, any one of the directors present may be elected to be Chairman of the meeting, or if no director is present, or if all the directors present decline to take the chair, the members present in person shall choose one of their member to be Chairman of the meeting.

46. EFFECT OF QUORUM BEING NOT PRESENT

If within half-an-hour from the time appointed for the meeting, a quorum is not present, the meeting if convened upon such requisition as aforesaid shall be dissolved, but in any other case it shall stand adjourned to the same day in the next week at the same time and place, and if at such adjourned meeting a quorum is not present within half an hour from the time appointed for it, the members present being not less than Two shall be a quorum.

47. ADJOURNMENT OF MEETINGS

The Chairman 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 unfinished at the meeting from which the adjournment took place. When a meeting is adjourned for more than seven days, notice of the adjourned meeting shall be given as in the case of an original meeting. Save as aforesaid it shall not be necessary to give any notice of an adjournment or of the business to be transacted at an adjourned meeting.

48. CASTING VOTE OF CHAIRMAN

In the case of an equality of votes the Chairman shall, both on a show of hands and at the poll have a casting vote in addition to the vote or votes to which he may be entitled as a member.

49. RESOLUTION TO BE VOTED BY SHOW OF HANDS OR BY POLL

(1) At any general meeting a resolution put to the vote of the meeting shall be decided on a show of hands, unless a poll is (before or on the declaration of the result of the show of hands) demanded in accordance with paragraph (2) of this article, and unless a poll is so demanded, a declaration by the Chairman of the meeting that a resolution has, on a show of hands, been carried, or carried unanimously, or by a particular majority, or lost, and an entry to that effect in the book or electronic record of the proceeding of the Company shall be conclusive evidence of the fact, without proof of the number or proportion of the votes recorded in favour of, or against, the resolution.

(2) A Poll may be ordered to be taken by the Chairman of the meeting of his own motion and shall be ordered to be taken by him on a demand made by the following persons;

(a) Five members having the right to vote on the resolution and present in person or by proxy; or

(b) Any member or members present in person or by proxy having not less than one-tenth of the total voting power in respect of the resolution.

50. MANNER OF TAKING POLL

If a poll is demanded, as aforesaid, it shall be taken (subject to Section 168 of the Ordinance) in such manner and at such time and place as the Chairman of the meeting directs, and either at once or after an interval or adjournment of not more than fourteen days from the day on which the poll is demanded, and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was held. The demand for a poll may be withdrawn at any time by the person or persons who made the demand. In case of any dispute as to the admission or rejection of a vote, the Chairman of the meeting shall determine the same, and such determination made in good faith shall be final and conclusive. On a Poll the chairman or his nominee and representative of the members demanding the poll shall scrutinize the votes given on the Poll and the result shall be announced by the Chairman subject to provision of the Ordinance and these articles, the Chairman shall have power to regulate the manner in which a Poll shall be taken.

51. TIME FOR TAKING POLL

Any poll duly demanded on the election of a Chairman of a meeting or on a question of adjournment shall be taken forthwith at the meeting and without adjournment. A poll demanded on any other question shall be taken at such time, not being more than 14 days from the day on which the poll is demanded as the Chairman of the meeting directs.

52. MEETING TO CONTINUE

The demand of a poll shall not prevent the continuance of a meeting for the transaction of any business other than the question on which a poll has been demanded.

VOTES OF MEMBERS

53. RIGHT TO VOTE

Subject to Section 160 and any rights or restrictions for the time being attached to any class or classes of shares, every member present in person (where all the participants of a general meeting can see each other) shall have votes proportionate to the paid up value of the shares or other securities carrying voting rights held by him according to the entitlement of the class of such shares or securities, as the case may be provided that the provisions of Section 178 shall apply in the case of the election of directors.

54. VOTING BY SHOW OF HANDS, POLL AND FOR ELECTION /REMOVAL OF DIRECTORS

On a show of hands, every member present in person shall have one vote and upon a poll every member present in person or by proxy shall have one vote in respect of each share held by him. Provided always that in the case of an election or removal of a director, the provisions of Section 178 shall apply.

55. VOTING ON POLL

On a poll a member entitled to more than one vote need not, if he votes, use all his votes or cast all the votes he uses in the same way.

56. VOTING BY CORPORATIONS AND COMPANIES

Any company or other corporation which is a member of the Company may by resolution of its directors or other governing body authorise such person as it thinks fit to act as its representative at any meeting of the Company or of any class of members of the company, and the person so authorised shall be entitled to exercise the same powers on behalf of the company or corporation which he represents as that company or corporation could exercise if it were an individual member of the Company, present in person. The production before or at the meeting of a copy of such resolution purporting to be signed by a director or the secretary of such company or corporation and certified by him as being a true copy of the resolution shall be accepted by the Company as sufficient evidence of the validity of the appointment of such representative.

57. RIGHT TO VOTE

Any person entitled under article 34 to any shares may vote at any general meeting in respect thereof in the same manner as if he were the registered holder of such shares, provided that forty-eight hours at least before the time of holding the meeting or adjourned meeting, as the case may be, at which he proposes to vote he shall satisfy the directors of his right to such shares, or the directors shall have previously admitted his right to vote at such meeting in respect thereof.

58. VOTING BY JOINT HOLDERS

Where there are jointly registered holders of any share, any one of such persons may vote at any meeting either in person or by proxy in respect of such share as if he were solely entitled thereto; and if more than one of such joint-holders be present at any meeting, either in person or by proxy, that one of the said persons so present whose name stands first in the register in respect of such share shall alone be entitled to vote in respect thereof. Several executors or administrators of a deceased member in whose name any share stands shall for the purposes of this article be deemed joint holders thereof.

59. VOTE MAY BE GIVEN IN PERSON OR BY PROXY ON POLL

On a poll votes may be given either in person (including without limitation an authorized representative of a company or corporation) or by proxy.

60. **OBJECTIONS ON VOTING**

No objection shall be raised to the qualification of any voter except at the meeting or adjourned meeting at which the vote objected to is given or tendered, and every vote not disallowed at such meeting shall be valid for all purposes. Any such objection made in due time shall be referred to the Chairman of the meeting, whose decision shall be final and conclusive.

61. **PROXY TO BE IN WRITING**

The instrument appointing a proxy shall be in writing under the hand of the appointer or of his attorney duly authorised in writing or if such appointer is a corporation under its common seal or signed by an officer or an attorney duly authorised by. No person shall be appointed a proxy who is not a member of the Company.

62. **INSTRUMENT APPOINTING PROXIES TO BE DEPOSITED**

The instrument appointing a proxy and the power of attorney or other authority (if any) under which it is signed, or a notarially certified copy of that power or authority, shall be deposited at the office not less than forty-eight 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.

63. **REVOCATION OF PROXY**

A vote given in accordance with the terms of an instrument appointing a proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the instrument or transfer of the share in respect of which the vote is given, provided no intimation in writing of the death, insanity, revocation or transfer of the share shall have been received at the office before the meeting. Provided nevertheless that the Chairman of any meeting shall be entitled to require such evidence as he may in his discretion think fit of the due execution of an instrument of proxy and that the same has not been revoked.

64. **FORM OF PROXY**

Every instrument appointing a proxy shall, as nearly as circumstances will admit, be in the following form or in the form set out in Regulation 39 of Table A of the First Schedule to the Ordinance and shall be retained by the Company:

BAHAWALPUR ENERGY LIMITED

I, ________________________ of ________________________, being a member of **Bahawalpur Energy Limited**, hereby appoint ____________________ of ___________ (or failing him ______________ of ________________________ or failing him _ of ________________) as my proxy in my absence to attend and vote for me and on my behalf at the (Annual or Extraordinary, as the case may be) General Meeting of the Company to be held on the ___ day of ________________ and at any adjournment thereof.

As witness my hand this _____ day of _______________.

Signed by the said
In the presence of

DIRECTORS

65. MINIMUM NUMBER OF ELECTED DIRECTORS

The Company shall have not less than three (3) directors to be elected in a general meeting in the manner provided in Section 178 of the Companies Ordinance. The following are the names of first directors.

1. Chaudhry Khan M. Ashraf
2. Ubeda Ashraf
3. Fiza Ashraf

66. DIRECTORS TO FIX NUMBER OF ELECTED DIRECTORS

Subject to Article 72 and the provisions of the Ordinance, the directors shall fix the number of elected directors 35 days before the convening of the general meeting at which the directors are to be elected. The number of elected directors so fixed by the directors shall not be changed except with the prior approval of the Company in general meeting.

ALTERNATE DIRECTORS

67. APPOINTMENT OF ALTERNATE DIRECTORS

When any director intends to be, or is living outside Pakistan or otherwise he may with the approval of the directors appoint any person to be his alternate director, and such alternate director during the absence of the appointer from Pakistan, shall be entitled to receive notice of and to attend and vote at meeting of directors and shall be subject to and entitled to the provisions contained in these articles with reference to directors and may exercise and perform all such powers, directions and duties as his appointer could have exercised or performed including the power of appointing another alternate director. Such appointment shall be recorded in the directors' minute book. A director may at any time by notice in writing to the Company remove an alternate director appointed by him. The alternate director shall cease to be such provided that if any director retires but is re-elected at the meeting at which such retirement took effect any appointment made by him pursuant to this article which was in force immediately prior to this retirement and re-election and which has not otherwise ceased to be effectively shall continue to operate after his re-election as if he had not so retired. All appointments and removals of alternate directors shall be effected by writing under the hand of the director making or revoking such appointment and left at the office. For the purpose of assessing a quorum, an alternate director shall be deemed to be a director. An alternate director may resign as such upon giving thirty (30) days prior notice to the board to this effect.

68. RIGHT OF ALTERNATE DIRECTORS TO RECEIVE NOTICES ETC

An alternate director shall, in the absence of a direction to the contrary in the instrument appointing him, be entitled to notice of general meetings of the Company on behalf of his appointer.

CHIEF EXECUTIVE

69. APPOINTMENT OF CHIEF EXECUTIVE

The Company shall have an office of Chief Executive which shall be filled from time to time by the directors who may appoint a director or (subject to Section 201 of the Ordinance) any other person to be the Chief Executive of the Company for a period not exceeding three years and on such terms and conditions as the directors may think fit, and such appointment shall be made within fourteen days from the date on which the office of Chief Executive falls vacant. If the Chief Executive at any time is not already a director he shall be deemed to be a director of the Company notwithstanding that the number of directors shall thereby be increased and he shall be entitled to all the rights and privileges and shall be subject to all liabilities of the office of director. Upon the expiry of his period of office, a Chief Executive shall be eligible for re-appointment. The Chief Executive may be removed from office in accordance with the provisions of Section 202 of the Ordinance notwithstanding anything contained in these articles or in any agreement between the Company and the Chief Executive.

70. **REMUNERATION OF CHIEF EXECUTIVE**

A Chief Executive of the Company shall receive such remuneration as the directors may determine.

71. **POWERS OF CHIEF EXECUTIVE**

The directors may from time to time entrust to and confer upon the Chief Executive for the time being such of the powers exercisable under these articles by the directors as they may think fit, and may confer such powers for such time, and to be exercised for such objects and purposes, and upon such terms and conditions, and with such restrictions as they think expedient; and they may confer such powers, either collaterally with, or to the exclusion of, and in substitution for all or any of the powers of the directors in that behalf; and may from time to time revoke, withdraw, alter or vary all or any of such powers. Directors may also appoint the Chief Executive as general attorney of the company and execute a power of attorney in his favour.

REMUNERATION OF DIRECTORS

72. **REMUNERATION FOR EXTRA SERVICES**

Any director who serves on any committee or who devotes special attention to the business of the Company, or who otherwise performs services which in the opinion of the directors are outside the scope of the ordinary duties of a director, may be paid such extra remuneration as the directors may determine from time to time. The remuneration of a director for attending meetings of the board shall from time to time be determined by the directors.

73. **EXPENSES OF MEETINGS**

Each director of the Company may, in addition to any remuneration receivable by him, be reimbursed his reasonable travelling and hotel expenses incurred in attending meetings of the directors.

74. **DIRECTOR TO BE MEMBER**

Save as provided in Section 187 (1) (h) of the Ordinance, no person shall be appointed as a director of the company unless he is a member of the company.

75. **DIRECTORS MAY ACT NOTWITHSTANDING ANY VACANCY**

The continuing directors may act notwithstanding any vacancy in their body so long as their number is not reduced below the number fixed by or pursuant to these articles as the necessary quorum of directors.

76. **VACATION OF OFFICE OF DIRECTOR**

The office of a director shall ipso facto be vacated if:

(a) he ceased to hold the share qualification, if any, necessary for his appointment; or

(b) he is found to be a unsound mind by a court of competent jurisdiction; or

(c) he is adjudged an solvent; or has applied to be adjudicated as an insolvent and his application is pending or is an un discharged insolvent; or

(d) he has been convicted by a court of law for an offence involving moral turpitude;

(e) he or any firm of which he is a partner or any private company of which he is a director without the sanction of the Company in general meeting accepts or holds any office of profit under the company other than that of a chief executive or legal or technical adviser or a banker in contravention of the provisions of section 188 (i) (c) of the Ordinance;

(f) he absents himself from three consecutive meetings of the directors or from all meetings of the directors for a continuous period of three months, whichever is the longer, without leave of absence from the board of directors; or

(g) he or any firm of which he is a partner or any private company of which he is a director accepts a loan or guarantee from the Company in contravention of section 195 of the Ordinance; or

(i) by notice in writing to the Company he resigns his office; or

(j) he is removed from office by resolution of the Company in general meeting in accordance with section 181 of the Ordinance;

(k) his appointment is withdrawn by the Authority nominating him as director;

77. INTEREST OF DIRECTORS

Subject to authorisation being given by the directors in accordance with section 196(2)(g) of the Ordinance, a director shall not be disqualified from contracting with the Company either as vendor, purchaser or otherwise, nor shall any such contract or arrangement entered into by or on behalf of the Company with any company or partnership of or in which any director of the Company shall be a member or otherwise interested, be avoided, nor shall any such director so contracting or being such member or so interested be liable to account to the Company for any profit realised by any such contract or arrangement by reason of such director holding that office or of the fiduciary relationship so established. A director who, or whose spouse or minor child, is in any way, whether directly or indirectly, concerned or interested in any contract or arrangement or proposed contract or arrangement with the Company shall disclose the nature of such concern or interest in accordance with section 214 of the Ordinance that is to say:

(a) in the case of a contract or arrangement to be entered into, at the meeting of the directors at which the question of entering into the contract or arrangement is first taken into consideration or, if the director was not, on the date of that meeting, concerned or interested in the contract or arrangement, at the first meeting of the directors held after he becomes so concerned or interested; and

(b) in the case of any other contract or arrangement, at the first meeting of the directors held after the director becomes concerned or interested in the contract or arrangement.

78. GENERAL NOTICE OF INTEREST BY DIRECTOR

A general notice that any director of the Company is a director or a member of any other named company or is a member of any named firm and is to be regarded as interested in any subsequent transaction with such company or firm shall, as regards any such transaction, be sufficient disclosure under this article. Provided, however, that any such general notice shall expire at the end of the financial year in which it was given and may be renewed for a further period of one financial year at a time by giving fresh notice in the last month of the financial year in which it would otherwise expire

79. DISCLOSURE TO MEMBERS OF DIRECTORS INTEREST IN APPOINTMENT OF CHIEF EXECUTIVE, DIRECTORS ETC

Whereby any contract or resolution of the directors an appointment or a variation in the terms of an existing appointment is made (whether effective immediately or in the future) of a Chief Executive, whole time director or secretary of the Company, in which appointment of any director of the Company is, or after the contract or resolution becomes, in any way, whether directly or indirectly, concerned or interested, or whereby any contract or resolution of the directors, an appointment or a variation in the terms of appointment is made (whether effective immediately or in the future) of a Chief Executive, the Company shall inform the members of such appointment or variation in the manner required by Section 218 of the Ordinance and shall comply with the requirements of that section in regard to the maintaining of such contracts and resolutions open for inspection by members at the office, the provision of certified copies thereof and extracts there from and otherwise.

80. REGISTER OF CONTRACTS AND APPOINTMENTS

In accordance with section 219, the Company shall maintain at its office a register or electronic record, in which shall be entered separately particulars of all contracts, arrangements or appointments in which the directors are interested. Such register or electronic record shall be open to inspection to the members during business hours, subject to any reasonable restriction that may be imposed by the Company in general meeting.

81. DIRECTOR MAY BECOME DIRECTOR OF ANOTHER COMPANY

A director of the Company may be or become a director of any other company promoted by the Company or in which the Company may be interested as a vendor, shareholder or otherwise, and no such director shall be accountable for any benefits received as a director or member of such other company.

ELECTION OF DIRECTORS

82. PROCEDURE FOR ELECTION OF DIRECTORS

The number of directors determined by the directors under Section 178 shall be elected to office by the members in general meeting in the following manner, namely:

(a) a member present in person or by proxy shall have such number of votes as is equal to the product of voting shares held by him and the number of directors to be elected

(b) a member may give all his votes to a single candidate or divide them between more than one of the candidates in such manner as he may choose, and

(c) the candidate who gets the highest number of votes shall be declared elected as director and then the candidate who gets the next highest number of votes shall be so declared, and so on until the total number of directors to be elected has been so elected.

If the number of persons who offer themselves to be elected as directors is not more than the number of vacancies for which elections are being held, such persons being otherwise eligible shall be deemed to have been elected as directors from the date on which the election was proposed to be effective.

83. TENURE FOR OFFICE OF DIRECTORS

A director elected under Section 178 shall hold office for a period of three years unless he earlier resigns or becomes disqualified from being a director, or otherwise ceases to hold office.

84. ELIGIBILITY OF RETIRING DIRECTOR

A retiring director of the Company shall be eligible for re-election.

85. REMOVAL OF DIRECTORS

The Company in general meeting may remove a director from office by a resolution passed with the requisite number of votes determined in accordance with the provisions of Section 181 of the Ordinance.

86. CASUAL VACANCY

Any casual vacancy occurring among the directors may be filled up by the directors not later than ninety (90) days thereof and the person so appointed shall hold office for the remaining period of the director in whose place he is appointed provided that the directors may not fill a casual vacancy by appointing any person who has been removed from the office of a director of the Company.

87. NOTICE OF INTENTION TO BE FILED

No person including a retiring director of the Company shall be eligible for election to the office of director of the Company at any general meeting unless he has, not less than fourteen days before the date of the meeting, left at the office, a notice in writing, and duly signed, signifying his candidature for the office.

88. REGISTER OF DIRECTORS AND OFFICERS

The Company shall keep at the office a register of the directors and officers, containing the particulars required by Section 205 of the Ordinance and the Company shall otherwise comply with the provisions of that Section as regards furnishing returns to the Registrar and giving inspection of the register.

PROCEEDINGS OF DIRECTORS

89. DECISION BY MAJORITY AND CASTING VOTE

The directors shall meet together for the despatch of business, adjourn and otherwise regulate their meetings and proceedings as they may think fit In accordance with the Ordinance. Questions arising at any meeting shall be decided by a majority of votes and in case of an equality of votes the Chairman shall have a second or casting vote.

90. QUORUM FOR DIRECTORS MEETINGS

The quorum necessary for the transaction of the business of the directors shall not be less than two directors. An alternate director whose appointment is effective shall be counted in a quorum. In case directors qualified to vote are less than the minimum quorum, the matter should be decided in general meeting.

91. CONVENING OF DIRECTORS MEETINGS

A director may, and the secretary on the requisition of a director shall, at any time summon a meeting of the directors. Such meetings may be held using any technology consented to by all the directors including but not limited to telephone and video conferencing. The consent may be a standing one, withdrawable by a director only within a reasonable period of time before the meeting. It shall not be necessary to give notice of a meeting of directors to any director for the time being absent from Pakistan.

92. CHAIRMAN BOARD OF DIRECTORS

The board of directors of the Company shall from time to time elect one of the directors as Chairman of the board of directors of the Company and determine the period for which he is to hold office, his role, remuneration and other terms and conditions, if any. The Chairman shall preside over all meetings of the board of directors, but if at any meeting neither the Chairman is present in person within half an hour of the time appointed for holding the same, the directors present in person may choose one of their number to be Chairman of the meeting.

93. EXERCISE OF POWERS BY THE DIRECTORS

A meeting of the directors at which a quorum is present shall be competent to exercise all or any of the authorities, powers and discretion by or under these articles for the time being vested in or exercisable by the directors generally.

94. DELEGATION OF POWERS

The directors may from time to time delegate of their powers to committees consisting of such members or members of their body as they think fit, and may from time to time revoke such delegation. Any committee so formed shall, in the exercise of the powers so delegated, conform to any regulations that may from time to time be imposed upon it by the directors.

95. MEETING OF COMMITTEES

The meeting and proceedings of any such committee consisting of two or more members shall be governed by the provisions herein contained for regulating the meetings and proceedings of the directors, so far as the same are applicable thereto.

96. WHEN ACTS OF DIRECTORS OR COMMITTEE VALID

All acts done by any meeting of the directors or by a committee of the directors or by any person acting as a director of the Company shall, notwithstanding that is shall afterwards be discovered that there was some defect in the appointment or continuance in office of any such directors or person acting as aforesaid, or that they or any of them were disqualified or had vacated office, or were not entitled to vote, be as valid as if every such person had been duly appointed or had duly continued in office and was qualified and had continued to be a director and had been entitled to be a director. Provided that nothing in this article shall be deemed to give validity to acts done by any such director after the appointment of such director has been shown to be invalid.

97. RESOLUTION BY CIRCULATION

A resolution circulated through fax or email or any form of electronic transmission to all the directors for the time being entitled to receive notice of a meeting of the directors passed without any meeting of the directors or of a committee of directors and signed or affirmed through fax or email or any form of electronic transmission, by a majority of all directors in writing under the hands of all directors (or in their absence their alternate directors) for the time being in Pakistan, being not less than the quorum required for meetings of the directors, or as the case may be of the members of the committee, shall be valid and effectual as if it had been passed at the meeting of the directors, or as the case may be of such committee, duly called or constituted. The resolution in writing of the Company may consist of several copies of a document signed by one or more director(s) and takes effect at the date and time on which the last director, necessary for the resolution to be passed, signs a copy of the resolution; or a record of several signed electronic messages each indicating the identity of the sender, the text of the resolution and the sender's agreement or disagreement to the resolution, as the case may be and such a resolution takes effect on the date on which the last director's message, necessary for the resolution to be passed, is received.

98. REMUNERATION FOR EXTRA SERVICES

If any director of the Company, being willing, shall be called upon to perform extra services or to make any special exertions in going or residing away from his place of business for the time being for any of the purposes of the Company or in giving special attention to the business of the Company as a member of a committee of the directors, the Company may remunerate such director so doing either by a fixed sum or by a percentage of profits or otherwise as may be determined by the directors.

MINUTES

99. MINUTES OF MEETINGS

The directors shall cause minutes to be duly entered in books provided for the purpose of or as an electronic record, of,

(a) all appointments of officers;

(b) the names of the directors present in person at each meeting of the directors and of any committee of the directors;

(c) all decisions, directions and orders made by the directors and committees of the directors;

(d) all resolutions and proceedings of general meeting and of meetings of the directors and of the committees of the directors;

and any such minutes of any meeting of the directors or of any such committee or of the Company, if purporting to be signed by the Chairman of such meeting or by the Chairman of the next succeeding meeting, shall be prima facie evidence of the matter stated in such minutes.

POWER AND DUTIES OF DIRECTORS

100. DIRECTORS TO COMPLY WITH THE LAW

The directors shall duly comply with the provisions of the Ordinance, Insurance Ordinance and the Code as modified or amended or substituted from time to time and rules, regulations, guidelines framed there under.

101. DIRECTORS TO CONTROL AND MANAGE COMPANY AFFAIRS

The control of the Company shall be vested in the directors, and the business of the Company shall be managed by the directors who may exercise all such powers of the Company as are not by the Ordinance or by these articles or by a special resolution expressly directed or required to be exercised or done by the Company in general meeting.

102. POWER OF THE DIRECTORS

Without prejudice to the general powers conferred by Ordinance and to any other powers or authorities conferred by these articles on the directors, it is hereby expressly declared that the directors shall subject to the exercise in accordance with the Ordinance have the following powers, that is to say, power:

(1) To purchase or otherwise acquire for the Company any property, rights or privileges which the Company is authorised to acquire at such price and generally on such terms

and conditions as they think fit, and to sell, let, exchange or otherwise dispose of absolutely or conditionally any part of the property, privileges and undertaking of the Company upon such terms and conditions, and for such consideration, as they may think fit.

(2) At their discretion to pay for any property, rights, privileges acquired by or services rendered to the Company either wholly or partially in cash or in shares (subject to the provisions of section 86 of the Ordinance) bonds, debentures or other securities of the Company. Any such bonds, debentures or other securities may be either specifically charged upon all or any part of the property of the Company or not so charged.

(3) To open account with any bank or financial institution and deposit into and withdraw money from such accounts from time to time.

(4) To make, draw, endorse, sign, accept, negotiate and give all cheques, bills of lading, drafts, orders, bills of exchange, and other promissory notes and negotiable instruments required in the business of the Company.

(5) To secure the fulfilment of any contracts, agreements or engagements entered into by the Company by mortgage or charge of all or any of the property of the Company for the time being or in such other manner as they may think fit.

(6) Subject to the provisions of the Ordinance, to appoint and at their discretion remove or suspend such agents (other than Managing Agents), managers, secretaries, officers, employees for permanent, temporary or special services as they may from time to time think fit, and to determine their powers and duties and fix their salaries or emoluments and to require security in such instances and to such amount as they think fit.

(7) To appoint any person or persons (whether incorporated or not) to accept and hold in trust for the Company any property belonging to the Company or in which it is interested or for any other purposes, and to execute and do all such deeds, documents and things as may be requisite in relation to any such trust and to provide for the remuneration of such trustee or trustees.

(8) To institute, conduct, defend, compound or abandon any legal proceedings by or against the Company or its officers or otherwise concerning the affairs of the Company and also to compound and allow time for payment or satisfaction of any debts due and of any claims or demands by or against the Company.

(9) To refer claims or demands by or against the Company to arbitration and observe and perform the awards.

(10) To make and give receipts, releases and other discharges for money payable to the Company and for the claims and demands of the Company.

(11) To determine who shall be entitled to sign on the Company's behalf bills, notes, receipts, acceptances, endorsements, cheques, releases, contracts and documents.

(12) From time to time to provide for the management of the affairs of the Company either in different parts of Pakistan or elsewhere in such manner as they think fit, and in particular to establish branch offices and to appoint any persons to be the attorneys or agents of the Company with such powers (including power to sub-delegate) and upon such terms as may be thought fit.

(13) To invest and deal with any of the moneys of the Company not immediately required for the purposes thereof upon such securities and in such manner as they may think fit, and from time to time to vary or realise such investments.

(14) From time to time to make, vary and repeal bye-laws for the regulation of the business of the Company, its employees.

(15) To enter into all such negotiations and contracts and rescind and vary all such contracts and execute and do all such acts, deeds and things in the name and on behalf of the Company as they may consider expedient for or in relation to any of the matters aforesaid or otherwise for the purposes of the Company.

(16) To establish, maintain, support and subscribe to any charitable or public object, and any institution, society, or club which may be for the benefit of the Company or its employees, or may be connected with any town or place where the Company carries on business; to give pensions, gratuities, or charitable aid to any person or persons who have served the Company or to the wives, children, or dependants of such person or persons, that may appear to the directors just or proper, whether any such person, his widow, children or dependants, have or have not a legal claim upon the Company.

(17) Subject to the provisions of section 227 of the Ordinance, before recommending any dividends, to set aside portions of the profits of the Company to form a fund to provide for such pensions, gratuities, or compensation; or to create any provident or benefit fund in such or any other manner as to the directors may seem fit.

(18) Subject to the provision of the Ordinance to accept from any member on such terms and conditions as shall be agreed a surrender of his shares or any part thereof.

(19) To make advances and loans without security or on such security as they may deem proper and as permissible under the law.

(20) To delegate all or any of the powers hereby conferred upon them to such person or persons as they may from time to time think fit subject to the provision of Section 196 of the Ordinance.

(21) To approve appointment of alternate director/directors.

POWER OF ATTORNEY

103. APPOINTMENT OF ATTORNEY

The directors may from time to time and at any time by power of attorney appoint any company, firm or person (including any director or officer of the Company) or body of persons, whether nominated directly or indirectly by the directors, to be the attorney or attorneys of the Company for such purposes and with such powers, authorities and discretions and for such period and subject to such conditions as they may think fit, and any such powers of attorney may contain such provisions for the protection and convenience of persons dealing with any such attorney to delegate all or any of the powers, authorities and discretions vested in him, and without prejudice to the generality of the foregoing any such power of attorney may authorise the attorney to institute, conduct, defend, compound or abandon any legal proceedings by or against the Company, whether generally or in any particular case.

BORROWING POWERS

104. DIRECTORS POWERS TO BORROW

(1) The directors may exercise all the powers of the company to borrow money and to mortgage or charge its undertaking, property and assets (both present and future), and to issue debentures, debenture stocks, and other securities, weather outright or as collateral security for any debt, liability or obligation of the company or of any third party

(2) In exercising the powers of the Company aforesaid the directors may, from time to time and on such terms and conditions as they think fit, raise money from banks and financial institutions and from other persons under any permitted system of financing, whether providing for payment of interest or some other form of return, and in particular the directors may raise money on the basis of the mark up on price, musharika, modaraba or any other permitted mode of financing.

(3) In regard to the issue of securities the directors may exercise all or any of the powers of the Company arising under Sections 87 and 120 of the Ordinance and in particular the directors may issue any security as defined in Section 2(1) (34) of the Ordinance or may issue any instrument or certificate representing redeemable capital as defined in section 2(1) (30A) of the Ordinance or participatory redeemable capital as defined in section 2(1) (25) of the Ordinance.

(4) Any debentures, debenture-stock, bonds or other securities may be issued at a discount, premium or otherwise and with any special privileges as to redemption, surrender, drawing, allotment of shares, attending and voting at general meetings of the Company, appointment of directors of the Company or otherwise.

105. REGISTER OF MORTGAGESAND CHARGES

The directors shall cause a proper register to be kept in accordance with the provisions of Section 135 of the Ordinance, of all mortgages and charges specifically affecting the property of the Company, and shall duly comply with the provisions of the sections of the Ordinance, namely, Sections 121 and 122 (Registration of mortgages and charges), Section 128 (Endorsement of certificates), Section 129 (Filing of prescribed particulars), Section 130 (Keeping of a copy of every instrument creating any mortgage or charge by the Company at the office) and Section 132 (Giving of intimation of the payment or satisfaction of any charge or mortgage created by the Company).

BOOKS OF ACCOUNTS

106. DIRECTORS TO KEEP BOOKS OF ACCOUNTS

The directors shall cause to be kept proper books of account as required under section 230.

107. WHERE TO KEEP BOOKS OF ACCOUNTS

The books of account shall be kept at the registered office of the company or at such other place as the directors shall think fit and shall be open to inspection by the directors during business hours.

108. INSPECTION BY MEMBERS

The directors shall from time to time determine whether and to what extent and at what time and places and under what conditions or regulations the accounts and books or papers of the company or any of them shall be open to the inspection of members not being directors, and no member (not being a director) shall have any right of inspecting any account and books or papers of the company except as conferred by law or authorised by the directors or by the company in general meeting.

109. **PREPARATION OF ACCOUNTS**

The directors shall as required by sections 233 and 236 cause to be prepared and to be laid before the company in general meeting such profit and loss accounts and balance sheets duly audited and reports as are referred to in those sections.

110. **ACCOUNTS TO BE LAID BEFORE THE MEMBERS**

A balance sheet, profit and loss account, and other reports referred to in the preceding Article shall be made out in every year and laid before the company in the annual general meeting made up to a date not more than three months before such meeting. The balance sheet and profit and loss account shall be accompanied by a report of the auditors of the company.

111. **ACCOUNTS AND REPORTS TO BE SENT TO MEMBERS**

A copy of the balance sheet and profit and loss account and report of auditors shall, at least twenty-one days preceding the meeting, be sent to the persons entitled to receive notices of general meetings in the manner in which notices are to be given.

112. **ERRORS DISCOVERED AFTER APPROVAL OF ACCOUNTS**

Every account of the company when audited and approved by a general meeting shall be conclusive except as regards any errors discovered therein within three months next after the approval hereof. Whenever any such error is discovered within that period the account shall forthwith be corrected and henceforth shall be conclusive.

113. **DIRECTORS TO COMPLY SECTION 230 AND 236**

The directors shall in all respects comply with the provisions of sections 230 to 236.

ANNUAL RETURNS

114. **FILING OF FORM A**

The Company shall make the requisite annual returns in accordance with the provisions of section 156 of the Ordinance.

DIVIDENDS AND RESERVES

115. The company in general meeting may declare dividend but no dividend shall exceed the amount recommended by the board.

116. The directors may from time to time pay to the members such interim dividends as appear to the directors to be justified by the profits of the company.

117. No dividend shall be paid otherwise than out of profits of the year or any other undistributed profits. No unpaid dividend shall bear interest against the company.

118. The dividend warrants shall be sent by the company by registered post unless the shareholder entitled to receive the dividend requires otherwise.

119. With the sanction of a resolution in the general meeting, any dividend may be paid wholly or in part by the distribution of specific assets and in particular of paid-up shares or debentures of any other company or in any one or more of such ways. The directors may fix the value for distribution of such specific assets or any part thereof and may determine that cash payments shall be made to any members upon the footing of the value so fixed, in order to adjust the rights of all members, and may vest any such specific assets in trust for the members entitled to the dividend as may seem expedient to the directors.

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

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

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

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

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

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

126. The dividend shall be paid within the period laid down in section 251.

127. All dividends unclaimed for one year after having been declared may be invested or otherwise made use of by the directors for the benefit of the company until claimed and all dividends unclaimed for three years after having been declared may be forfeited by the directors for the benefit of the company, but the directors may annul the forfeiture whenever they may think proper.

AUDIT

128. **APPOINTMENT OF AUDITORS**

Auditors shall be appointed and their duties regulated in accordance with Sections 252 to 255 of the Ordinance or any statutory modification thereof for the time being in force.

SEAL

129. **COMMON SEAL OF THE COMPANY**

The directors shall provide a common seal of the Company which shall not be affixed to any instrument except by the authority of a resolution of the board or by a committee of directors authorised in that behalf by the directors, and two (2) directors, or one (1) director and the secretary of the Company, shall sign every instrument to which the common seal is affixed.

130. **USE OF OFFICIAL SEAL OUTSIDE PAKISTAN**

The directors may provide for the use in any territory, district or place not situated in Pakistan, of an official seal which shall be a facsimile of the common seal of the Company, with the addition on its face of the name of every territory, district or place where it is to be used. The official seal shall not be affixed to any instrument except by the authority of a resolution of the board or by a committee of directors authorised in that behalf by the directors, and two (2) directors, or one (1) director and the secretary of the Company, or such other person as the directors may appoint for the purpose, shall sign every instrument to which the official seal is affixed. The provisions of section 213 shall apply to the use of the official seal.

NOTICES

131. **NOTICES TO MEMBERS**

Notice shall be given by the company to members and auditors of the company and other persons entitled to receive notice in accordance with section 50 and will include electronic form as may apply to the manner in which notices are to be issued, served and/or received by the company.

132. **MERGER, DE-MERGER AND RECONSTRUCTION OF THE COMPANY**

Subject to and in accordance with the provisions of section 287, the Company may reconstruct, amalgamate into another Company or divide into two (2) or more companies in the process of which the whole or any part of the undertaking, property or liabilities of the Company or any other company, may be transferred to any other Company or the Company, respectively, as the case may be. Provided that any sale of the undertaking of the Company, the directors, or the liquidator on a winding up, may, if authorised by a special resolution, accept fully paid shares, debentures or securities of any other company, whether incorporated in Pakistan or not, either then existing or to be formed, for the purchase in whole or in part of the property of the Company, and the directors (if the profits of the Company permit) or the liquidator (in a winding up) may distribute such shares, or securities, or any other property of the Company amongst the members without realisation, or vest the same in trustees for them, and any special resolution may provide for the distribution or appropriation of the cash, shares or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the members or contributories of the Company, and for valuation of any such securities or property at such price in such manner as the meeting may approve, and all holders of shares shall be bound to accept, and shall be bound by any valuation or distribution so authorised, and waive all rights in relation thereto, save only in case the Company is proposed to be or is in the course of being wound up, such statutory rights (if any) under section 367 of the Ordinance as are incapable of being varied or excluded by these articles.

SECRECY

133. **DECLARATION TO OBSERVE SECRECY**

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

134. **NO MEMBER TO ENTER THE PREMISES OF THE COMPANY**

No member or other person (not being a director) shall be entitled to enter upon the property of the Company or to inspect or examine the Company's premises or properties of the Company without the permission of the directors for the time being or, subject to the provisions of article 122, to require discovery of or any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade, or secret process or of any matter whatsoever which may relate to the conduct of the business of the Company and which in the opinion of the directors it will be inexpedient in the interest of the members of the Company to communicate.

ARBITRATION

135. **APPOINTMENT OF ARBITRATOR**

Whenever a difference arises between the Company on the one hand and any of the members, their executors, administrators, or assignees on the other hand touching the true intent or construction or the incident or consequences of these presents, or of the status of enactment's of the legislature, or touching anything then or thereafter done, executed, omitted or suffered in pursuance of these presents or of the status of enactment's touching any breach or alleged breach or otherwise relating to the premises or to these presents, or to the status or to any of the affairs or officers of the Company, the Company by written agreement refer to arbitration in accordance with the Arbitration Act 1940 (X of 1940) and every such difference shall be referred to the decision of an arbitrator to be appointed by the parties in difference or if they cannot agree upon a single arbitrator, to the decision of two arbitrators, one appointed by such party, or in the event of disagreement of the arbitrators, to that of an umpire appointed by arbitrators themselves. The provisions of Arbitration Act 1940 (X of 1940) shall apply to all arbitrations between the Company and persons having such difference.

136. **FAILURE TO APPOINT ARBITRATOR BY ONE PARTY**

If either party to the difference makes default in appointing the arbitrator for fifteen days after the other party has given to him notice to appoint the same, such other party may appoint an arbitrator to act in the place of the arbitrators of the defaulting party.

137. **COST OF ARBITRATION**

The costs of, or incidental to any such reference and award shall be in the discretion of the arbitrator/arbitrators or umpire as the case may be who may determine the amount thereof an may award by whom, and to whom, and in what manner the same shall be borne and paid.

WINDING UP

138. **DISTRIBUTION OF ASSETS ON WINDING UP**

If the Company shall be wound up and the assets available for distribution among the members, subject to the rights attached to any preference share capital, as such shall be insufficient to repay the whole of the paid-up capital, such assets shall be distributed so that as nearly as may be the losses shall be borne by the members in proportion to the capital paid up on the shares held by them respectively. And if in a winding up the assets available for distribution among the members shall be more than sufficient to repay the whole of the capital paid up at the commencement of the winding up, the excess shall be distributed amongst the members in proportion to the capital at the commencement of the winding up, paid up on the shares held by them respectively. But this article is to be without prejudice to the rights of the holders of shares issued upon special terms and conditions.

139. **DISTRIBUTION OF ASSETS IN SPECIE OR KIND**

If the Company shall be wound, whether voluntarily or otherwise, the liquidator may with the sanction of a special resolution divide among the members in specie or kind any part of the assets of the Company, and may with the like section vest any part of the assets of the Company in trustees upon such trusts for the benefit of the members or any of them as the liquidator with the like sanction shall think fit.

INDEMNITY

140. Every director or officer of the Company and every person employed by the Company as auditor shall be indemnified out of the funds of the Company against all liability incurred by him as such director, officer or Auditor in defending any proceedings, whether civil or criminal, in which judgement is given in his favour, or in which he is acquitted, or in connection with any application under section 488 of the Ordinance in which relief is granted to him by the Court.

We, the several persons whose names and addresses are subscribed, are desirous of being formed into a Company in pursuance of this Articles of Association, and we respectively agree to take the number of shares in the Capital of the Company as set opposite to our respective names.

Name and Surname in Full	Father's/ Husband name in Full	Nationality	Occupation	CNIC Number	Residential address in full	No. of Shares	Signature
Chaudhry Khan M. Ashraf	Muhammad Zaka Ashraf	Pakistani	Business	31202-1302899-3	H. No. 19 Zafar Road Lahore Cantt	2,300,000	
Ubeda Ashraf	Usman Akram	Pakistani	Business	35201-6933192-0	H. No. 19 Zafar Road Lahore Cantt	500,000	
Fiza Ashraf	Muhammad Zaka Ashraf	Pakistani	Business	31202-6738953-6	H. No. 19 Zafar Road Lahore Cantt	500,000	
Chaudhry Muhammad Zaka Ashraf	Chaudhry Muhammad Ashraf	Pakistani	Business	31202-8858092-9	H. No. 19 Zafar Road Lahore Cantt	600,000	
Naushaba Zaka Ashraf	Ch Muhammad Zaka Ashraf	Pakistani	Business	31202-7764863-4	H. No. 19 Zafar Road Lahore Cantt	600,000	
Zunaira Atif	Atif Yaseen	Pakistani	Business	33100-2714321-2	H. No. 03, Civil Lines, Race Course Road, Faisalabad	250,000	
Sana Ashraf	Muhammad Ameer Sultan	Pakistani	Business	31202-1245633-2	H. No. 17 Zafar Road Lahore Cantt	250,000	

CERTIFIED TO BE TRUE COPY

Total Shares Taken: 5,000,000 (Five Million)

JOINT REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

Dated this **03 November 2016**

Witness to the above Signatures:

Signature: ________________

Full Name: National Institutional Facilitation Technologies (Pvt) Ltd

Occupation: NIFT

Full Address: 5th Floor, AWT Plaza, I.I. Chundrigar Road, Karachi.

SPONSOR PROFILE

Management Profile- Bahawalpur Energy Limited

Ch. Khan Muhammad Ashraf (Chief Executive Officer):

Ch Khan Muhammad Ashraf, Chief Executive Officer, is a graduate from Canada, an agriculturist cum landlord and was associated with ASML as a Director on Board since 2010. During this period, Ch Khan Muhammad closely worked with his father to administer the operations including the expansion of power house of the sugar mills. ASML, in addition to producing power for its internal usage, is exporting up to 4.5 MWH power to MEPCO from its Low-Pressure power generating setup during the crushing season. Under his valued leadership, the Mills has achieved several operational goals including certification for food safety and security and ISO, becoming quality producer of beverage grade sugar, joined the group of approved suppliers of two main beverage players (PEPSI International and Coca Cola). Now ASML is working on efficiencies and initiated a phased program of automation of different equipment and improvement in balanced operations. Ch Khan Muhammad has plans to setup state of the art biomass fuel supply chain for the power and other industries in the region.

Ch. Muhammad Zaka Ashraf (Shareholder):

Ch Muhammad Zaka Ashraf had been Chairman Pakistan Cricket Board and President / Chief Executive Zarai Taraqiati Bank Ltd as well as Chairman & Chief Executive of Ashraf Group of Industries from 1983 to 2008. He also held portfolios of Advisor to Chief Minister Sindh, Central Chairman of All Pakistan Sugar Mills Associations (National and Punjab zone), Member Executive Committee Lahore Chamber of Commerce & Industry and Vice Chairman of the Federation of Pakistan Chamber of Commerce and Industry Standing Committee on Food and Agriculture. A well-known industrialist who is respected by all members of Society.

BAHAWALPUR ENERGY LTD.

Mrs. Naushaba Zaka Ashraf (Shareholder):

She is Chief Executive of Ashraf Sugar Mills Limited and belong to a family having vast experience of agriculture and industry. She is on the Board of Ashraf Sugar Mills Limited since 1984. She is also Director in H.M. Iqbal Coal Mines (Pvt.) Ltd which is Group Company of Ashraf Group of Industries and is engaged in coal mining business.

Mrs. Ubeda Ashraf (Director):

She belongs to an agriculturist/industrial family and she has been associated with ASML organization as a Director on board since 2008 before becoming director BWEL.

Miss Fiza Ashraf (Director):

She belongs to an agriculturist family and she is associated with this group operations for more than 6 years before becoming director of BWEL.

BAHAWALPUR ENERGY LTD.

PLANT LOCATION AND CHARACTERISTICS

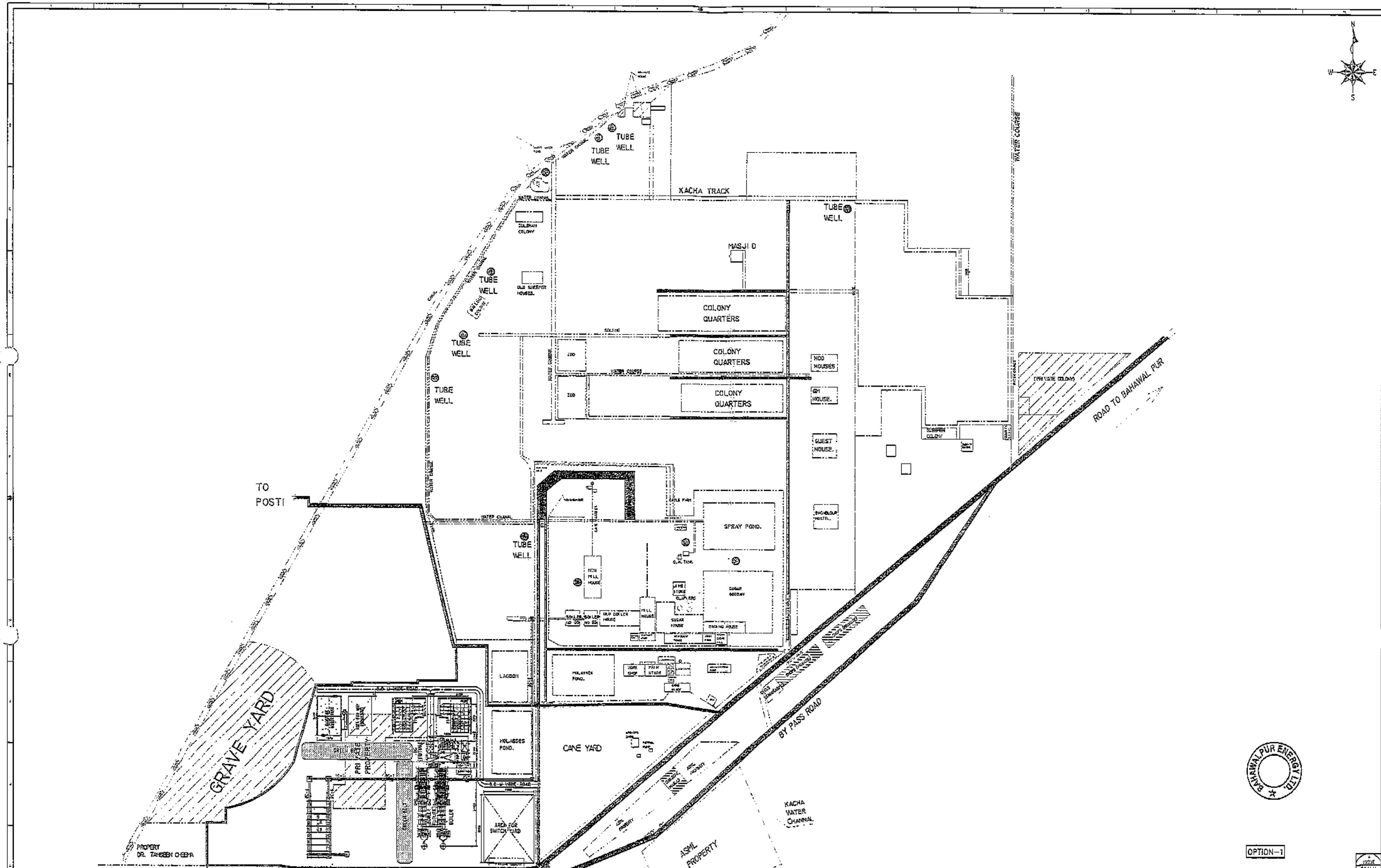
Plant Location

The proposed plant of BWEL project will be located within the premises of the sugar mill at Ahmedpur Road, in District Bahawalpur. GPS Coordinates of the location are 29°N, 71 °E. The nearest airports are at Bahawalpur (20 km) and Multan (80 km), and the nearest sea port is at Karachi at a distance of approximately 1,000 km. The proposed plant is well connected with Islamabad and Lahore through the National Highway.

Documents attached.

BAHAWALPUR ENERGY LTD.


Ashraf Sugar Mill
Latitude: 29°17'24.34"N Longitude: 71°30'29.12"E
AH2



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BAHAWALPUR ENERGY LIMITED

BAGASSE BASED COGENERATION PROJECT

AVANT-GARDE ENGINEERS & CONSULTANTS (FZC), SHARJAH, UAE

ENGINEERING CONTRACTOR:

AVANT-GARDE

CHENNAI 600 116, INDIA.

SCALE 1:1500

OVERALL PLANT LAYOUT

0-15308-600-0020

REV 0

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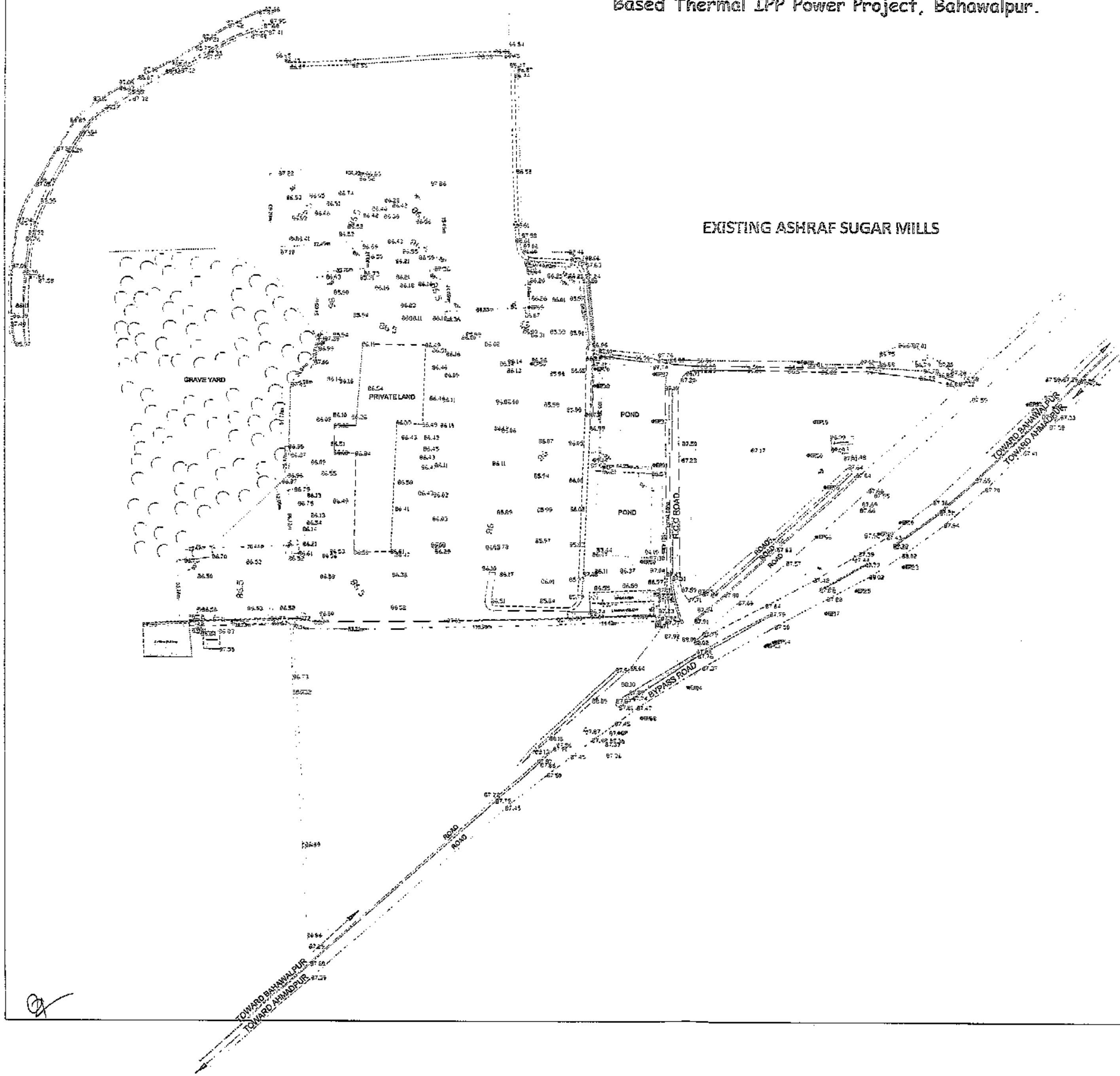
Topographical Survey for 31.2MW HP CO-Generation Bagasse Based Thermal IPP Power Project, Bahawalpur.



N
W E
S

SHEETS INDEX

01

General Notes

LEGEND

Notes

1. Contour Interval at 0.5m,
2. All Levels are in Meter,
3. Grid Station 220/132 KV 10KM from Ashraf Sugar Mills in Mari Sheikh Sajja, Bahawalpur.

LIST OF BENCH MARK

S.No	Easting	Northing	Elev	Desc
1	743335.895	3242334.323	88.134	BM-1
2	743380.873	3242351.991	87.672	BM-2
3	743619.355	3242503.689	87.44	BM-3
4	743718.6	3242650.438	87.466	BM-4
5	743317.874	3242795.247	86.615	BM-5
6	743395.706	3242463.855	93.739	BM-6
	750604.0	3245359.00		

Project:

Topographical Survey of 31.2 MW HP Co-Generation Bagasse Based Thermal IPP Power Project, Bahawalpur.

Client:

Bahawalpur Energy Limited.

Contractor:

AJK

AREA DETAIL

AREA = 97492.3561 SQ.M

PERIMETER LENTH =1812.4799.M

TITLE.	Topographical Map
DRG No.	AJK-T-16/71
DATE	November, 2016
DRAWN BY:	Mazhar
CHECKED BY:	Waqas Ahmad

BAHAWALPUR ENERGY LTD.

Plant Details

1. General Information

(i)	Applicant's Name	Bahawalpur Energy limited
(ii)	Registered Office	128 – Tufail Road, Lahore
(iii)	Plant Location	Ashrafabad, District Bahawalpur
(iv)	Type of Generation Facility	Bagasse / Biomass fired Cogeneration Power Plant
(v)	Commissioning/Commercial Operation Date	20 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)	31.2 MW (Gross)
(ii)	Type of Technology	Cogeneration Power Plant with high pressure boilers and Turbo-Generators
(iii)	Number of Units	One (01)
(iv)	Unit Make and Model	110 bar Travelling grate boiler with steam capacity of 160 TPH from Wuxi Turbo generator - Extraction cum condensing type based on HTC
(v)	Installed Capacity	Power Generation: 31.2MW (Season operation) 31.2 MW (Off-season operation)
(vi)	Auxiliary Consumption	10 % approximately
(vii)	Interconnection	8.0 KM

BAHAWALPUR ENERGY LTD.

3. Fuel / Raw Material Details

(i)	Primary Fuel	Bagasse / Biomass
(ii)	Alternate Fuel	NIL
(iii)	Fuel Source (Imported/Indigenous)	Indigenous
(iv)	Fuel Supplier	Ashraf Sugar Mills
(v)	Supply Arrangement	Through conveyor belts/loading trucks/tractor trolleys etc.,
(vi)	Sugarcane Crushing Capacity	12,000 TCD
(vii)	Bagasse Generation Capacity	3600 TPD
(viii)	Bagasse Storage Capacity	100,000 Tons
(ix)	Number of Storage Tanks	Not Applicable, bagasse shall be

		stored in open yard
(x)	Storage Capacity of each tank	Not Applicable
(xi)	Gross Bagasse Storage	100,000 Tons

4. Emission Values

Emission values are as below

1. Particulate matter <150 mg/M3
2. SO_2 <264 mg/ M3
3. NO_x < 100 mg/M3
4. Exhaust flue gas temperature 150 to 175 Deg C
5. CO < 200 mg/M3
6. CO_2 12.5%

5. Cooling System

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

6. Plant Characteristics

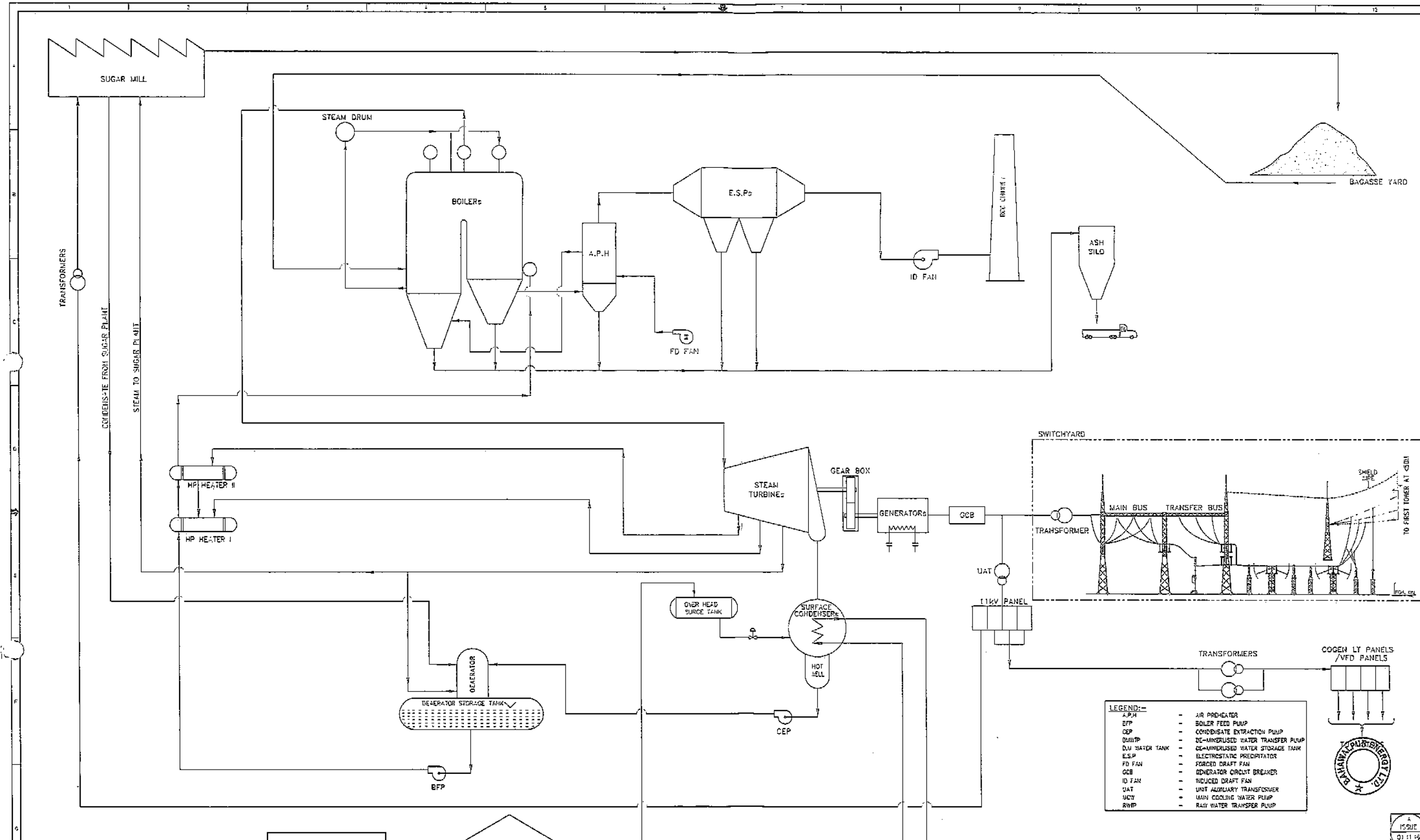
(i)	Generation Voltage	11000 volts	
(ii)	Frequency	50 Hz	
(iii)	Power Factor	0.8 lagging, 0.9 Leading	
(iv)	Automatic Generation Control (AFG)	By Turbine Governing System	
(v)	Ramping Rate	600 rpm	
(vi)	Time Required to Synchronize to Grid and Loading the Complex to Full Load from Cold Start	During cold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

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).

BAHAWALPUR ENERGY LTD.

SINGLE LINE DIAGRAM



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CUSTOMER: BAHAWALPUR ENERGY LIMITED
PROJECT: BAGASSE BASED COGENERATION PROJECT
PROJECT CONSULTANT: AVANT-GARDE ENGINEERS & CONSULTANTS (FZC), SHARJAH, UAE

ENGINEERING CONTRACTOR:
AVANT-GARDE
ENGINEERS AND CONSULTANTS (P) LTD.
CHENNAI 600 116, INDIA.

	NAME	SIGN	DATE
DRAWN	S.PRASHU		
CHKD.	S.SIVAKUMAR		
APPD.	S.BALSUBRAMANIAN		

DEPT PM	FIRST ANGLE PROJECTION	SCALE	WEIGHT (Kg)	REF ASSY. DRG. NO.	NO OF ITEMS
CODE 800		-	-	-	-

TITLE: PROCESS SCHEMES

DRAWING NO: 1-15308-800-0017
REV: 0

REV. NO	DATE	DESCRIPTION	REV. BY	CHD.	APPD.
		REVISIONS			

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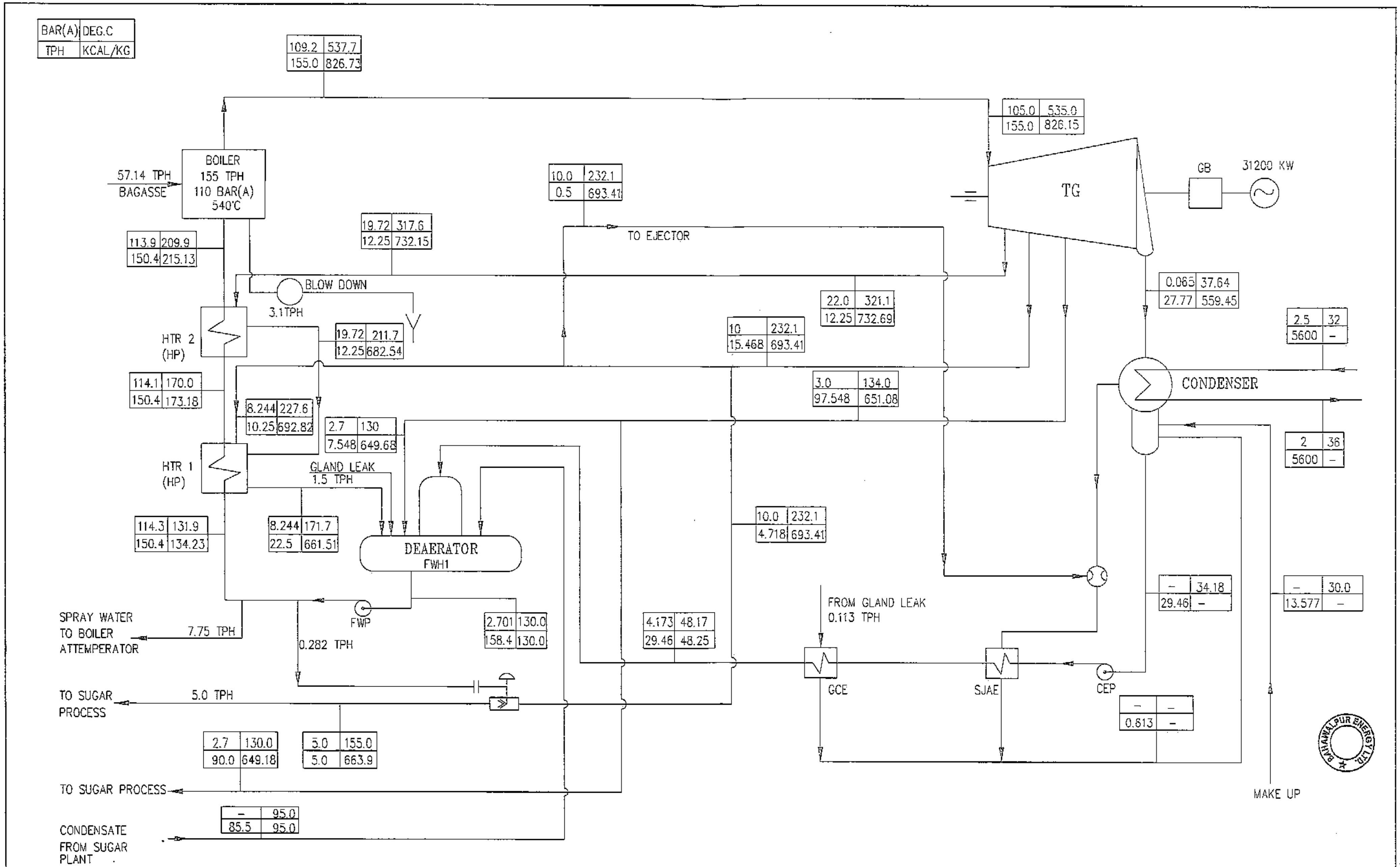

ENGINEERING CONTRACTOR: AVANT-GARDE ENGINEERS AND CONSULTANTS (P) LTD. CHENNAI- 600 116, INDIA.			
	CUSTOMER	BAHAWALPUR ENERGY LIMITED	
	PROJECT	BAGASSE BASED COGENERATION PROJECT	
	PROJECT CONSULTANT	AVANT-GARDE ENGINEERS & CONSULTANTS (FZC.,),SHARJAH,UAE	
	TITLE	MASS BALANCE - SEASON OPERATION	

	NAME	SIGN	DATE
DRN	S.PRABHU		01.11.16
CHD	S.SIVAKUMAR		01.11.16
APPD	S.BALASUBRAMANIAN		01.11.16

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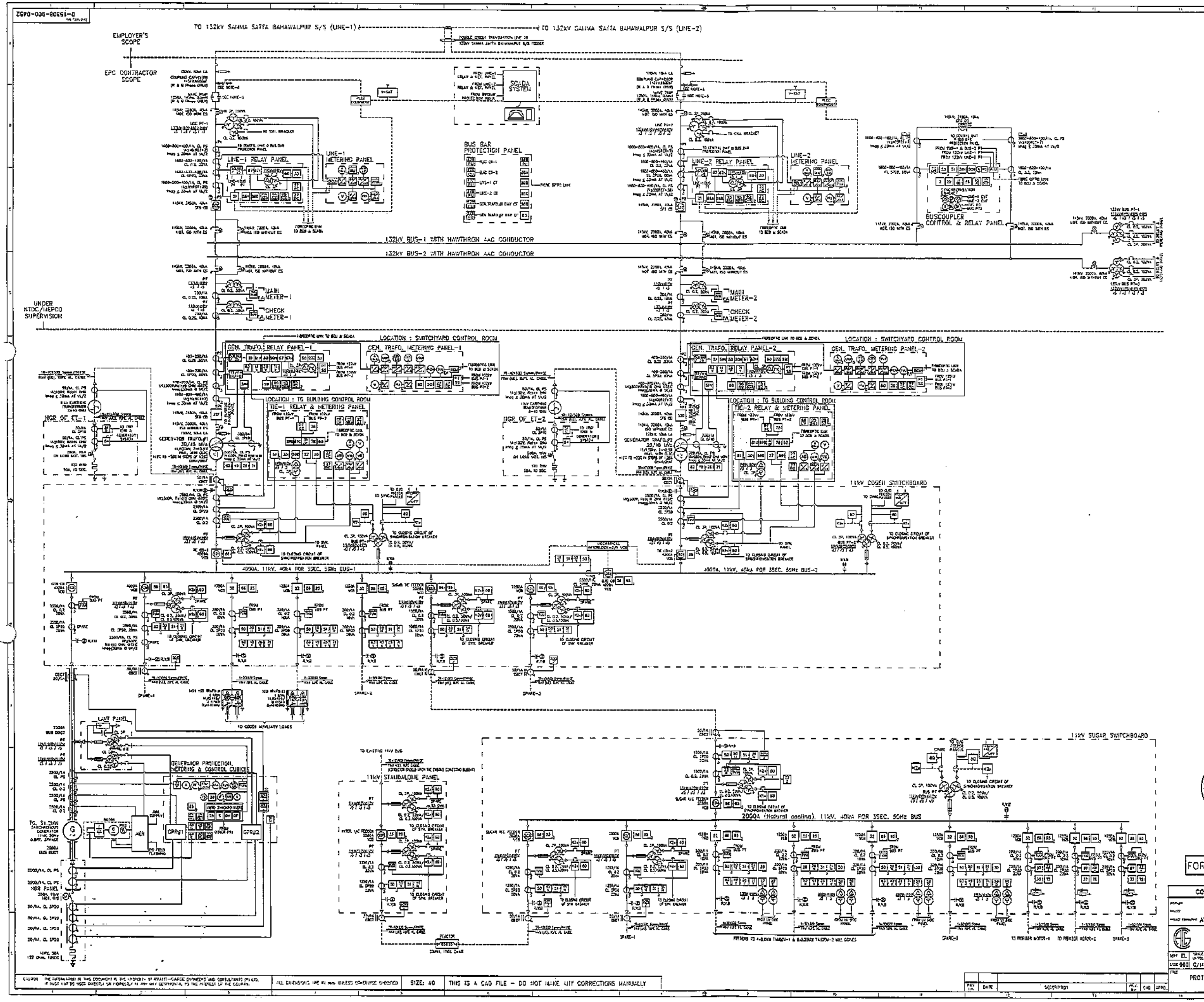

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BAHAWALPUR ENERGY LIMITED
BAGASSE BASED COGENERATION PROJECT
AVANT-GARDE ENGINEERS & CONSULTANTS (FZC..).SHARJAH.UAE

AVANT-GARDE
ENGINEERS AND CONSULTANTS (P) LTD
CHENNAI 600 115, INDIA.

DEPT EL | 900 | C/14/F

PROTECTION, METERING & CONTROL SCHEMATIC DIAGRAM

0-15308-900-0452

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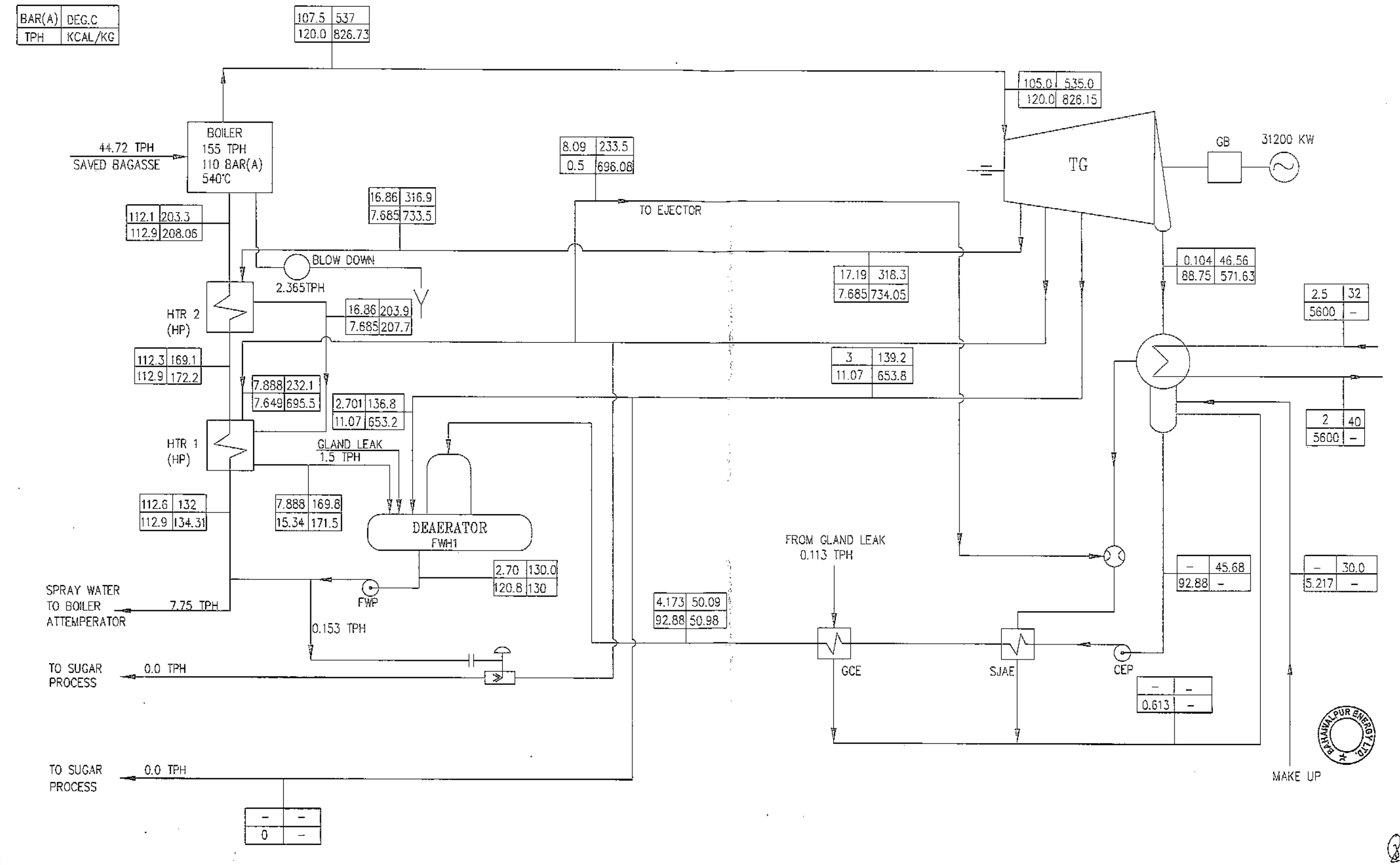

ENGINEERING CONTRACTOR:
AVANT-GARDE
ENGINEERS AND CONSULTANTS (P) LTD.
CHENNAI 600 116, INDIA.

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CUSTOMER	BAHAWALPUR ENERGY LIMITED
PROJECT	BAGASSE BASED COGENERATION PROJECT
PROJECT CONSULTANT	AVANT-GARDE ENGINEERS & CONSULTANTS (FZC.,),SHARJAH,UAE
TITLE	MASS BALANCE - OFF SEASON OPERATION

	NAME	SIGN	DATE
DRN	S.PRABHU		01.11.16
CHD	S.SIVAKUMAR		01.11.16
APPD	S.BALASUBRAMANIAN		01.11.16

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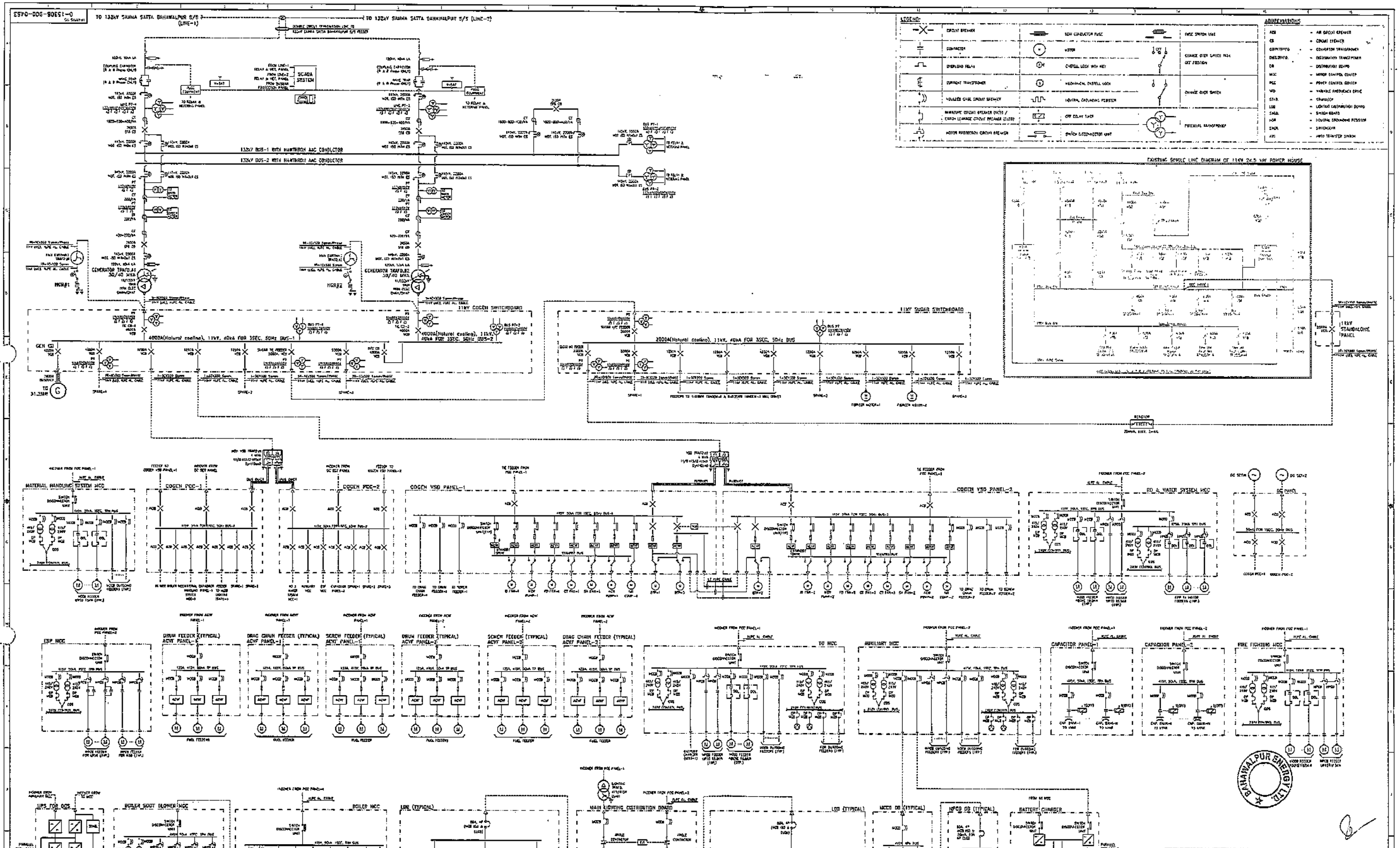

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BAGASSE BASED COGENERATION PROJECT

AVANT-GARDE ENGINEERS & CONSULTANTS (FZC.),SHARJAH,UAE

AVANT-GARDE ENGINEERS AND CONSULTANTS (P) LTD CHENNAI 600 116, INDIA.

DEPT EL | C/M/F

TITLE: OVERALL KEY SINGLE LINE DIAGRAM

DRAWING NO: D-15308-900-0453

REV: 0

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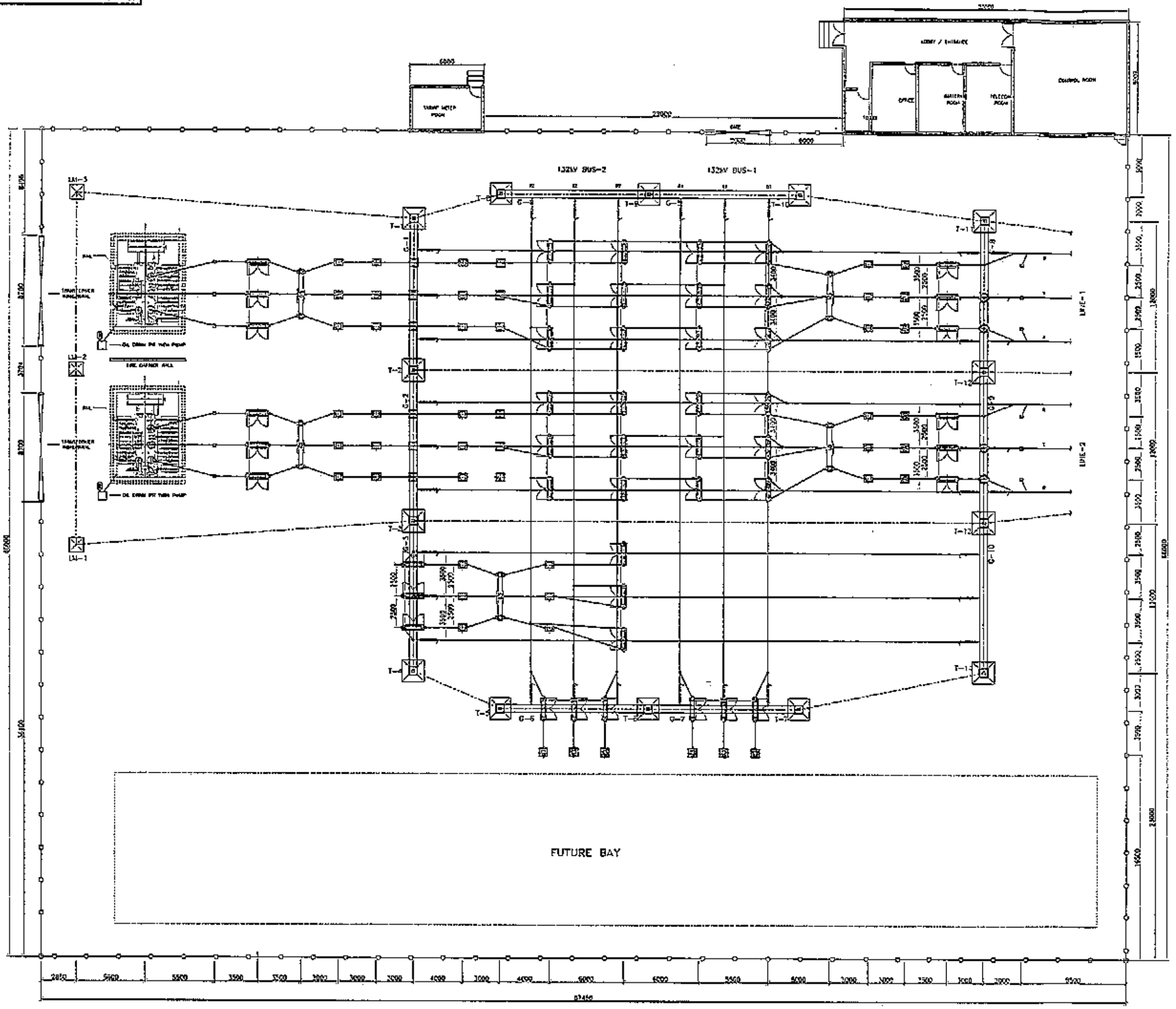
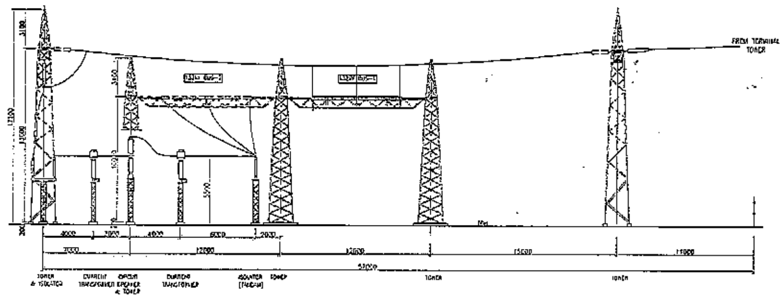
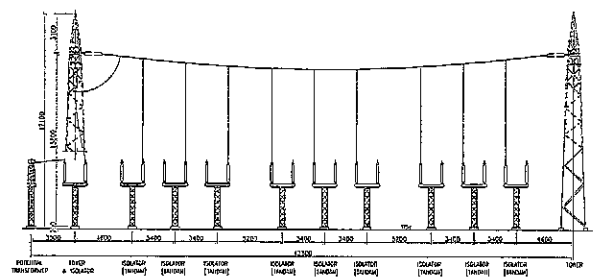
1-15308-900-0454



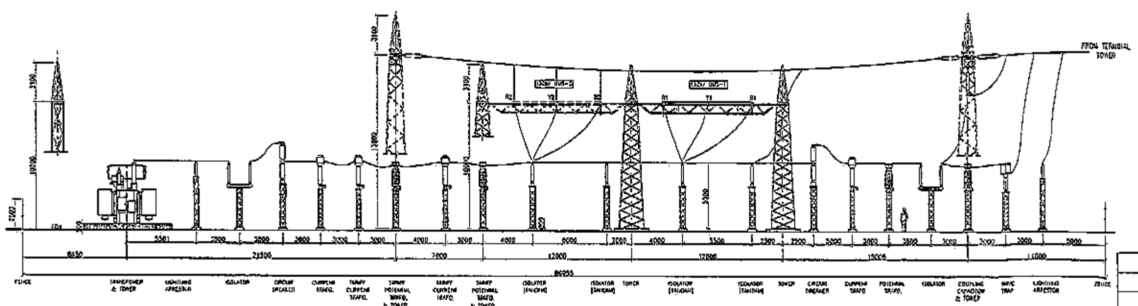
PLAN



BUS COUPLER BAY



BUS BAY



TRANSFORMER & LINE BAY

NOTE:

1. CONDUCTOR TENSION FOR DESIGNING TAKE OFF GANTRY SHALL BE 1000KG PER PHASE AT 0°C UNDERLOADED CONDITION WITH ±30° DEVIATION HORIZONTALY & VERTICALLY. MAIN BUS / CROSS BUS CONDUCTOR TENSION SHALL BE CONSIDERED AS 1000KG PER CONDUCTOR AT 0°C UNDER LOADED CONDITION.
2. SHIELD WIRE TENSION FOR DESIGNING TAKE OFF GANTRY SHALL BE 500KG, 0°C UNDER LOADED CONDITION
3. PEDESTAL LEVEL FOR ALL 132kV STRUCTURES SHALL BE +200MM ABOVE FINISHED GRAVEL LEVEL (FGL).
4. ARRANGEMENT SHOWN IN THE LAYOUT FOR SWITCHYARD AREA IS INDICATIVE AND SUPPLIER SHALL DESIGN THE LAYOUT AS PER SYSTEM REQUIREMENT.
5. EQUIPMENT INTERCONNECTION : HAWTHRON AAC CONDUCTOR

LEGEND:

ICON	DESCRIPTION
	POWER TRANSFORMER
	DOUBLE BREAK ISOLATOR
	DOUBLE BREAK ISOLATOR [TANDAM]
	WAVE TRAP
	CURRENT TRANSFORMER
	POTENTIAL TRANSFORMER
	CIRCUIT BREAKER
	LIGHTNING ARRESTER
MK	MARSHALLING KIOSK

SYSTEM PARAMETERS

Sl.No.	DESCRIPTION OF PARAMETER	132kV SYSTEM
1	SYSTEM OPERATING VOLTAGE	132kV
2	MAX. OPERATING VOLTAGE OF THE SYSTEM (rms)	145kV
3	RATED FREQUENCY	50Hz
4	NO. OF PHASES	3
5	RATED INSULATION LEVELS i) FULL WAVE IMPULSE WITHSTAND VOLTAGE ii) ONE MINUTE POWER FREQUENCY DRY & WET WITHSTAND VOLTAGE (rms)	 650kVp 275kV
6	MIN. CREEPAGE DISTANCE	AS PER SPECIFICATION
7	MIN. CLEARANCE i) PHASE TO PHASE ii) PHASE TO EARTH iii) SECTIONAL CLEARANCE iv) GROUND CLEARANCE	 1300MM 1300MM 4000MM 4600MM
8	RATED SHORT CIRCUIT CURRENT FOR 3 SEC. DURATION	40kA
9	SYSTEM NEUTRAL EARTHING	EFFECTIVELY EARTHED

A ISSUE 07.11.16

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CUSTOMER BAHAWALPUR ENERGY LIMITED

PROJECT BAGASSE BASED COGENERATION PROJECT

PROJECT CONSULTANT AVANT-GARDE ENGINEERS & CONSULTANTS (FZC.,),SHARJAH,UAE

AVANT-GARDE
ENGINEERS AND CONSULTANTS (P) LTD.
CHENNAI 600 116, INDIA.

	NAME	SIGN	DATE	NO OF ITEMS
DRAWN	S.BASKAR		07.11.16	-
CHKD.	D.RAVINCHAN RAO		07.11.16	
APPD.	S.BALAGURU		07.11.16	

DEPT EL / CODE 900	GRADE OF UN'TOL DIM C/M/F		SCALE 1:200	WEIGHT (Kg) -	REF. ASSY. DRG. NO. -	ITEM NO. -

REV. NO.	DATE	DESCRIPTION	REV. BY	CHD.	APPD.
		REVISIONS			

TITLE SWITCHYARD LAYOUT PLAN AND SECTION

DRAWING NO. 1-15308-900-0454 REV 0

CAD DRAWING NO. 15308454

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APPROVAL OF GRID INTERCONNECTIVITY STUDY

LETTER OF INTENT

ISSUED BY ALTERNATIVE ENERGY DEVELOPMENT BOARD (AEDB)

LOI

Government of Pakistan
Alternative Energy Development Board
Ministry of Water & Power
2nd Floor, OPF Building, Sector G-5/2, Islamabad
Tele: 051-9222360, Fax: 051-9222364

AEDB

Ref: B/3/21/2016/Bagasse-Biomass/BEL

October 05, 2016

Chauhdhary Khan Muhammad Ashraf
Chief Executive / Managing Director,
M/s Bahawalpur Energy Limited,
Ashraf Sugar Mills Limited,
Upper Mall Scheme,
Lahore.
Ph: 042-3571333-555
Fax: 042-35716999

Subject: **LETTER OF INTENT (LOI) TO M/S BAHAWALPUR ENERGY LTD FOR DEVELOPMENT OF 31.20MW (GROSS) CO-GENERATION POWER PROJECT AT ASHRAF SUGAR MILL LIMITED , ASHRAF ABAD, DISTRICT BAHAWALPUR, PUNJAB.**

Reference: This refers to your proposal No. 01/07/2016/01 dated July 18, 2016 on the subject cited above.

Alternative Energy Development Board ("AEDB") hereby confirms its interest in your proposal for establishing a 31.20 MW (Gross) Bagasse /Biomass based High Pressure Co-generation Power Plant under SPV i.e. M/s Bahawalpur Energy Limited (BEL) for development of 31.20MW (Gross) Cogeneration Power Project at Ashraf Sugar Mills Limited, Ashraf Abad, Punjab, ("Project") under the Framework for Power Co-Generation 2013 Bagasse/Biomass. AEDB acknowledges receipt of the Bank Guarantee No. MD1626400003 furnished by the Sponsor(s) dated September 20, 2016 to the tune of PKR 1,700,000/- (equivalent to US$ 15,600/-) with validity period up to March 19, 2018.

2. The Sponsor(s) is required to achieve the milestones listed at the Annex to this LOI ("LOI Milestones") for the subject project, at no risk and at no cost to, and without any obligation on the part of the AEDB, the Government of Pakistan, any Provincial Government or their respective agencies, within a period of 12 calendar months from the date of issuance of this Letter of Intent ("LOI").

3. The Sponsor(s) is required to carry out grid interconnection studies and environmental study. The Sponsor is also advised to liaise with the power purchaser while determining the sub-station design and layout, the transmission line, interconnection arrangements, and other related matters.

4. The validity of this LOI is 12 calendar months from the date of its issue, where after it will automatically lapse immediately (unless extended pursuant to clauses 5 or 6), being the **October 05, 2017** (the "Expiry Date"). Issuance of this LOI or the lapsing of its validity, cannot form the basis of any claim for compensation or damages by the Sponsor(s) or the project company or any party claiming through or under them against the Government of Pakistan, the Provincial Government, AEDB or any of their agencies, employees or consultants on any grounds whatsoever, during or after the expiry of the validity of the LOI.

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5. The Sponsor(s) is therefore required to achieve the LOI Milestones for the subject project within the validity of this LOI. The Sponsor(s) is also required to submit monthly progress reports. Provided the Sponsor(s) continues to pursue the project diligently, the Expiry Date of this LOI shall be extended on a day-for-day basis for the number of days of delay by which the approval or review by the relevant public sector entity listed in the LOI Milestones is delayed beyond the corresponding period stated in the LOI Milestones. In case there is a delay in achieving milestones within the validity of this LOI for reasons not attributable to a public sector entity, a one-time extension may be granted up to a maximum period of 90 days if AEDB is satisfied with the progress, provided that the Sponsor(s) enhance the amount of the bank guarantee to twice its original amount and extend its validity for a period of 06 months beyond the extended Expiry Date.

6. The Sponsor(s) shall apply to NEPRA for award of Upfront tariff within the period of validity of this LOI. Upon Upfront tariff being given, the Sponsor(s) shall forthwith submit a new Performance Guarantee in the sum of US$ 78,000/- (US Dollars Seventy Eight Thousands Only) and obtain the Letter of Support ("LOS") from AEDB within the validity period of this LOI, provided, if the award of the Upfront tariff is delayed beyond the initial validity of the LOI, the Sponsor(s) shall extend the bank guarantee for a further period of 06 months and the Expiry Date shall be extended *ipso facto* for a further period of 03 months, and the Sponsor(s) shall obtain the LOS and submit the Performance Guarantee within the extended period afore-said.

7. In case the Sponsor(s) fails to meet the LOI Milestones or perform any other obligations set forth in the Policy and this LOI, including the extension of the date of expiry of bank guarantee as provided herein, AEDB will terminate this LOI and encash the bank guarantee.

8. M/s Ashraf Sugar Mills Limited (Bahawalpur Energy Limited) and its majority shareholders as of the date of this LOI shall be the Main Sponsors of the Project.

9. Arrangement of land and fuel (Biomass/Bagasse) will be the responsibility of Sponsor.

10. This LOI is not assignable and non-transferable. This LOI shall be void upon any actual or purported assignment or transfer hereof without the prior written consent of AEDB.

11. This LOI is issued in duplicate on the date hereof, and it shall come into effect when one copy is received by AEDB after being duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at AEDB within 07 days of its issuance.

(Chauhdhary Khan Muhammad Ashraf)
Chief Executive / Managing Director,
M/s Bahawalpur Energy Limited

BAHAWALPUR ENERGY LTD.

(Mr. Amjad A. Awan)
Chief Executive Officer
Alternative Energy Development Board

Annex

S.No.	Activity	Maximum Time
1	Power Producers to submit request for Letter of Intent (LOI) with Standard proposal document and Bank Guarantee to AEDB.	
2	Issuance of Standard LOI by AEDB.	i) 7 days for sugar mills ii) 30 days for other entities as per procedure described in Renewable Energy Policy 2006.
3	Generation License to be issued by NEPRA.	10 days
4	Acceptance of Upfront tariff to the project.	10 days
5	Power Purchaser to approve Grid Interconnection Study.	30 days after submission of Grid Interconnection Study to the relevant agency by the Power Producer.
6	Issuance of LOS by AEDB upon submission of Performance Guarantee by Power Producer.	15 days
7	Energy Purchase Agreement finalization.	30 days
8	Signing of Implementation Agreement.	15 days

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FEASIBILITY REPORT OF

BAHAWALPUR ENERGY LIMITED(BWEL)

BAHAWALPUR ENERGY LTD.

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Executive Summary

1.0 Introduction

1.1 The unabated Green House Gas (GHG) emissions and its potential to cause serious damages to the environment are causing worldwide concerns. 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, and inundation of low lying seacoast areas etc. are staring at the mankind. The Earth is in 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 biomass, wind and solar energy.

1.2 Bagasse based Cogeneration, for additional power generation in 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 is close to 1800 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), Brazil etc.

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2.0 Background

2.1 Ashraf Sugar mill (ASML) operates its sugar mill in Bahawalpur district of the Punjab Province in Pakistan. This sugar mill has a capacity of 12000 Tonnes of Cane per day, 500 (TCH), and crushing period of about 130 days in a year. ASML was incorporated in Pakistan in 1980 as a Public Limited Company under the Companies Ordinance. The company's operations from the time it started commercial operations in the year 1982 has been steady. ASML belongs to The Ashraf Group, which has expanded and broadened its operations in the fields of manufacturing and agricultural activities. With a firm belief in growth & diversification and strongly committed to their motto "Commitment to Excellence" the group, after the establishment of the sugar mill,

2.2 ASML's sugar mill is modern and they have installed the most modern plant & machinery in the sugar mill. ASML, with an excellent management team and the best machinery ensure good performance of the sugar mill and consequently the mill is among the top sugar mills in the Punjab Province in terms of sugarcane crushing, production, recovery and efficiency. ASML is located in an excellent cane growing area of the Punjab Province. Located at Ashrafabad dist Bahawalpur, Punjab. The mill has good access by road. The factory is about 10 Km from the city of Bahawalpur. The nearest airport is at Bahawalpur and the nearest seaport is Karachi at a distance of about 1000 km. The factory is well connected by road to Islamabad and Lahore through highway.

2.3 Considering the good cane potential in the command area of the sugar mill, ASML is planning to enhance the crushing capacity of the sugar mill from 12000 TCD to 16000 TCD.

3.0 Project Rationale & Drivers

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3.1 While expanding the crushing capacity of the sugar mill, ASML is planning for the implementation of the high pressure Cogeneration program to generate grid quality exportable power. Even though the sugar mill operation with the existing steam and power generation system is quite comfortable, ASML is contemplating high pressure 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 Cogeneration in mind, the company had taken adequate care in ensuring the sustainability of the crushing. To that effect ASML has been concentrating on cane development to get assured cane for crushing. Also ASML, with the view to 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, the 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 framework in 2013 which promises great hopes for bagasse based Cogeneration in Pakistan. Under this new policy framework, 4 power plants have

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already achieved successful commercial operation and contributing electricity to the national grid.

4.0 Project Sponsors

4.1 For the implementation of the Cogeneration program, The Ashraf Group has set up a new company called the "Bahawalpur Energy Limited" (BWEL). BWEL will be undertaking the power project development, construction and operation activities. BWEL will sell power and steam to ASML for latter's operation and get bagasse in return from ASML. BWEL will sign the Energy Purchase Agreement with the Central Power Purchase Agency (CPPA)/National Transmission and Despatch Company (NTDC) - the Power Purchaser and sell the surplus power to the Power Purchaser. In the new company ASML will be a major stakeholder.

4.2 The bagasse generation in the sugar mill is reasonably good, at 30% 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 12000 TCD, ASML saves and hence sells a lot of 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, ASML has proposed the Cogeneration project and BWEL will take up the implementation of the Cogeneration project in sugar mill.

4.3 Under the present arrangement, the sugar plant's complete steam and power requirements are being met by 1x100, 1x80, 4x15 TPH 24 bar(a) and 350 °C boilers with matching 1x5, back pressure turbines and 1x15 MW condensing extraction turbine. In addition, there are quite a few steam turbine drives to drive the mills and the cane preparatory system devices, which are inherently inefficient. Under the Cogeneration program, the low-pressure boiler and the existing turbogenerators will be retired in phases. The drive turbines will be replaced by electric motors. The entire quantity of the steam and power requirements of the sugar plant will be met by the new Cogeneration plant.

4.4 ASML being progressive has already initiated measures to make the sugar mill energy efficient and consequently the steam consumption in the process is 41% 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. This existing facility will meet with the requirements of the mill even with the enhanced crushing more than 12000 TCD. ASML had embarked on the energy conservation measures, to bring down the steam consumption to 41%, while the contemporary mills are consuming around 55. When the Cogeneration plant is installed and operating, the process steam consumption of the sugar plant will be 41% and partial steam is considered to be extracted from the Cogeneration plant and partial from existing system. This steam quantity works out to 205 TPH for the crushing rate of 500 TCH, out of which 104 TPH can be supplied from HP Cogen and at 3 bar(a) and the 05 TPH will be supplied at 8 bar(a), remaining 101 TPH will be drawn from existing LP system at 3 bar (a). In LP system existing boiler will operate to produce 116 TPH steam, from which 15 TPH will be allowed to condenser.

4.5 With the establishment of the proposed Cogeneration project, ASML will enter into agreement with BWEL, the operator of the Cogeneration plant, for selling bagasse and buying power and steam.

5.0 Technology

5.1 For the proposed Cogeneration program BWEL is interested in going in for the proven latest technology. With the gasification of bagasse has 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 process steam required for the sugar mill. To enhance the efficiency of operation, regenerative heaters are used in the feed water circuit. For the Cogeneration power plant proposed for BWEL, the Cogeneration cycle is based on the parameters of 110 bar(a) and 540 °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 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 BWEL proposes 2x160 TPH capacity boilers and 2x31.2 MW extraction condensing turbogenerators. In this scheme ASML is planning to establish 1x160 TPH capacity boiler with 1x31.2 MW turbogenerator in its first phase. After completion of first phase BWEL will start second phase to install another plant of 31.2 MW to complete the power plant of 62.4 MW. 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 biomass fuels.

5.1 Considering 130 days of crushing operation, the sugar plant will generate around 393120 MT of bagasse. Much of the bagasse, about 165672 MT will be used for running the Cogeneration plant during the crushing period. During crushing period 1x100 TPH and 1x80 TPH existing boiler and 1x15 MW turbogenerator will also be in service which will consume 162864 MT of bagasse during 130 days of operation, producing 80 TPH and 36 TPH steam capacity basis. The season operation of the Cogeneration plant

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leaves a surplus of about 64584 MT and the same could be used for the operation of the power plant for a period of about 60 days during the maintenance periods and during the off-season. The number of operation days in the off-season could be enhanced if bagasse from other sugar mills is purchased and also suitable compatible biomass fuel is identified. Even if the biomass 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.

5.2 The power requirement of the sugar mill during the season operation, excluding the power requirements of the Cogeneration power plant is expected to be 13 MW. During the off-season period, the power requirement is estimated to 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.

5.3 The gross power generation in the Sugar mill is 11.92 MW considering two boilers and one TG in service during the season, after the implementation of the Cogeneration program will be 31.2+11.92=43.12 MW. The sugar mill power consumption will be around 14 MW. The auxiliary power consumption of the Cogeneration plant during the season operation of the plant is estimated to be 2.8 MW. Considering the above, the exportable power to the national Grid comes to 26.32 MW. The Gross energy export from the Cogeneration plant, which includes the export to the sugar mill and to the national grid, will be 28.4 MW, during the season operation.

5.4 Considering the huge investment and also the round the year power requirement of the grid, BWEL will 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 30 days. BWEL wants to operate the plant for approximately 300 days in a year for which bagasse would be purchased from other sugar mills and compatible bio-mass fuel like rice husk, wood chips etc. shall also be arranged.

5.5 During the off-season operation, the gross generation in the plant will be 31.2 MW, either with bagasse or biomass as the fuel. The auxiliary power consumption will be 2.8 MW and the power supplied to the sugar mill for the maintenance and for meeting their other load requirements will be 500 KW. It means exportable Power to the grid will be 27.9 MW.

5.6 The plant and equipment for the new proposed Cogeneration system will consist of the high pressure boiler, extraction condensing turbogenerator, 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.

5.7 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 within boundary. The present raw water requirement of the sugar mill is being met by the drawl from these sources. The water from the bore wells 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 or EDI (Electro De Ionization) system.

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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 70% 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 87.6%. With the net usable electrical power output of 28.4 MW from the Cogeneration plant, the plant electric efficiency based on the fuel LCV comes to 21.64%. The plant heat rate works out to 16,628.26 kJ/kwh. However considering the useful thermal energy output from the Cogeneration plant, the Combined Heat and Power (CHP) efficiency of the Cogeneration plant comes to 76.65%.

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 27.9 MW. Using the bagasse, the net electric efficiency based on the LCV of the bagasse works out to 29.25%. The corresponding plant heat rate works out to 12,303.35 kJ/kwh.

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 TG will be at 11 kV level. The power plant's internal consumption requirement will be met by stepping down the voltage level to 0.4 KV. Similarly the sugar mill's requirement will be met by stepping down the voltage from 11 KV to 0.4 KV. 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 BWEL's Cogeneration plant, the paralleling with the grid will be done at the MEPCO.

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8 Implementation Schedule

8.1 The implementation of the proposed new Cogeneration system first phase is expected to be completed within Twenty one (21) months, from the date of opening LC to the Supply Contractors. The Commercial Operation Date (COD) of the cogeneration project is expected to be in Sept 2018.

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. BWEL plans for engaging an Operation and Maintenance team to take over the O&M of the plant or sign contract with any experienced O&M contractor for long/ medium term agreement.

8.3 The project shall be executed on EPC basis, For this BWEL will hire experienced consultants and EPC contractor.

9 Project Cost Estimate

The Project Cost for the implementation of the 1x31.2 MW cogeneration plant at BWEL, will be approx.US$ 41.2 Million. The Interest during Construction is calculated to be US$ 2.65 Million. The total installed project cost for the proposed Cogeneration power plant will be approx. US$ 43.85 Million.

10 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. ASML's sugar mill with 12000 TCD of crushing per day will be

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able to sustain the generation of 31.2 MW of power in BWEL's Cogeneration plant in first phase for a period of about 160 days, with the bagasse generated in the mill. The proposed Cogeneration plant of BWEL, 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.

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1.0 Introduction

1.1 The fact that known fossil fuel reserves are finite and will get exhausted one day has already dawned on mankind. The future will witness growing shortage of oil, gas & coal and escalating prices for the same. Frenetic developments over the last few decades and the consequent increased energy consumption is causing irreversible environmental damage. The Green House Gas (GHG) emissions, resulting from the indiscriminate energy consumption is posing a threat to 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 is widely practiced in the process Industries and any process industry which employs low-pressure steam for the process has the potential to become a virtual powerhouse. 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.

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, 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 °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:

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- 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 increases 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 km^2 and an approximate population of 175 million. The structure of Pakistan's economy has changed from a mainly 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.

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Currently Pakistan has an installed electric generating capacity of about 20,000 MW, with the demand far exceeding this 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 renewable energy policy 2013. 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.

1.7 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, the policy aimed at laying down clear guidelines about tapping the bagasse based Cogeneration potential, did not evoke much of interest. With the support of the new policy many of the sugar mills will be taking initiatives for the implementation of Cogeneration 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.

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1.8 Ashraf Sugar Mills Limited (ASML), belonging to the Ashraf Group of industries, was incorporated in 1980 as Public Limited Company. The company which is not listed, manufactures and markets white refined sugar and it's by products, molasses and bagasse. Located Ashrafabad dist Bahawalpur in Punjab Province of Pakistan, the Company commenced its commercial production in 1982. ASML has installed most modern plant & machinery. ASML, 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 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 recently completed balancing, modernization and replacements (BMR) with the aim of "energy conservation". This "Energy Conservation" program has called for the installation of new sophisticated machinery which will increase the mill's average sugarcane crushing, reduce fuel consumption and reduce steam consumption in the process, thus enabling the mill to save more bagasse. This additional saved bagasse will be used for generating electricity for export.

1.9 The foundations for the Ashraf Group were laid in the year 1980, with the starting of the sugar mill. Since its inception as a sugar manufacturing unit, the group has expanded and broadened its operations in the fields of manufacturing and agricultural activities.

1.10 ASML is located in an excellent cane growing area of the Punjab Province. Located Ashrafabad dist Bahawalpur in Punjab Province of Pakistan The nearest airport is at Bahawalpur city at a distance of 30 Km and the nearest seaport is Karachi at a distance of about 1000 km. The factory is well connected by road to Karachi, Lahore and Islamabad through highways.

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. ASML with the daily crushing capacity of 12000 MT is one of the bigger mills in the sugar industry. ASML is planning to further increase the crushing to 16000 TCD. Realizing that the cane development is core to the business, the group has acquired 2000 acres of fertile land & established Ashraf Sugarcane Development Farms to develop their own Cane Seed for distribution to the farmers on interest free loan basis.

1.12 The progressive management of ASML, 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 31.2 MW in first phase and similar to this in second phase. BWEL proposes to implement a most modern high pressure bagasse based Cogeneration in ASML'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.

1.13 The subsequent sections of the report highlight, the scheme proposed for the BWEL'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.

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2.0 Present Factory Operation, Future plans and Cane availability

2.1 ASML is planning to upgrade the crushing capacity to 16000 TCD from the present 12000 TCD. Leaving ASML to focus on the core business of sugar, the Ashraf Group of Industries wants to implement the Cogeneration program at ASML through Bahawalpur Energy Limited (BWEL). BWEL, a separate entity, will install the Cogeneration plant and operate the same adjacent to the premises of ASML. When it comes to Cogeneration, unlike any other 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 Ashraf Sugar Mills Limited (ASML) is a 12000 TCD sugar plant operating for about 130 days in a year. The factory has a crushing capacity of about 500 TCH (on 24 hour basis) and the factory is basically a milling plant. There are two milling tandem with six mills in each tandem, the size of rollers for tandem 1 are as follows,

Mill 1	45"x84"
Mill 2 to 5	40"x80"
Mill 6	42"x84"

In tandem 1 two drives for mill no 1 and 6 have been already converted to VFD drives.

Tandem 2 as follows

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Mill 1 to 6 all sizes are 30"x60"

2.3 The fibre content on cane is high and hence the bagasse generation in the plant is 30% 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% 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 boiler is respectively 150 TPH, 5 TPH and 57.14 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 174 meters above mean sea level. The global co-ordinates of the plant are 29° 17' 35.4" N (latitude) and 71° 30' 32.4" E (Longitude). The average daily maximum temperature varies from around 28 °C in December and January to around 39 °C in June and July. The average daily Minimum temperatures vary from around 9 °C in December and January to around 21 °C in June and July. The average rainfall is insignificant, more often less than 360 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 ASML's plant are being met from internal generation. ASML processes 500 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 220 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 total steam requirement is at a pressure of 2.5 bar (a) and at about 130 °C at the consumption points in the sugar mill. The total power consumption of the sugar mill, as of now is about 10 MW. Part of the power requirement of the sugar mill is being supplied by the steam turbine drives (for the mills and shedders) and the balance requirement is being met from in house power generation.

2.6 Using the fuel (bagasse) generated in-house ASML generates the total steam and power requirements internally. The total steam generation for the plant is being met from six steam boilers. All the boilers are with the MCR capacity of 1x100, 1x80 and 4x15 TPH. All existing boilers have the same outlet steam parameters of 24 bar(a) and 350 °C. The boilers are designed to burn bagasse. All the boilers are designed with a feed water inlet temperature of 105 °C, with the feedwater heated in a deaerator. With 240 TPH of aggregate steam generation capacity, all the boilers will be operating, although under lower capacity, to meet with the process steam requirements of 220 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 2.0.

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 is provided with the steam turbine drives are the mills and shredders of the sugar plant. 15 MW turbine is of extraction-condensing type and 05 MW turbine is of back pressure type. The electric power requirement of the sugar plant is being met by these turbogenerators of 15MW and 5 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 345 °C. The exhaust pressure of the

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backpressure turbine and the extraction turbine from both turbines are at 2.5 bar(a), and the entire exhaust and extraction steam from the turbines are taken to the process. The exhaust temperature is at around 180 °C. This exhaust steam is de-superheated with spray water to around 130 °C and taken to the sugar process. During normal operation, the exhaust steam from the turbines substantially meets with the low-pressure process steam requirements. The balance of the process steam requirement is met through the steam drawn through the pressure reducing and de-superheating (PRDS) stations.

2.8 Presently, the total power requirement of the plant works out to about 26 kW per Tonne of cane crushed and for a crushing rate of 500 TCH, the total power requirement works out to about 13 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 capacity of 350 KVA, with 415 V bus bar. This DG set is used for providing the start up power and emergency power requirements. Apart from this, the plant also has grid power connection.

2.9 ASML 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 wastewater. The wastewater 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 final clarification. The treated water BOD levels and COD levels are brought down to <20 ppm and <30 ppm respectively and then let out into the fields/canal. The molasses is sold off.

2.10 Future Plans

The plant with the present crushing capacity of 12000 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. ASML is planning to increase the crushing capacity to 16000 TCD and the capacity up-gradation 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 Phase 1 of the new Cogeneration plant, the existing two boilers and one turbogenerator and the drive turbines will be retired. 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 TCH of cane crushed.

2.11 Cane Availability

ASML is located at Ashrafabad dist Bahawalpur in the Punjab province. The operational area is adjacent to the district boundaries of Faisalabad and Okara. The operational area is located at an average altitude of 461 meters above the mean sea level. The cultivable area surrounding the sugar mill is approximately 1,75,000 Acres distributed over 136 Chaks. While about 40% of the area is ground water irrigated, the balance of 60% is irrigated through canals. The operational area is with a good system of irrigation canals, which helps in the irrigation during the periods when water is available in the canals. However during the drought conditions when water is not available in the canals, these areas are also irrigated with ground water. The major advantage in the operational area is that in the whole of the operational area, the ground water availability is very good and suitable for irrigation. The major crops in the area are sugar cane, wheat, Maize, Potatoes, Peas and Rice and sugar cane. Every though the sugar cane is considered as a predominant crop in the command area, it still forms only 30% of the agricultural production in the area.

Soil & Irrigation:

Soils in operational area of the sugar mill are typically loamy and clayey. The soil in this area is mostly clayey. The whole of the operational area is levelled and semi levelled and is very well drained without water logging. The soil pH is typically 7.5.

Irrigation play vital role for sugarcane growing, as it is required right through the crops life from the pre-sowing till harvesting. The approximate requirement of irrigation for cane crop is to the tune of 64 acre-inches. As seen elsewhere the operational area is catered by both canal irrigation and ground water irrigation. However, unfortunately with the prevailing situation with regard to water availability for irrigation is causing great concern. Due to increasingly less rainfalls, low water storage in the dams due to less water arrivals and silting, there is lack of adequate water for areas catered by canal irrigation systems. There are also problems with the ground water as the depth at which water is available is too deep. Although there is adequate ground water fit for irrigation, owing to frequent load-shedding and high prices of diesel, many a times the cost of cultivation goes up.

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Climatic conditions:

Temperature & Humidity:

Climate plays an important role in sugarcane productivity and sugar cane is basically a tropical crop. The temperature range conducive to growth and maturity is from 10 °C to 35 °C, with the humidity remaining optimum. Unfortunately in the operating area of ASML, the temperature remains at the extremes between below "0" to 48 °C. This temperature is not very conducive for cane growth and this is one of the reasons why the yield and recovery remain low in the area of the sugar mill.

Rainfall:

The rainfall in the operational area is between 100 mm to 200 mm per annum. Out of this 70% rainfall happens between July and mid September during the monsoon and the balance portion is spread in the remaining months. This rainfall is inadequate for sugar cane, which needs typical tropical rainfall ranging from 900 mm to 2000 mm per annum.

Land Holding and Present Status of Sugar Cane Cultivation:

There are around 8800 growers engaged in sugar cane cultivation and supply in ASML's command area with a radius of 25 to 30 kMs. The number of farmers holding up to 10 acres, between 11 to 20 acres, between 20 to 25 acres and above 25 acres is respectively 45%, 28%, 18% and 9%. It may be seen that the percentage of small and marginal farmers is very high at 45%.

High prices of all sugarcane related inputs like the fertilizer, pesticides/weedicide, restricted availability of electricity and high electricity rates, high diesel prices are driving away the farmers from sugar cane cultivation. ASML has been interacting with the farmers on day to basis and does a lot of handholding by providing technical assistance from sowing to harvesting. ASML is also providing fertilizer, pesticides/weedicides and improved variety of seeds to the farmers on interest free loan basis. ASML has also established a Biological, soil and water testing laboratory to help the farmers technically.

Sugarcane Development

The main objectives of the Sugar Cane development program are to achieve the following.

- To increase the productivity i.e., sugarcane and sucrose yield
- To protect the crop from pest and diseases, weeds.
- To minimize the cost of cane production.
- To conduct research and development.
- To increase area under irrigation by exploiting ground water.

ASML's Plans for Improving Cane Yield:

Every sugar mill embarks on programs to improve the cane yield, which will increase the cane arrival to the factory. These programs include, changing the cane varieties, improving irrigation, ratoon management, harvesting, pest control etc. The peculiar problem ASML faces from the point of view of enhancing the cane arrivals is that the whole of the operational area is already under cultivation and there is no additional uncultivated area available for bringing under cultivation. The only option for ASML to increase the cane arrival to the factory is to increase the cane yield per acre with minimum utilization of the resources. As seen earlier, sugar cane forms only 30% of the agricultural production and by motivating the farmers with support and timely help ASML can make them move away from other crops to sugar cane. However, considering the other cash crops grown in the area, these efforts may only marginally increase the sugar cane area in the operational area. The following gives the program of ASML to maximize the sugar cane yield and to get maximum recovery.

1. Introducing high yielding sugar rich and location specific cane varieties, like HSF-240, CPF-237, HSF-242, CPF-246, CPF-247 ETC.

2. Timely supply of Seed, Fertilizer, Micronutrients, Compost and other Bio-inputs for good production.

3. Financial assistance for improvement of irrigation resources.

4. Link roads through sugarcane (Dev) Cess Fund, particularly towards River Bank side.

5. Adopt wide spaced cultivation and mechanization.

6. Introduce the system of Computerized Software for monitoring of individual Farm cultivation activities.

7. Introducing usage of deep tillage implements, Ridger, Sugarcane Planter, Trash Shredder and Ratoon Shaver, through Factory purchase.

8. Establishment of Bio Technology Units (Tissue Culture Lab) for micro propagation of sugarcane varieties and production of disease free planting material.

9. Plant and soil testing Laboratory for sugarcane growers.

10. Compost production units for bio-compost production and supply to growers at subsidies rates.

11. Bio-Pesticide production Units, to produce biological pest and disease control for sugarcane like, Trichograma Cards.

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12. Induction of Agricultural Graduates (about 8 - 10) in the rolls of ASML, to inculcate the growers about latest agro practices.

13. To set up various sugarcane plots, consisting on 25 - 50 Acres area, under proper Supervised Programme which will cover the whole gamut of cane cultivation from pre-sowing activities to harvesting of crop. This will be done in the Group's Agricultural Farms.

Cane Supply Assurance:

ASML's existing crushing capacity is 12000 TCD and it is proposed to increase the crushing to 16000 TCD. Most of the sugar mills in Pakistan have higher crushing capacities and are still expanding the crushing capacities. The large milling capacity enables rapid processing of cane and reduces crushing delays for growers and this is very big advantage to the farmers. However, it is a challenging task for the company's cane management to feed the mills consistently during the crushing season. Without the assurance of the continuous arrival of cane the mill cannot run effectively and efficiently.

The foregoing gives ASML's efforts to bring in more cane to the factory and to ensure that the sugar mill operates at the designated capacity at least for a period of 130 days in a year. With the company's efforts to improve the cane yield, ASML is confident of continued crushing for a minimum of 130 days, which will ensure the fuel for the proposed BWEL's Cogeneration project.

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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 biomass is used as the fuel for running the Cogeneration plant.

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

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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.

3.1.2 One of the major advantages with the bagasse based Cogeneration projects is that the fuel, at least 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.

3.1.3 Gasification is the most promising technology and could be the technology of the future for most of the biomass 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 BWEL, 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.

3.1.4 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.

3.1.5 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.

3.1.6 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 °C and later with 510 °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 fine-tuned 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 °C, at the inlet of the turbine.

3.1.7 Looking from purely the Cycle Efficiency point of view, with the selection of 535 °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).

3.1.8 Based on the considerations enumerated in the preceding paragraphs, the cycle parameters are decided as 105 bar(a) and

535 °C at the turbine throttle valve inlet. Correspondingly the boiler outlet parameters shall be 110 bar(a) and 540 °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). 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 BWEL

The Cogeneration plant proposed of BWEL will be based on the boiler outlet steam parameters of 110 bar (a) and 540 °C. The steam parameters at the inlet of the turbine will be 105 bar(a) and 535 °C. Operating in parallel with the sugar mill and synchronizing 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 and / or purchased bagasse and / or on biomass 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 BWEL is developed.

3.3.1 The nominal cane crushing capacity of the sugar plant, for designing the Cogeneration plant, will be 12000 TCD in 24 hours or 500 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 ASML's sugar plant will continue to be 130 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 ASML has done a lot of improvements in the operation of the sugar mill and consequently the sugar mill had been undergoing a lot changes. The present crushing capacity of 12000 TCD will be upgraded to 16000 TCD to coincide with the implementation of the Cogeneration plant. Depending on the cane availability and many other factors, there could have been a lot of ups and downs in the crushing and the actual factory time efficiencies recorded earlier will not be relevant. Considering the efforts being made by ASML 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 12000 TCD and the Cogeneration program is implemented.

3.3.4 The average bagasse percentage on cane is 30% 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% (on cane) of bagasse will be available for the operation of the Cogeneration plant. With 500 TCH of crushing the bagasse generated in the plant will be 150 TPH. Out of this 5 TPH of

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bagasse (about 3.33% 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 ASML for sale to BWEL.

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 °C. The requirement of this low-pressure steam shall be 44% 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 8 bar(a) steam will be 180 °C. On the whole the total process steam consumption comes to 44% on cane. Considering the fact that ASML manufactures white refined sugar, this steam consumption may be only slightly on the higher side. As ASML is constantly modernizing and updating the technology, this steam consumption could also come down to 41% on cane. The actual quantities of 2.5 bar(a) and 8 bar(a) steam required by the mill are respectively 220 TPH and 5 TPH. Apart from the process steam requirement of the sugar mill.

3.3.6 With the view to enhancing the export from the Cogeneration plant, ASML/BWEL will be replacing the inefficient steam turbine drives in the sugar mill with electric motors drives. The mills that crush the cane are presently driven by steam turbines 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 13 MW. All the rotating equipment in the sugar mill will be electric motor driven and there will be no steam driven drives.

3.3.7 The sugar mill presently operates 1x100, 1x80, 4x15 TPH boilers with the outlet steam parameters of 24 bar (a) and 350

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ASML also operates one backpressure turbine 1x5 MW and one condensing extraction turbine 1x15 MW respectively. With the commissioning of Phase 1 of BWEL's Cogeneration plant, 4x15 TPH existing low pressure boiler and 5 MW turbogenerator at ASML will be retired. With the construction of phase 2 that will be total 62.4 MW, all existing old boilers and turbogenerators will be retired.

3.3.8 The Cogeneration plant boilers will be designed with a travelling grate with hydraulic drive to burn bagasse, and biomass fuels. The outlet steam parameters will be 110 bar (a) and 540 °C. The boiler MCR capacity will be 155 TPH. The inlet feed water temperature will be 210 °C, with the feed water heated in two stage high pressure feed water heaters. The deaerator outlet water temperature will be around 130 °C, depending on the extraction pressure.

3.3.9 The proposed new turbogenerator will be of 31.2 MW nominal capacity. The turbine will be extraction condensing type machine. The turbine steam inlet parameters will be 105 bar(a) and 535 °C and there will be three steam extractions form 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 21 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.

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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 °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, process steam requirement of the sugar mill will be partially catered by the steam drawn from the turbine extraction. Suitably sized pressure reducing and de-superheating stations will be provided for meeting the process steam requirement of ASML, 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 turbogenerator will be operating in parallel with the national grid. Partial 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 turbogenerator. 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 nearby MEPCO grid sub-station or LI LO in 132 Kv system through double circuit overhead transmission lines.

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. 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, new bores will be established. As the existing system in the sugar plant is just sufficient to meet with the requirements of the sugar mill, it is proposed to provide totally independent raw water and treated water system for the proposed Cogeneration project. The new system will include the storage reservoir, Ultra-filtration, Reverse Osmosis, EDI 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, However, for the present, the extractions from the Cogeneration plant turbine will just meet with the requirements of the sugar mill process only.

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 requirement. As the bagasse percentage in cane is quite 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 to supply in national grid.

3.4 Description of the Proposed Cogeneration Scheme

For Phase 1, the Cogeneration scheme proposed at BWEL envisages one unit of 31.2 MW capacity. Unit will be designed

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with a 160 TPH capacity boiler with the outlet steam parameters of 110 bar(a) and 540 °C, with the feed water inlet temperature of 210 °C. Turbogenerator will be of 31.2 MW nominal capacity and designed with an extraction (with two uncontrolled extractions and one controlled extraction) condensing turbine. Second phase of 31.2 MW will be constructed after successful completion of phase 1. The Cogeneration plant will be designed with all the auxiliaries for the new boiler and the turbogenerator 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.

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 MEPCO's nearest transmission line.

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 21 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.

The 31.2 MW Cogeneration plant consisting of new 160 TPH boiler and the 31.2 MW turbogenerator and all the auxiliary plants and systems will be located adjacent to sugar mill complex.

boundary. 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 The Scheme of operation of one 31.2 MW Cogeneration plant. All descriptions pertaining to the configuration of the power plant below are given for a single unit. There will be one unit in the Cogeneration plant. This system is configured with a 160 TPH boiler and an extraction-condensing 31.2 MW turbogenerator. During the normal crushing period operation, the boiler will generate 160 TPH of steam with the outlet parameters of 110 bar(a) and 540 ° C., while taking in the feedwater at 210 °C from the high pressure feedwater heaters. During the season operation, the boiler essentially operates on bagasse and consumes 59 TPH of bagasse, for the generation of the above-said 160 TPH of high-pressure steam.

The entire steam generated in the boiler is fed to the extraction-condensing turbogenerator. The un-controlled extraction from the turbine at 21 bar(a) gives 12 TPH of steam at a temperature of 320 °C. The entire quantum of 21 bar(a) steam will be used in the high pressure feed water heater II for raising the feed water temperature from 170 °C to 210 °C. The un-controlled extraction at 9 bar(a) gives 10 TPH of steam approximately at a temperature of 230 °C and this meets with the requirements of the high pressure feed water heater I, 8 bar(a) steam requirements of the sugar mill process and the requirements of the ejector in the condenser. A quantity of 12 TPH is supplied to the high pressure feed water heater, to heat the feed water from 130 °C to 170 °C, a quantity of 2.5 TPH goes towards meeting 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.

The controlled extraction at 3.0 bar(a) provides 119 TPH of steam at around 134 °C. Out of this 119 TPH of steam is taken to the sugar process, for heating and boiling the sugarcane 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 10 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 °C.

The condensate of the 205 TPH of process steam supplied to the sugar mill, will be returned back to the deaerator to be used as boiler feed water. There will be a loss of a maximum of about 5% of the quantity of steam supplied and a condensate quantity of 100 TPH is returned to the Deaerators of existing boilers and remaining to Cogen boiler.

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 feedwater 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 100 °C and could be directly inducted into the Cogeneration plant's deaerator. However, the condensate temperature of 95 °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/ EDI system based water treatment plant.

3.5.1.2 Power Balance during the Season Operation:

With the installation of Phase 1 of the new Cogeneration plant, the total power generation in the sugar plant, with 500 TCH crushing will be 43.12 MW, showing 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 2.8 MW. This comes to about 8.9% of the electrical power generated. The total power requirement of the sugar plant including the power requirement of the colony, HP Cogen and administration buildings etc., is estimated to be 16.8 MW.

With the in-house auxiliary consumption of 2.8 MW and with the power export of 14 MW to the sugar mill complex the export power to the national grid comes to 26.32 MW. 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 MEPCO's network at 132 KV nearby transmission line with LI LO scheme.

3.5.2 Off-Season Operation

3.5.2.1 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 shutdown 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.

The scheme for the operation of the 31.2 MW Power plant system during the off-season period of the sugar plant 160 TPH boiler will generate 120 TPH of steam at the outlet parameters of 110 bar(a) and 540 °C. The generation in the boilers is restricted to match with the turbogenerator requirement for generating 31.2 MW under operation with no steam extraction from the turbine port for the sugar mills process. The gross power generation of the turbogenerator will be 31.2 MW. The feed water will be supplied to the boilers at 210 °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. The boiler consumes 45 TPH of bagasse, under the above-required generation.

The total steam quantity of 120 TPH generated in the boiler will be fed into the 31.2 MW turbine. The uncontrolled extraction at 21 bar(a), now supplying steam only at 15 bar(a) will be 8 TPH at about 300 °C. The entire steam quantity will be supplied to the second stage high-pressure feedwater heater. The second uncontrolled extraction at 10 bar(a), now supplying steam at only 8 bar(a) will be supplying 8.8 TPH of steam. Out of this 8.8 TPH, about 8 TPH will go to the first stage high pressure feed water heater, and the balance of 0.8 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 10 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 92 TPH is supplied to the LP section of the turbine and is then exhausted into the surface condenser at a condenser operating pressure of 0.102 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 feedwater pumps.

With the above given steam input and extractions the 31.2 MW turbogenerator generates 31200 kW at the generator terminals.

3.5.2.2 Power balance during the off-season Operation

The total gross power generation from the 31.2 MW TG systems will be 31200 kW. This 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 31.2 MW Cogeneration system is estimated to be 2.65 MW, 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 cooling towers. Net exportable energy to grid will be 28.1 MW.

This exportable power will be supplied to the network at the MEPCO's 132 KV system.

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4.0 Fuel for the Power Plant & Plant Efficiencies

4.1 Design Fuels

The proposed Cogeneration power plant of BWEL will be designed for operation with the bagasse and biomass fuels. Bagasse is the cane residue that remains after the extraction of the juice from cane and this bagasse will be supplied to BWEL under the fuel sale agreement with ASML. This bagasse will be supplied to BWEL during the cane crushing operation of ASML. 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 purchased bagasse and acceptable biomass fuels. BWEL will look for compatible biofuels to supplement bagasse so that the plant could be run for a longer duration with biomass fuels. Even if such a compatible biomass 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. BWEL will undertake a study on the availability of the biomass 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.

4.1.1 Bagasse

Bagasse is a biomass fuel and is considered to be belonging to the category of renewable energy source. Bagasse, as is the sugarcane 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 biomass is considered to be carbon neutral and hence is environment friendly. 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/m^3. The quantity of bagasse generated in the sugar mill and the quantity made available for the operation of the BWEL are dealt with in the Section 3 "Technology and Proposed Scheme for the Project".

The major advantage of using the bagasse in the power plant 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.

4.1.2 HHV and LCV of the Fuels

The Higher Heating Value (HHV) or the Gross Calorific Value (GCV) includes the heat of vapourisation 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 vapourization is not available as the heating value of the fuel.

The design fuels, 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.

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

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

For Bagasse, LCV = 9311.44 - (218.55*2.895 +24.28*50)
LCV = 7457.09 kJ/kg

4.2 Fuel Balance during the Seasonal operation

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% moisture) percentage in cane being 30%, on an average, and with the crushing rate of 500 TPH of cane the bagasse generated will be 150 TPH. Out of this about 5 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 393,120 MT.

Generating 160 TPH, Cogeneration plant boiler will consume 59 TPH of bagasse. Seasonal consumption comes to 328,536 MT. This leaves a surplus of 64,584 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.

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 sugarcane crop attractive compared to the other crops in the region. BWEL's idea is to operate the plant more as a plant using the renewable biomass 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 biomass fuels. The boilers are designed for such an operation.

4.3 Fuel Balance for the off-season Operation

As seen earlier, after the consumption of the bagasse in the season operation, a quantity of 64,584 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 45 TPH for one boiler, with this saved bagasse the power plant can run for about 60 days in the off-season. The number of off-season operation days could be improved with the availability of purchased bagasse and some compatible biomass fuels.

4.4 Efficiency of Operation during the Season

It is proposed to operate the new high-pressure Cogeneration plant boiler with bagasse during the seasonal operation. The boiler designed for bagasse could also use other compatible biomass 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 70%.

The boiler efficiency with LCV of bagasse will work out to 87.6%. The HHV and the LCV of 50% moisture bagasse respectively are 9311.44 kJ/kg and 7457.09 kJ/kg.

The net electrical output of the power plant during the season operation will be 28400 MW, considering the auxiliary power consumption of 2800 MW 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 104 TPH at the parameters of 3 bar(a) and 131 °C and 5 TPH at 8 bar(a) and 175 °C. Each kg of 3 bar(a) process steam carries a thermal energy of 2719.33 kJ and the each kg of 8 bar(a) process steam carries a thermal energy of 2779.62 kJ.

The fuel supplied for the operation of the boiler will be 59 TPH of bagasse with the gross calorific value of 2224 kcals/kg or 9311.44 kJ/kg. The LCV of the fuel will be 1781.09 kcals/kg or 7457.09 kJ/kg. The Fuel heat input, based on LCV of the fuel, to the boilers per hour will be 425.051 GJ /hr.

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 24.05% (28400x3600x1000/425.051E09). 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 76.65%.

The net electric power	: 28400 KW : 102.24 GJ/hr.
Heat energy supplied to Sugar process	: 270.5 GJ/hr
Heat Energy returned to Cogeneration plant	: 40.62 GJ/hr

Net Thermal Energy Supplied per Hour	: (270.5-40.62) : 229.88 GJ.
CHP Efficiency	: ((102.24+229.88)/425.051)x100 : 78.13 %

4.5 Efficiency of Operation during the Off-Season

As seen earlier in this section of this report, the plant will be operating with bagasse and compatible biomass fuels during the off-season. However, for the purpose of this report the off-season fuel is restricted to saved/purchased bagasse from the season operation. Under bagasse firing, the boiler efficiency with HHV of bagasse is estimated to be 70%. The boiler efficiency with LCV of bagasse will be 87.6%.

The net electrical output of the power plant during the off-season operation will be 28,200 kW, considering the auxiliary power consumption of 2,652 kW and 500 KW will required for sugar mill maintenance 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 28.05 MW.

The fuel supplied for the operation of the boiler, under bagasse firing will be 45 TPH. The Fuel heat input to the Cogeneration power plant, based on LCV of bagasse, per hour of off-season operation will be 335.569 GJ/hr.

The net electric efficiency of the plant, based on LCV, under bagasse firing will be 30.89% (28800 x 3600 x 1000/335.569E06).

4.6 Commentary on the Plant Efficiency

Conventionally the bagasse fired boilers in the sugar mills had been designed for lower operating pressure and temperatures 23 bar(a) & 350 °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:

1. With the sizes being small, the boilers and turbines are made only for lower pressures and temperatures. On the temperature front the modern plants come closer to the sub-critical utility parameters, but the pressure still remains lower.

2. The boilers and Turbine manufacturers have typical Industrial equipment standards and try to fit these plants into the existing designs.

3. These sizes of plants typically do not use reheat cycle.

4. The size of the turbines does not allow many extractions and hence the extent of use of feed water heating is limited.

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5. 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 at least by 2 to 3%.

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

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5.0 Justification for the Project

5.1 To meet Country's Growing Energy Need

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 hydroelectric 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.

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.

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.

The BWEL project will approximately replace 120,000 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

The present crushing capacity of ASML is 12000 TCD and this could be achieved through 24 hours of operation of the plant. ASML 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

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steam generation capacities are adequate even for meeting these requirements.

The existing boilers are with the steam parameters of 24 bar(a) and 350 °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 240 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. Even though 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 21 bar (a) and 340 °C. Here again the turbines are of older design and not comparable to the new generation of turbines with regard to the efficiency.

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 sugarcane 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.

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.

The above justifies the need for the Cogeneration plant to be operated in parallel with ASML's sugar mill. Even though 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, ASML's plant could go ahead with the present operation without resorting to Cogeneration or any of these proposed changes. Even with the crushing to 12000 TCD, the steaming capacity available with the existing three boilers is adequate for the plant's operation. As a business proposition ASML 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 most probably be implemented through a separate company called Bahawalpur Energy Limited (BWEL). 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:

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 °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 CO_2, 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 CO_2 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.

Electric utilities contribute greatly to the emission of the GHG to the atmosphere. Wherever, 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.

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.

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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

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.

There are a lot of issues involved like determination of the base line technology, ways of ensuring that there will be increase 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.

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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.

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.

Looking at the project from the above perspective, there is ample justification for BWEL to go ahead with the project implementation at the earliest.

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6.0 Cogeneration Plant Design Criteria

6.1 General

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.

The proposed new cogeneration facility at Bahawalpur Energy Limited (BWEL) will be operating 130 days during the cane-crushing season and will be operating during the off-season period with saved bagasse, and compatible fuels. 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 Ashraf Sugar Mills Limited (ASML). The cogeneration plant at BWEL consists of one unit of 31.2 MW. unit comprises of one (1) 160 TPH capacity boiler along with other auxiliaries and one 31.2 MW Turbogenerator.

The condensate from the sugar mill evaporators will be taken back to cogeneration plant deaerator and existing LP boiler Deaerator 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.

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.

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.

6.3 Ambient Conditions

Plant Elevation above Mean Sea Level (MSL): 115 meters

Temperatures:

- Maximum Temperature : 39.0 °C
- Minimum Temperature : 9.0 °C
- Plant Design Temperature (Performance design) : 30 °C
- Plant Design Wet Bulb Temperature : 29 °C
- Plant Design Temperature for Electrical Equipment : 50 °C

Relative Humidity:

• Maximum	: 72.0 %
• Minimum	: 36.0 %
• Plant Design Relative Humidity	: 70.0 %

Precipitation:

• Total Annual Rainfall	:360 mm average

Wind:

• Wind Direction	: West to East
• Design Wind Velocity	170 Km/Hr
Seismic Coefficient	**: as per UBC Vol.II 1997**

Soil Bearing Capacity:

• **At 2m Depth (MT/Sq.M)**	**9 (sandy)**

6.4 Design & Guarantee Fuel for the new cogeneration plant

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

BWEL receives bagasse from ASML's sugar plant and it generates bagasse during its cane crushing operation and the bagasse percentage on the cane is an average of 30%. With the crushing rate of 12000 TCD or 500 Tonnes per Hour (TPH), the bagasse generated per hour will be 145 Tonnes per Hour. This 145 TPH bagasse will be with 50 % moisture content. Out of the generated bagasse, 5 TPH will be used for meeting the process requirements and the balance of 140 TPH will be made available for the Cogeneration boilers operation. This bagasse will be consumed in the cogeneration boiler and existing LP boiler during the season operation and saved bagasse will be stored in the bagasse yard. Additional Storage area for bagasse will be made available by BWEL. In the off-season operation or during cleaning days of sugar plant, the power plant will be in operation with this saved bagasse and biomass fuels.

6.4.1 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	:	2224kcal/kg

b. Typical bagasse ash analysis:

ASH ANALYSIS	Design	Minimum - Maximum
Fe_2O_3	18.10	15.0 to 21.0
MnO	1.04	0.5 to 1.5
Cr_2O_3	0.13	0.05 to 0.20
V_2O_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_2O	3.26	2.00 to 12.00

ASH ANALYSIS		Design	Minimum - Maximum
P_2O_5		1.83	1.00 to 2.50
SiO_2		54.80	45 to 75
Al_2O_3		7.80	5.00 to 10.00
MgO		9.10	7.00 to 15.00
Na_2O		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	

6.5 **Raw Water**

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. .

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

Physical Examination

Appearance when Analysed	Clear
Appearance after Filtration	Clear
Turbidity	1.3 NTU
Total Suspended Solids	<5.0 mg/l
Smell	No Smell

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Colour	4.0 PtCo/Hazen
pH Value at 25 °C	7.71
Electrical Conductivity	1005 μs/cm
Colloidal Non-Reactive Silica	N.D.
Chemical Examination (Cations)	
Calcium as Ca^{++}	18.24 mg/l
Magnesium as Mg^{++}	66.76 mg/l
Sodium as Na^{+}	135.5 mg/l
Potassium as K^{+}	6.26 mg/l
Ammonium as NH_4^{+}	N.D.
Aluminium as Al^{+++}	N.D.
Barium as Ba^{++}	0.039 mg/l
Copper as Cu^{++}	N.D.
Iron as Fe^{++} (Ferrous)	0.213 mg/l
Iron as Fe^{+++} (Ferric)	N.D.
Manganese as Mn^{++}	<0.5 mg/l
Zinc as Zn^{++}	0.005 mg/l
Strontium as Sr^{++}	2.585 mg/l

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Chemical Examination (Anions)

Chloride as Cl^-	47.14mg/l
Fluoride as F^-	.05 mg/l
Nitrate as NO_3^-	0.7 mg/l
Nitrate Nitrogen as N	0.22 mg/l
Nitrite as NO_2^-	.003 mg/l
Total Phosphate as PO_4^{---}	0.163 mg/l
Sulphate as SO_4^{--}	225 mg/l
Sulphide as S^{--}	N.D.
Sulphite as SO_3^{--}	N.D.
Lime as CaO	146 mg/l
Reactive Silica as SiO_2	1.78 mg/l
Total Volatile Solids	120 mg/l
Total Fixed Solids	736 mg/l
Total Dissolved Solids	676 mg/l
Total Hardness as $CaCO_3$	319.2 mg/l
Methyl Oranges Alkalinity as $CaCO_3$	430 mg/l
Phenolphthalein Alkalinity as $CaCO_3$	N.D.

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Organic Constituents Examination

Biochemical Oxygen Demand (BOD_5) at 20 °C	< 2.0 mg/l
Chemical Oxygen Demand (COD)	5 mg/l
Dissolved Oxygen as O_2	4.9 mg/l
Total Organic Carbon (TOC)	1.24 mg/l
Ammonical Nitrogen as N	N.D.
Albuminoid Nitrogen as N	N.D.

Toxic Substances

Lead as Pb (Heavy Metal)	N.D.
Cyanide as CN	N.D.
Mercury as Hg (Heavy Metal)	N.D.
Chromium as Cr (Heavy Metal)	N.D.
Nickel as Ni (Heavy Metal)	N.D.
Cadmium as Cd (Heavy Metal)	N.D.
Arsenic as As (Heavy Metal)	0.002 mg/l
Sulphide as H_2S	N.D.

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Gases	
Free Carbon Di Oxide as CO_2	17 mg/l
Ammonia as NH_3	N.D.
Microbiological Examination	
Sulphate Reducing Bacteria (SRB) MPN/100 ml	N.D.
Total Bacterial Count (CFU/ml)	86 CFU/ml
Additional Parameters	
Bisulphate as HSO_4	110 mg/l
Bisulphite as HSO_3^-	N.D.
Bicarbonate as HCO_3^-	430 mg/l
Carbonate as CO_3^{-2}	N.D.

6.6 Steam Generator & Auxiliaries

The new steam generating system for the Cogeneration plant will consist of one bagasse fired boiler with a Maximum Continuous Rating (MCR) of 160 TPH each, with the outlet steam parameters at 110 bar(a) and 540 °C. The tolerance on the superheater outlet temperature shall be ± 5 °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.

The dust Concentration in the flue gases leaving the boiler shall be a maximum of 150 mg/N.Cum.

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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 %.

Boiler Feed Water

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

- pH	:	8.8 - 9.2
- Oxygen	:	0.007 ppm
- Hardness	:	0
- Total Iron	:	0.01 ppm
- Total Copper	:	0.01 ppm
- Total Silica	:	0.02 ppm
- Hydrazine	:	0.01-0.02 ppm
- 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

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

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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.

6.7 Turbogenerator & Auxiliaries

The TG shall be a 1 no. 31.2 MW nominal capacity triple extraction condensing machine. The speed of the turbine shall be preferably around 6000 rpm, however a turbine directly driving the alternator without a gearbox 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, Process steam requirement for sugar plant and diary 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.

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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 ± 5%. The complete electrical systems will be designed to meet with the requirements of the National Grid Code.

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.

6.8 Auxiliary Plant and Equipment

6.8.1 Fuel handling

The fuel for the cogeneration plant operation during the season is bagasse from the ASML'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 21° The Belt speed shall be approximately 1.1 meters/sec. The maximum moisture percentage in bagasse shall be 56%. The fuel handling capacity will be 150 TPH considering phase 2.

The fuel for the power plant during off-season operation shall be saved bagasse and other biomass fuels.

6.8.2 Ash handling

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

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.

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.

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/m^3 and that to be used for load calculations shall be 600 $kg/\ m^3$ for bagasse ash.

All the ash will be collected in storage silo having a suitable capacity & will be disposed-off by trucks / trailers.

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6.8.3 Cooling Tower

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 31.2 MW shall be a minimum of 6800 m^3/hr, and there shall be a minimum of two (2) Cells. For each of capacity 3400 M^3/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 29°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.

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.
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 eliminator	Minimum 80%, if a circle is projected on the drift plan area at 45 ° angle from fan cylinder opening

6.8.4 Pumps

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 at least 130% of duty point flow.

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

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.

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

6.8.5 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.

6.8.6 DM / RO Plant

The RO plant shall be designed to have a single stream of 60 Cu.M / Hr. Based on the water quality the following scheme is proposed for the treating the raw water:

Multigrade Filter → Micron Catridge Filter→ Reverse Osmosis system →

Degasser → Strong Acid Cation → Strong Base Anion → Mixed bed

Polishing System

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

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

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.

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.

6.8.7 Crane for the Turbogenerator Building

An Electrically operated overhead travelling (EOT) crane with the main hook lifting capacity of Approx 75 Tonnes suitable for erection and maintenance requirement of turbogenerator and an auxiliary hook lifting capacity of 10 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.

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.

6.8.8 Vessels & Heat Exchangers

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.

6.8.9 Tanks

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.

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.

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.

6.8.10 Compressed Air System

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, 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 500 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 °C at the atmospheric pressure.

6.8.11 Piping

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

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.

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

6.8.12 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: Galvanized pipe shall be used.

6.8.13 Insulation

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 °C shall be insulated for personnel protection. In refractory walls suitable expansion gaps shall be provided at regular intervals.

6.8.14 Ventilation System and Air Conditioning system

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

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

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

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

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The air conditioning system will maintain a temperature of 22 ° C inside the rooms.

6.8.15 Fire Fighting System

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

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.

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.

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.

6.9 Codes & Standards

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.

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American Society of Mechanical Engineers (ASME)

ASME Section I	:	Rules for construction of power Boilers
ASME Section IX	:	Welding & Brazing Qualifications
ASME Section VIII	:	Unfired Pressure Vessels Code
ASME Section IX	:	Welding Qualification

ASME Performance Test Code

ASME PTC 4.1	:	Steam Generating Units
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	:	Water and Steam in the Power Cycle (Purity and Quality, Leak detection and Measurement)
ASME PTC 25.3	:	Safety and Relief Valves

American National Standards Institute

ASME B13.5	:	Pipe flanges and flanged fittings
ASME B 13.9	:	Butt welding fittings
ASME B 13.1	:	Socket Welding and Threaded fittings
ASME B 31.1	:	Code for Power piping

IEEE Standards

IEEE:80	:	Guide for safety in AC Substation Grounding
IEEE:141	:	Recommended Practice for

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		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.

IEC Standards

IEC:34	:	Rotating Electric machines
IEC:44	:	Instrument Transformers
IEC:56	:	HVAC circuit breakers
IEC:71	:	Coordination of Insulation
IEC:76	:	Power Transformers
IEC:85	:	Thermal evaluation and classification of Electrical insulations
IEC:99	:	Lightning Arrestors
IEC:129	:	Alternating current

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		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
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IEC:85	:	Thermal evaluation and classification of Electrical insulations
IEC:99	:	Lightning Arrestors
IEC:129	:	Alternating current

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		transformers
IEC:694	:	Degrees of protection provided by enclosure (IP code)
IEC:885	:	Electric test methods for electric cables
IEC:909	:	Short-circuit current calculation in three phase AC systems
IEC:947	:	LV switch gears and control gear
IEC:1036	:	Static meters

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)

Turbine:

IEC Recommendation Publication No: 45
CSN 080030
DIN 1943

British Standards

BS 4592	:	Industrial type metal floors, walkways and Stair treads
BS 5395	:	Stairs, ladders and walkways
BS:2573	:	Permissible Stresses in Cranes
BS:466	:	EOT Cranes for general use in factories, workshops and Warehouses.
BS:5316	:	Performance Testing of Pumps Part-I Class C

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7.0 Plant and Machinery (Mechanical) for Cogeneration Plant

7.1 General

7.1.1 The proposed new cogeneration plant at BWEL 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 Cogeneration plant will consist of one boiler 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 and biomass fuels during the off-season operation.

7.2.3 The Feed Water Quality Requirement for the boiler shall be,

-	pH	:	8.8 - 9.2
-	TDS	:	1 ppm
-	Oxygen	:	0.007 ppm
-	Hardness	:	0
-	Iron	:	0.01 ppm
-	Copper	:	0.01 ppm
-	Silica	:	Max. 0.02 ppm
-	Hydrazine	:	0.02 to 0.04 ppm
-	Conductivity	:	2 microsiemens/cm

With the above feed water quality, the boiler shall be capable of giving the following steam purity.

- Solids content : 0.10 ppm
- Silica : 0.02 ppm

The following are the basic technical requirements for the steam generator:

- 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.

- 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

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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)".

- The furnace EPRS should be so selected to give acceptable furnace outlet temperatures, not exceeding 920 °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.

- Furnace absorption = $A*\sigma*(\xi_g*T_g^4 - \alpha_g*T_s^4)$, 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.

- 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.

- 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 b 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.

- 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.

- 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.

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- 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 at least for 10 minutes of the MCR requirement, 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.

- 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.

- 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.

- The combustion air from the FD fan, heated in the airheater to a temperature not more than 200 °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.

- 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,

    - 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.

    - 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.

    - 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.

    - 2 x 100% Cinder refiring air fan for 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, if applicable.

    - All air and flue gas ducting with required stiffeners, expansion joints, guide vanes for bends, dampers, insulation, cladding, supports etc.

- 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 ° C, only long retractable soot blowers shall be used. For the gas temperatures exceeding 600 ° C the lance material shall be a minimum of stainless steel.

- 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 150 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.

- 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 valv

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exhaust piping, start-up vent with silencer, blow down systems etc.

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.

- One Blowdown tank (BD) shall be provided. The flash steam from the blow down tank shall be vented to the atmosphere.

- One (1) Deaerator along with the deaerated water storage tank for 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.

- 3 x 60% High pressure Boiler feed water pumps (two working and One standby) for each boiler, along with variable frequency driv

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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.

- Boiler refractory, insulation and inner and outer casing with all fixing material for boiler, ducting, piping, valves, fittings and equipment's etc.

- 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.

- 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.

- Ash hoppers with outlet gate for furnace and motor operated rotary discharge valve for other hoppers.

- Chimney connecting flanges, counter flanges, expansion joints near chimney and all fasteners for the connections.

- Industrial Lift (common for two boilers) with carrying capacity of 600 kgs may be considered, during 2nd phase erection.

7.2.4 The drawing Nos. 1-15308-800-0041, 2-15308-800-0021 gives the schemes for the steam & water system and air & flue gas system for generator and auxiliaries.

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7.3 Steam Turbines and Auxiliary System

7.3.1 The turbogenerator for the BWEL's cogeneration plant will be one number of 31.2 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 °C inlet cooling water temperature even with 20 % of the tubes plugged.

The sizing of the coolers shall consider a tube side (water side) fouling factor of 0.0002 Hr.Sq.M.°C/Kcal. The water velocity shall be not less than 1.5 M/sec.

- 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)

- 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.°C/kcal. The total water side pressure drop in the condenser shall not exceed 8 MLC.

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- 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 tube sheet thickness shall be respectively a minimum of 12 and 40 mm.

- 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.

- 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.

- 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.

- 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.

7.3.10 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.

7.3.11 The governing system shall have the following important functions:

- Speed control
- Over speed Trip
- Load control
- Steam pressure control

7.3.12 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.

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- Axial thrust wear trip.
- High temperature trip for LP stage steam flow.

A direct-coupled turbine and generator system without the intervening gearbox 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 gearbox may be used. If provided the reduction gearbox 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 gearbox design shall be as per the requirements of AGMA. The flexible couplings between the turbine and the gearbox and between the gear box and the generator shall be provided.

7.3.13 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.

7.3.14 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

The cogeneration plant cycle is designed with one Low pressure Heater (Deaerator) and Two High Pressure (HP) Feed water heaters. First HP Heater is provided with heating steam from the Uncontrolled extraction at 9 bar (a) and second HP heater is provided with heating steam from the uncontrolled extraction at 23.0 bar(a).

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.

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

An Electrically operated overhead travelling (EOT) crane with the main hook lifting capacity of approximately 75 MT and an auxiliary hook lifting capacity of 10 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.

Electro-magnetic brake and electro hydraulic thrustor 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.

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.

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.

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.

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7.6 Fuel Handling System

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.

Bagasse handling system:

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.

Bagasse Belt conveyor assembly 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. shall be provided. Apart from the above conveyors, few of the existing conveyors will also be running. Slat Chain conveyor including trough, chains, drive assembly, support frames, walkways, structural etc. shall also be provided.

The following paragraph gives the details of the paths:

Path I:

This path feeds the bagasse from the mill directly to the cogeneration boiler.

Bagasse from the existing chain carrier shall be discharged on to a proposed belt conveyor BC-1. The belt conveyor BC-1 runs in south direction and discharges bagasse on BC-2. The belt conveyor BC-2 runs in west direction and discharges bagasse on SCC. The SCC runs in west direction and will drop bagasse in each chute of boiler for supplying bagasse to screw feeders to feed in to boiler for combustion, after feeding all chutes surplus bagasse will be fed on BC-3. The belt conveyor BC-3 runs in west direction and discharges bagasse on BC4. BC4 runs in south direction and discharges bagasse on BC-5. BC-5 runs in east direction and discharges complete bagasse in bagasse yard. The Belt conveyor BC-2 shall be provided with two way chute & flap gate assembly to discharge bagasse either to slat chain conveyor SCC or to divert wet bagasse on BC-3 to discharges high moist bagasse in the yard.

In this path the conveyors BC-1, BC-2, SCC, 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(s) and sent to the steam generators. The stored bagasse could be that excess bagasse stored during the operation of the sugar plant stored in the yard.

The bagasse will be reclaimed from the yard by manually / Front End Loader and fed into underground reclaiming belt conveyor BC-6. This belt conveyor BC-6 runs in North direction and discharges bagasse to another belt conveyor BC-7. This belt conveyor BC-7 also runs in East direction and discharges bagasse on SCC to feed in chutes towards screw feeders for combustion inside furnace. After filling in chutes surplus bagasse will be dropped again on BC-3 to return back the bagasse towards bagasse yard by discharging on BC-4. Belt conveyor BC-4 will discharge bagasse on BC-5. BC-5 will drop complete bagasse in yard for either storage or discharges on BC-6 for re-cycling towards boiler.

In this path the conveyors BC-6, BC-7, SCC, BC-3, BC-4, BC-5.

The drive assembly shall include motor, gearbox, couplings, holdback, common base frame, Motor & coupling guards etc.

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.

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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.

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.

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.

Junction towers including cladding, operating platforms, staircase, landings, hand railing, toe plate etc.

Hood for all conveyors with Perspex window of size 200 x 200 mm, shall be provided at a spacing of 20 meters.

The Drawing No. 2-15308-300-0104 gives the scheme for fuel handling system for bagasse.

7.7 Ash Handling System

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

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) 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.

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.

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.

The fly ash collected in the blow tanks shall be conveyed to the fly ash silo through MS pipes and long radius ACI 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.

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.

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.

The ash handling system shall be designed and constructed aiming for totally dust free operation. Fugitive dust emission in any area shall not exceed 150 mg/m^3 for all solid particles.

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.

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.

The control and monitoring of fly ash handling system shall be through the DCS located in the control room.

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.

The Drawing No. 3-15308-300-0109 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.

- Raw water system
- Cooling water system
- DM water system
- Service and potable water system

Cooling Water System

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 31.2 MW unit, A two cell, induced draft counter flow cooling tower of capacity 6800 m^3/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 °C and an approach of 5 °C while operating under the atmospheric wet bulb temperature of about 29 °C. The cooling tower shall be of RCC construction.

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.

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.

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.

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.

Tubular, floating type drive shaft assemblies with flexible couplings & bearings for each cell.

Fan drive motor with base frame for each cell. The drive motor shall be of energy efficient and shall be suitable for VFD application.

Extended gear reducer oil line of stainless steel material with dipstick assembly, oil filling and drain arrangement for each cell

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.

Access door along with the frame for FRP fan stack for each cell. The access door shall be air tight.

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.

Main, Auxiliary Hot water inlet puddle pipes embedded in RCC hot water trough as shown in the tender drawing.

PVC headers along with the lateral distribution pipes.

PVC Drift Eliminators. PVC film type fills and polypropylene spray nozzles. The fill material shall be capable of withstanding temperature upto 55 °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.

Supporting arrangement for fills. The fills shall be of suitable size for easy erection.

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.

Basin screen handling facility consisting of one monorail beam for each cell and one no: of chain pulley block.

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Mechanical equipment support shall be mounted on RCC beams using MSHDG frames.

Cage ladder for cooling tower and inspection ladder for fills for each cell

Complete lightning protection system with all copper strips and interconnection upto ground level.

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.

The Drawing No. 0-15308-800-0029 gives the scheme for the cooling water system.

7.9 DM Water System

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 → Micron Catridge Filter→ Reverse Osmosis system → EDI/ → Degasser → Strong Acid Cation → Strong Base Anion → Mixed bed Polishing System

The Multigrade Filter shall be sized for the RO feed flow rate. The RO plant shall be designed for a permeate output of 1040 cu.m./day in 20 hours of operation. The DM plant system shall be designed for a flow rate of 60 cu.m./hr. with an OBR of 1040 cu.m.

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.

The Demineralized water quality at the outlet of the water treatment plant after MB shall be as follows:

*	Hardness (ppm)	0
*	pH at 25 °C (after pH correction)	8.5 - 9.2
*	Conductivity at 25 °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
*	Permangnate 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

The following gives the details for the 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%.

Degasification system to handle RO permeate water consisting of one no of degasser tower and two Nos. of blowers with motor (one working and one standby).

Degassed water Storage tank with level gauges and level transmitters. The surface velocity of degasser tower shall be 60 cu.m/ hr/ sq.m. The minimum height of the degasser tower shall be 3300 mm. The degassed water storage tank shall be designed for 60 cu.m capacity.

Degassed water transfer pumps with motor (one working & one standby).

Strong Acid Cation exchanger, Strong Base Anion exchanger and Mixed bed exchanger with initial charge of resins, frontal piping and valves. The size of the vessel shall have minimum 120% freeboard.

Blowers with motor (one working and one standby) for Mixed Bed Exchanger regeneration.

Side stream filters (Four working) with frontal pipe work and initial charge of sand bed with all valves, instruments and interconnecting piping and blowers

Bulk Caustic handling system & bulk hydrochloric 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. 0-15308-800-0028 gives the scheme for raw water, DM water and condensate system.

7.10 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.

7.11 Compressed Air System

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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 600 Ncum/hr at 7 kg/sq.cm (g). The air compressor shall be of lubricated screw compressor with suitable pre and after oil filters Air driers, Air receivers and control panel.

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.

The air receiver capacity shall be 2.0 Cum, 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.

The Drawing No. 1-15308-800-0030 gives the scheme for the instrument/ compressed air system.

7.12 Air Conditioning System

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

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

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°C ± 1.1°C and a relative humidity of 55 ± 5% will be maintained in the control rooms.

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.

7.13 Ventilation System

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.

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

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Fire Pump House
Toilets

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

7.14 Fire Protection System

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

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).

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.

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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.

7.15 Main Steam, Medium Pressure and Low Pressure Steam Systems

The outlet steam from the boiler will be conveyed through alloy steel main steam piping to 31.2 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, Flowmeters, hangers, supports & specialities. The Piping from the main steam header will be conveyed to the Pressure Reducing & Desuperheating Stations for reducing the pressures, which is a standby arrangement for the turbine extractions. The piping from the main steam header will be connected to a low capacity Pressure Reducing & Desuperheating Station for meeting just the ejector and gland sealing steam requirements during start up and similarly there will be a low capacity Pressure Reducing & Desuperheating Station for meeting just the start up and deaerator steam requirements. Also, a Pressure reducing and desuperheating station will be provided to meet the process steam requirements of the diary plant and sugar plant.

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 spherica 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.

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 °C shall be 100 Kg/Cum. The application density for temperatures above 400 °C shall be 125 Kg/Cum.

The sheeting material for all insulated piping and equipment shall be aluminium conforming to British Standards (BS) /ASTM codes.

The Drawing No. 1-15308-800-0041 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 one (1) no. 11 kV, 50 Hz, 3 Phase, 0.8 PF Synchronous generators each having nominal capacity of 31.2 MW. The generator will operate in parallel with National grid. A portion of the power generated in the turbogenerator 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 one (1) number 11/132kV, 30/40 MVA generator transformers, which will be located in the proposed outdoor switchyard. Enclosed electrical system single line diagram 0-15308-900-0453 gives the electrical scheme / power generation arrangement of co-generation plant and & interconnection arrangement 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 ±10 % and ±5 % respectively. The enclosure will be of dust, vermin and waterproof. 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, 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 electrical system single line diagram 0-15308-900-0453 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

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f. Auto power factor control

8.3.2 The system will have double 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.

8.4 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 breaker and tie breaker. 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 Each panel 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

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- 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

Following additional stage of protections shall be used to trip tie CB with grid interconnection:

- Over voltage
- Over frequency
- Under voltage
- Under frequency

8.5 LAVT and NGR Cubicles

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 5P10), 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 from 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:

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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	:	750 MVA
Maximum bus bar Temp.	:	As per IEC
Operating Duty	:	O-0.3sec-CO-3min-CO
Control Voltage	:	110 V DC

8.6.2 The 11 kV indoor switchgear board will be provided in the TG house, for power distribution and evacuation. 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 for earthing the cable side terminals. All panels will have earth switch with interlock or separate earthing trolley. 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 60044-1and 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 will be provided with the necessary relays and meters 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 Xd" of the generator and other system parameters.

8.7 Distribution System

11 KV feeders will be provided to ASML for interconnection with 11 KV switch board of ASML to support their load from Cogen system as indicated in the enclosed single line diagram.

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	Converter / Distribution transformers for co-generation plant	
Cooling	-	ONAN	
MVA	-	5 MVA	
Ratio	-	11/0.415/0.415kV	
Highest system Voltage	12 KV	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, ±7.5%in steps of2.5%	
Voltage Vector	-	Dyn11 zn0	
Neutral Earthing	Solid 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 converter transformers.

8.8.3 The LT distribution panels conforming to the latest revision of IEC:439 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 aluminium alloy, 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 above 18.5 kW, indication lamps, suitable for remote operation.

8.8.5 LT Busduct of suitable rating will be used for interconnecting converter 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 converter transformers by equally distributing the loads on both the side of the transformers to minimise the harmonic injected at 11kV bus by the converter 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 (IE-3). 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 ° 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 Emergency power requirement

One (1) No. of 1400 kVA DG set will be considered for cogeneration plant emergency loads. The DG set voltage rating shall be 415V.

8.10 Earthing System

Neutral point of the converter & distribution 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 three core aluminium conductor, XLPE insulated, screened, armoured and overall PVC sheathed confirming to IEC:502.

8.11.1.2 The power cables of 1.1 kV grade will be of PVC insulated, aluminium 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 1.1 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 unit 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 one float cum boost charging (FCBC) and one float charging (FC) 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 IES 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 / IEEE 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. The plant shall be effectively connected with NTDC (National Transmission and Dispatch Company) / DISCO (Distribution Companies) load dispatch centre through a suitable telephonic system as per NTDC/DISCO requirement.

8.17 Suitability of power unit 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

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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 with LI LO with 132 KV transmission line sama satta at the distance of 4 Km from BWEL. 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 tappings 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

8.18.1 The Co-generation Project envisages a power export of 26.32 MW during season operation and about 28.1 MW during off season of the plant generated from the TG set. With this, the switchyard electrical system will be designed for export of maximum 31.2 MW of power, after in-house consumption by the co-generation plant loads, sugar plant loads. It is proposed to export this surplus power to grid connecting the generated power to MEPCO 132kV transmission line which is at a distance of 4 km.

8.18.2 The exportable power from the plant shall be evacuated by stepping up the power from 11 kV to 132 kV through one of 11/132 kV, 30/40 MVA generator transformers located at each transformer bay. The switchyard in the plant will be provided

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with a two transformer bays and two line bays with Bus-1 and Bus-2 bays.

8.18.3 Proposed 132kV switchyard in the plant premises will have one generator transformer with control and protection equipment, CTs, PTs, isolators, lightning arrestors and TVM for MEPCO measurement will be arranged as per the drawing electrical system single line diagram with Drg no. 0-15308-900-0453 enclosed to this report. The arrangement and layout of the equipment shall be as per the Switchyard layout drawing with Drg no. 1-15308-900-0454 sheet 1 & 2 of 2 enclosed in this report. Two nos of Line feeder will be arranged by MEPCO at their end to receive power from co-generation plant.

8.18.4 Switchyard arrangement and other requirements will be N-1 contingency double bus bars, breakers and metering system, in line with NTDC/MEPCO specifications and standards. Switchyard shall not have provision for extension in future.

8.18.5 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.

8.18.6 Tariff metering shall be accommodated in outdoor kiosk near metering CTs & PTs in the plant end switchyard as per NTDC/MEPCO standards/ requirements. The tariff meter shall register import as well as export parameters and shall be of digital type, with class of accuracy 0.2 as per IEC:687 / IEC:1036 an NTDC /MEPCO specifications.

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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 MEPCO Interconnection point shall be constructed by Power Purchaser.

8.19 Generator Transformer

8.19.1 Generator transformer 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	:	150 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.

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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, 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):

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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)

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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 line busbar protection panel:

i. Bus bar protection along with its CT supervision relays (Part of Bus coupler relay panel)

8.21.6 Other auxiliary relays and timers shall be provided as shown in the enclosed SLD

8.21.7 Metering for the line shall be provided as shown in the enclosed SLD.

8.21.8 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/MEPCO requirement. All the requirement of NTDC/MEPCO like real time power system monitoring, warning system etc. shall be met with.

8.21.9 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.

8.21.10 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.

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Interlocking between breakers / isolators / earth switches for safe operation of the system will also be ensured.

8.21.11 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 post rotating horizontal double break type and consist of 3 poles. 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:

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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 GI flat 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

This Section of the Report gives the general philosophy of the Instrumentation and Control system for the new Cogeneration Power Plant.

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

Centralized control and monitoring with provision for local intervention wherever necessary is the essence of the design philosophy.

Modular design concept will be adopted to ensure that single defective equipment will not disturb functioning of overall system.

The plant will be complete with the basic instrumentation and control system necessary for its safe and efficient operation.

Comprehensive instrumentation and control equipment will be provided for each major area of the plant i.e. Boilers, Turbo - generators, etc. The Drawing No. 1-15308-800-0454 gives the DCS System Architecture.

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9.2 Design Criteria

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.

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.

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

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.

The Cogeneration power plant will be mainly comprised of the following system.

9.3.1 Boiler and its Auxiliaries

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.

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
CBD Level Control (If Applicable)
Soot Blower Control
PRDS control

All the Boiler safety and protection interlocks shall be realized from DCS.

9.3.2 Steam Turbine and its Auxiliaries

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):

The open loops and interlocks & protections will be implemented in the DCS as per control schemes provided by the STG vendor.

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 Wood ward Governor will be hardwired to DCS.

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.

9.3.3 Bagasse Handling System

The bagasse handling systems can be operated from DCS at central control room.

9.3.4 Ash Handling System

The Ash Handling System can be operated from DCS at central control room.

9.3.5 Water Treatment Plant

The WTP can be controlled manually through Local control panel. The important signals of WTP are connected to DCS through hardwired.

9.3.6 Cooling water system

The cooling water system shall be controlled from DCS.

9.3.7 ESP

Operation and control of ESP shall be through DCS at central control room.

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9.3.8 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.

9.3.9 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.

9.3.10 Compressed Air System

The Control and Operation of compressed air system shall be from DCS at central control room.

9.3.11 Switchyard

All important parameters shall be connected to DCS through SCADA system.

9.3.12 Steam and Water Analysis System (SWAS)

Steam and Water Analysis System shall be furnished for continuous monitoring of water and steam purity in the plant.

The system shall comprise of all items like conductivity, pH, Silica and Hydrazine analysers, sample conditioning components and other accessories.

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

All the above signals can be hooked up to DCS through 4-20 mA signals.

9.3.13 Stack Monitoring System

The following signals can be hooked up to DCS through 4-20 mA signals for monitoring

SOX/NOX , and O2(Excess air)

9.3.14 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

9.4 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.

9.5 The design of the total control system will be such that the following sub-system's functions will be handled by the respective equipment :

a. **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

b. **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.

c. **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.

d. **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.

e. **Communication** sub-system for **interconnecting** all the above systems.

f. **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.

g. **Auxiliary units** such as system cabinets, printer consoles, marshaling cabinets and power **supply** distribution cabinets.

9.6 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.

9.7 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.

9.8 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.

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- 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.

9.9 The field instruments that are primarily responsible for measuring the process parameters will be having the following major design features:

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- 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.

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9.10 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.

9.11 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 already been completed and drawings are available.

10.3 Equipment Foundations

10.3.1 Turbogenerator foundation

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.

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.

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 at least 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.

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.

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.

The reinforcements shall be designed to the working stress methods for the worst load combinations of static and dynamic loads.

All necessary provisions by way of cut-outs, embedments, foundation bolt assemblies shall be incorporated into the foundation block to meet the functional requirements.

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.

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

All the static equipment foundations shall be constructed with cast-in-situ reinforced concrete. All foundations shall be

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extended to a depth, which conforms to the allowable bearing pressure of the soil.

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.

The design of foundations shall be carried out by Limit State Method.

All necessary provisions by way of cut-outs, embedment, foundation bolts assemblies shall be incorporated into the foundation block to meet the functional requirements.

The foundations will be isolated from building foundations and superstructures.

10.4 Buildings

10.4.1 General

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.

The sub structure of the building will be with concrete shallow foundations and superstructure with Structural steel framework, with concrete cast in situ floor slabs. The machine room will be with steel roof truss cladded with Galvalume steel sheet. The building will be cladded with Galvalume sheet steel. The building frame shall support the overhead Electrical Overhead Travelling (EOT) crane moving on gantries.

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.

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.

Around the buildings a 1.0 m wide smooth finished concrete walkway and necessary steps and ramps shall be provided.

10.4.2.2 Floor Finishes

Turbogenerator Room floors

The floor shall be finished with granolithic concrete with a surface hardener. Skirting shall be plastered and painted.

Switchgear room, AC & Ventilation machine room

The floor shall be finished with granolithic concrete with a surface hardener. Skirting shall be plastered and painted.

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.

Office & Passages

Mosaic Tiles

Toilets

Ceramic Tiles

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.

10.4.2.3 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

10.4.3 Non-Plant Buildings

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.

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.

Around the buildings a 1.0 m wide smooth finished concrete walkway and necessary steps and ramps shall be provided.

10.5 Switchyard

Transformers, breakers etc., shall be supported on reinforced concrete (Grade of concrete at least 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.

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.

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.

Cable Trenches will be constructed as per the requirement and as described in cable trenches.

10.6 Cooling Tower

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.

Water proofing admixture (plasticizer cum water proofing compound), shall be added to the concrete for basin, channels, drain pits, etc.

10.7 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.

10.8 Pipe Racks

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.

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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.

10.9 Roads and Pavement

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.

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.

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 up to full depth of the pavement. Expansion joints shall be provided at a maximum spacing of 15.0 m.

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Top surface of the pavement shall be provided with adequate slopes as required for the surface drainage.

10.10 Surface Drainage

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.

Contaminated area surface drainage shall be collected and discharged through catch pits. The catch pits shall 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.

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.

The paved areas shall be sloped towards the catch pits drains.

At the road and other crossings suitable pipe / open RCC culverts shall be provided.

10.11 Plumbing and Sanitary System

Plumbing and sanitary system shall serve all toilers, 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.

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.

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.

10.12 Sewerage Treatment plant & Drainage System

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.

10.13 Site Clearance

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.

10.14 Fencing / Compound Wall

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, shutdowns 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 BWEL 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

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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

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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 operating 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 31.2 MW Power plant. It is possible that some of the existing plant personnel in the ASML'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 Organogram gives the proposed organization chart for the Cogeneration plant. It is also possible that BWEL 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)

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b) Control Room Engineer (1)
c) Electrical technician (1)
d) Shift chemist (1)
e) Boiler operator (2)
f) Fuel / Ash handling operator (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 ASML's sugar plant maintenance and BWEL'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

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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.

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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 coordination 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
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

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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 (SO_2), oxides of Nitrogen (NO_x) and fine airborne particulate. All of these require specialized equipment for control.

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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 BWEL'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, SO_2, NO_x, CO, CO2, O2, 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.

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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 Demineralized 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
- Sulfur-di-Oxide in the flue gas.
- CO, CO2, O2.

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 150 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. These emissions have been calculated for both bagasse firing.

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, SOx emissions will not be a matter of concern from boilers during bagasse firing. The boiler & auxiliaries and chimney are sized for this operational requirement.

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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 airheater 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 Demineralized 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.

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 °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

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blow down from blow down 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 °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 Waste Water Treatment

Waste water treatment for the plant will be based on discharges of the various waste water streams to treatment ponds for clarification and filtration. Oily water will be treated separately to remove oil / grease before discharge into effluent ponds. The oily water collection in the plant is basically due to floor cleaning, leaky oil filters, etc.

It is proposed to have a waste water recycling plant at the Cogeneration plant.

The purpose of envisaging Effluent Recycling Plant is to treat the effluents generated from the power plant and recover around 50% to 60% of the total effluent for recycling. By recycling the treated effluent, the raw water consumption will get reduced by around 50% to 60%. Also, the quantity of effluent to be disposed off will be reduced to around 40% - 50%.

The following are the liquid effluents generated from the power plant.

a) Boiler Blow down
b) Cooling tower blow down
c) Side Stream Filter backwash

d) Multigrade filter backwash
e) Ultra-Filteration system fast flush
f) Ultra-Filteration system back wash
g) Reverse Osmosis system Reject
i) Reverse Osmosis system flushing
j) Strong Acid Cation Exchanger regeneration
k) Strong Base Anion Exchanger regeneration
l) Mixed Bed Exchanger regeneration

All the above effluents will be collected in the common effluent pit from the individual equipment through drain pipes / drain trenches. The collected effluent in the effluent pit will be neutralized by means of acid / alkali dosing. The common effluent pit will also act as equalization tank and effluent pit will be sized accordingly. The effluent from effluent pit will be treated in the effluent recycling plant. The scheme of typical effluent recycling plant is furnished below:

Multigrade filter → Ultra Filteration System → Reverse Osmosis (RO) System →EDI

The permeate / product water from Reverse Osmosis system will be mixed up with RO permeate of boiler makeup water treatment plant and will be used for boiler makeup. The reject from the Effluent Recycling Plant RO plant will be disposed off meeting with the local pollution control norms.

13.6 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.

13.7 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.

13.8 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.

13.8.1 Air Quality Monitoring Programme

The purpose of air quality monitoring is the acquisition of data for comparison against the prescribed minimum standards and thereby, assure 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, CO, CO2, O2.

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.

13.9 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.

13.10 Quantity & Quality of the effluents from the 31.2 MW Cogeneration Plant

The figures given below are for the normal operation of the plant during the seasonal with bagasse as the fuel.

13.10.1 Gaseous Effluents from the Cogeneration Plant

Flue Gases from the stack from: 276,978 kg/Hr
Both the boilers

Temperature of the gases leaving the stack	: 160 °C (max)
SO_2 Emission	: 181 kg/hr
NOx Emission	: Less than 80 ppm.
Particulate Emission through flue gases	: 150 mg/NCu.M

13.10.2 Solid Wastes from the Plant

Dry Fly ash	: 1.1 MT/Hr.

Wet bottom ash from Grate : 0.65 MT/Hr.

13.10.3 Liquid Effluents

a) Boiler Blowdown Water : 3.255 TPH

Total Dissolved Solids : 100 ppm (max)

pH @ 25 °C : 9.8 to 10.3

b) Cooling Tower Blowdown : 21.84 Cu.M/Hr

Total Dissolved solids : 400 ppm

pH @ 25 °C : 8 to 9

Chlorine : 0.2 ppm

c) Waste Water from: 24 TPH (average)
Neutralizing Pit

Total Dissolved solids : 1000 ppm

pH @ 25 °C : 7

The figures given below are for the normal operation of the plant during the off-season operation.

13.10.4 Gaseous Effluents from the Cogeneration Plant during bagasse firing.

Flue Gases from the stack Of boiler : 208,978 kg/Hr,

Temperature of the gases leaving the stack : 160 °C (max)

SO_2 Emission	: 104.4 Kg/Hr
NOx Emission	: Less than 80 ppm.
Particulate Emission through flue gases	: 150 mg/NCu.M

13.10.5 Solid Wastes from the Plant during bagasse firing

Dry Fly ash	: 0.9 MT/Hr.
Wet bottom ash from Grate	: 0.72 MT/Hr.

13.10.6 Liquid Effluents

a) Boiler Blowdown Water : 2.48TPH

Total Dissolved Solids : 100 ppm (max)

pH @ 25 °C : 9.8 to 10.3

b) Cooling Tower Blowdown : 30.68 Cu.M/Hr

Total Dissolved solids : 400 ppm

pH @ 25 °C : 8 to 9

Chlorine : 0.2 ppm

c) Waste Water from: 11 TPH (average)
Neutralizing pit

Total Dissolved solids : 1000 ppm

pH @ 25 °C : 7

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14.0 Site Features and Plant Layout

14.1 Location and Features of the Plant Site

The proposed Cogeneration plant at BWEL, will be located adjacent to the ASML's sugar plant complex. This complex presently consists of only the sugar plant. The Drg. No. 0-15308-600-0020 gives the Plot Plan of the proposed Cogeneration Plant.

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.

14.1.1 Space Availability

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 BWEL cogeneration project, the

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plant is located slightly away from the sugar plant due to the non-availability of space within the existing sugar plant compounds.

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.

14.1.2 Topographical and Geological Aspects

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.

The soil cannot be termed as good as the Soil bearing capacity is just about 9 Metric Tonnes per Sq.M at a depth of about two (2) meters. 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.

14.1.3 Rail and Road Facilities

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 at Ashrafabad dist Bahawalpur. Road connectivity to the plant is less than 1 Km. In addition the nearest railway station is Bahawalpur. and the nearest airport from BWEL's plant at a distance of 30 KM.

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14.1.4 Water Availability

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

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.

14.1.5 Availability of Fuel

The proposed Cogeneration plant operation will be based on the in house generation of Bagasse in the sugar plant, & biomass fuels. Bagasse is generated in-house from the cane received at the sugar mill. The biomass fuels will be transported for the operation of the plant.

14.1.6 Interconnection with transmission system

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 with LI LO basis.

14.1.7 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 Western side of the sugar factory. The switchyard of the Cogeneration plant is located on the South side of the cogeneration boiler and Turbogenerator building. The new bagasse yard will be used to store the bagasse saved in the season operation and the same located on the Western side of the Cogeneration power plant. Also the existing storage yard in the sugar plant will also be used to store the bagasse saved in season, which is located on the Western side of the sugar mill and Northern side of the cogeneration plant. The raw water tank will be located on the Western side of the TG building. The water treatment plant, DM & make-up water storage tanks, Cooling Tower are located adjacent to the raw water tank. 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 trucks & 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 North to South direction, with the steam generator front facing the North. 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.

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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 Southern 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 plant's 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 Northern side of the steam generator will be of size 40 m x 25 m, and will be sized to accommodate the Turbogenerators and its main auxiliary equipment. The turbogenerator operating floor shall be at 10 m elevation. The building superstructure will be of RCC Columns & Beams with Brick wall 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 Southern 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 East-West 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 at the centre 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. 1-15308-600-0035 to 0039 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 Southern 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 Southern side of the TG building at 3.5 M elevation. Con209roll room for the entire plant will be located on the Southern 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 tower shall be located adjacent to the raw water tank. The cooling water pumps shall be located near the cooling tower.

14.6.2 The Water treatment plant building will be located on the Northern side of the cooling tower and the western side of the raw water tank. This building will house only the RO systems. The downstream DM plant will be located outside the building. DM water storage tank and make up water tanks shall be located in this area. The acid and alkali bulk storage tanks required for storing the chemicals required for regeneration in the water treatment plant will be located close to the water treatment plant.

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.

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14.8 Distribution Transformers

The distribution transformers, required for meeting the Cogeneration plant's auxiliary power requirements, are located on the Southern side of the TG building.

14.9 Switch Yard

The 132 kV switchyard is located on the Southern side of the boiler & TG building. The area required for accommodating the power transformer, insulators and the structures, circuit breakers, isolators, etc., is indicated in the drawing no 1-15308-900-0454.

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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 Eighteen (18) months from the date of ordering of the Boiler & Turbogenerator. 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. 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.

- Alternate energy development board (AEDB)
- 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 and coal
- Ministry of commerce and Export promotion Board
- Pakistan Environmental Protection Authority
- Government of Punjab, Pakistan

BWEL 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.

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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.

15.4.1 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.

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- The terminal points of each of the packages are clearly defined and proper tie-ups of these points between the packages are ensured.

15.4.2 The following gives the tentative list of packages for this project. Each package will be covered in EPC package, wherein, the responsibility of engineering, procurement and construction is left to the EPC contractor with overall guarantees for all package clearly defined. The EPC route also gives an advantage as single point of contact and responsibility of whole project and performances. For this BWEL's has decided to construct project with EPC basis, not only this lenders also prefers to invest in EPC based projects.

- Steam generator and Auxiliaries and Dense phase ash handling.
- Turbogenerator and Auxiliaries and EOT crane.
- 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.
- 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

15.4.3 Preparation of the Tender Specifications, obtaining offers from qualified bidders, technical and commercial evaluation of offers, finalization of the contractor, formulation of the contract agreement, contract reviews, vendor drawing review and approval etc. are the major activities for the EPC project. The scope of the EPC will be the design and engineering, procurement, manufacturing, inspection, testing, transportation to the site, installation and commissioning & performance guarantee of the complete plant.

15.4.4 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.

15.4.5 Since the project execution calls for closer coordination among the contractors, consultants and BWEL'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.

15.4.6 Procurement

15.4.6.1 Procurement is an important function in the implementation of the Project. The procurement of the systems equipment and services will be done by Contractor through a series of suitably packaged contracts as outlined earlier. The Project team with the consultants may monitor enquiries with the appropriate technical conditions, delivery requirements, guarantees etc. to renowned suppliers. The specifications for the procurement of the equipment and systems will be provided by the consultants.

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15.4.6.2 Evaluation of the offers is done by the EPC contractor, 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 bidders. Once the purchase order is placed, the contractor and his project team follows up regularly to ensure smooth and timely supplies of the equipment. The procurement activity includes the review of the vendor drawings by the consultant/BWEL's project team and approve drawings and then give EPC contractor go ahead to proceed with procurement. BWEL team/ consultant will also ensures expediting, stage and final pre-delivery inspection, supervision of installation and commissioning.

15.4.6.3 When the contract will be awarded, detailed program in the form of network are tied up with the contractor to clearly indicate Engineering, Procurement, and construction obligations and the supplier's responsibilities. BWEL's inputs are in terms of land availability, all regulatory requirements, power and water availability, 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.

15.4.6.4 To expedite supplies from the contractor, regular visits to the supplier's works may have to undertake by the consultant/ BWEL's team. 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.

15.4.7 The Construction Phase

15.4.7.1 This is the critical phase of the project where work progresses in almost all the fronts. The erection and commissioning phase of the contracts proceed simultaneously and it is important to ensure that the contractor have adequate facilities and are established on the site in time to meet their programmed commitment. Adequate power and water shall be made available for the construction.

15.4.7.2 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 activities progressing simultaneously are interrelated and hence, the delay in any activity may invariably affect the progress of the other activity and ultimately the project progress.

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.

15.4.7.3 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.

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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.

15.4.7.4 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.

15.4.7.5 Major problems such as non-availability of drawings, clarifications, documents from contractor, non-receipt of required materials, 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.

15.4.8 Plant Commissioning

15.4.8.1 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.

15.4.8.2 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 BWEL & ASML

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

15.6.1 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 two (22) months from the date of release of advance payment to Contractor. The proposed COD date will be 18 months after financial close ie 2018.

15.6.2 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.

15.6.3 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 Project Cost Estimate

16.1 Methodology of the EPC Cost estimate

This section of the Detailed Project Report gives the project cost estimate for the proposed Cogeneration power plant at BWEL. It is assumed that the project will be executed through the EPC basis, where the Contractor carrying out the Engineering, Procurement and Construction/ commissioning Management activities. The Consultant will make specifications and assists BWEL in the finalisation of the contractor through bidding process. Once the Contractor finalised after technical and financial terms, contractor shall bound to submit advance bank guarantee, performance guarantee and commitment for warrantee bond to sponsor, he will submit design as per given specifications, the design will review by consultant and approve. Once design approve contractor shall expedite process of manufacturing complete equipment and submit complete schedule of equipment arrival and construction activities at site. Till arrival of equipment at site contractor will ensure that civil foundations must complete before delivery of supplies at site.

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. Contractor has vast experience in the implementation of these bagasse based Cogeneration projects both in Pakistan and in other countries.
The proposed plant site, the scheme for the Cogeneration plant and the location of the Cogeneration plant have been finalized.

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The proposed plant site, the scheme for the Cogeneration plant and the location of the Cogeneration plant have been finalized. Preliminary sizing of the major equipment and the auxiliary equipment have been finalized and the Cogeneration plant plot plan has been prepared. All the interfacing points with the sugar mill have been finalized and the routing of the fuel conveyors, Piping routing and the cable routing have been finalized and incorporated in the layout drawing 0-15308-600-0020. As the layout of the plant is one major factor affecting the cost of the balance of plant equipment, a detailed layout has been prepared for the Cogeneration plant. The cost estimate of all interconnections like piping, cabling, conveyors etc., have been made with this layout. The layout of the Cogeneration plant and the interfacing of the various packages of the Cogeneration plant will be responsibility of contractor and consultant will ensure that work is being done as per design.

16.2 Civil Works

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 75 m tall RCC/ metallic Chimney for the boiler. 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 BWEL through other contractors and the cost of these studies shall be part of the pre-operative expenses for the project.

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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.

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

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the major mechanical and electrical equipment and systems in the plant.

16.3.1 Mechanical Works:

- Steam Generator with travelling grate and with all its accessories including an Electro Static Precipitator. The capacity of the boiler will be 160 TPH each with the outlet steam parameters of 110 bar(a) and 540 °C.

- One extraction condensing Turbogenerators with all its accessories. The capacity of each of the Turbogenerators will be 31.2 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 equipment 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 the major mechanical and electrical equipment and systems in the plant.

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- 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 equipment 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

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- 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.

16.3.2 Electrical:

- Synchronous generator, along with coolers and accessories, PMG, brushless exciter, AVR, NGR and LAVT panel
- Generator transformer, 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

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transformers, Lightning arrestors, cablings, 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.

- PLCC panels along with 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.

- 415V PCCs, MCCs, distribution boards for the complete cogeneration plant.

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- DC system complete 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
- Power (HT & LT), Control and Signal cables along with termination kits, termination accessories, cable trays & accessories, support arrangements, etc. for the complete plant
- 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.
- 11kV 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.

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- 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:**

Electrostatic precipitators have been included as the dust collection equipment to control the particulate emission level

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from the boilers to 150 mg/N.Cu.m. The complete Electrostatic precipitator system is included in the Boiler scope.

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.

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.

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 reverse osmosis (RO) system. As the source of raw water is the deep borewells, it is proposed to include a Multigrade filter, Ultra filtration and other pre-treatment systems to the RO plant. The RO permeate water will be further treated in a Demineralization plant downstream of the RO plant, to make the water suitable for feeding to the high-pressure boiler.

The fuel handling system package will include the bagasse handling from the ASML's 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.

Induced draft cooling tower meeting with the requirements of the condensers and of the turbogenerator auxiliary equipment and this will be a separate package. The tower will be of counter flow type and shall be of RCC construction.

All pumps, not part of the main packages will be ordered separately, as a package. They will be ordered along with the drive motors.

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.

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.

Electrically operated overhead travelling crane for the maintenance of the turbogenerator etc.

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

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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 415 V level will be provided.

The cost of the transmission lines from the plant switchyard to the MEPCO's network and the modifications required in their system for the connection of the incoming power from the BWEL's Cogeneration power plant are in their scope.

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 EPC Cost

Total EPC cost is expected to be USD 34.94 Million. However, these are initial budgetary quotes and estimates and the Company shall finalize the same in due course.

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16.6 Non-EPC Cost

The Cogeneration project is proposed to be implemented in an area adjacent to the sugar mill. Cost related to land, development, O&M mobilization, colony, fuel during testing, security and others are estimated to be around USD 1.94 Million.

16.7 Development and Pre-operative costs:

These costs, other than the works costs, are incurred by the promoter prior to the commissioning of the project. The costs under this head include all the costs starting from the feasibility study, application to statutory bodies, Bank Guarantee and processing/legal fee etc., up to the plant start up.

The following gives the various activities that have bearing on the costs under this head.

- Preliminary expenses include the cost of the initial studies, feasibility study and all activities culminating in getting approvals for the project and including Environment Impact assessment studies.

- The pre-operative expenses include the cost towards the establishment of BWEL's project team, site clearances, obtaining statutory approvals and clearances for the project, arranging construction power and water requirements, arranging space (both open and covered) for the storage of the equipment and materials at the site, arranging site communication facilities, accommodation for the visiting personnel related to this project.

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- Appointment of Consultant for monitoring the implementation of the project. There will be some additional costs like the travel, additional site service personnel from the Consultants for the supervision work, problem solving during the construction and commissioning period etc. All these are included in the pre-operative costs.

- The cost of construction Management is the cost of managing the project during the construction and commissioning phases of the project. This is the cost of maintaining the required and adequate manpower for the supervision of the construction activities and project management. This could be outsourced to the consultants or BWEL themselves could employ the manpower and get these activities done. Any way there will be a cost component and the same to be included in the project cost.

- Cost towards the recruitment of the required manpower (like the advertisements in the news papers, interviews, payment of the travel charges as applicable, selection and appointing the right candidates etc.) for the operation and maintenance of the Cogeneration project, Training of the manpower where ever required etc.

- Insurance cover for the storage of the materials and the plant and machinery and all travels related to this project.

The estimated cost on the "development" head is US$ 2.83 Million. It is difficult to quantify the percentage of local currency and foreign currency expenditure out of the above at this point of time and the entire amount is taken as foreign currency expenditure at this point of time.

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16.8 Financing Arrangement Costs

This is the cost of arranging the finances for the project and is expected to be 1.22 Million USD of the long term debt.

16.9 Cost of Insurance during Construction

BWEL will take out all the insurance required during the project implementation. These insurance covers will include marine insurance, inland transit insurance, Comprehensive Insurance covering equipment unloading, storage, erection and commissioning and testing, insurance cover against injury to personnel and damage to properties, etc. The estimated insurance cover for the project implementation period is 1% of the total cost of civil works and equipment costs. This cost is estimated as US$ 0.35 Million and is capitalized.

16.10 Fund Flow for the Project & Interest During Construction

The estimated fund flow for the project is given hereunder, for the entire construction period of 20 months.

Quarter	Fund flow as a % of the Project Cost
1	23.89%
2	13.33%
3	13.33%
4	13.33%
5	13.33%
6	13.33%
7	9.44%
Total	**100%**

It is assumed that the debt will be in local currency. The effective interest rate for the local currency will be three months KIBOR plus 3% per annum.

16.11 Interest during Construction (IDC) Cost

Based on the fund flow given in the earlier clause and the proportionate debt draw down, the interest during the construction period is calculated. The total interest during construction works out to US$ 2.66 Million.

16.12 Installed Project Cost

The Project Cost, excluding the interest during construction, for the implementation of the 31.2 MW cogeneration plant at BWEL, will be US$ 41.29 Million. The Interest during Construction is calculated to be US$ 2.66 Million. The total installed project cost for the proposed Cogeneration power plant will be US$ 43.94 Million.

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17.0 Abbreviations

AC	:	Alternating Current
AGMA	:	American Gear Manufacturer's Association
API	:	American Petroleum Institute
ASHRAE	:	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
BC	:	Belt Conveyor
BOD	:	Biological Oxygen Demand
BS	:	British Standards
CACW	:	Closed Air Circuit Water Cooled
CBD	:	Continuous Blow Down
CCR	:	Central Control Room
CDM	:	Clean Development Mechanism
CEMA	:	Conveyor Equipment Manufacturer's Association
COD	:	Chemical Oxygen Demand
BWEL	:	Ashraf Energy Limited
CT	:	Current Transformer
CTI	:	Cooling Tower Institute
CU.M	:	Cubic Metre
DAP	:	Di-Ammonium Phosphate
DC	:	Direct Current
DCS	:	Distributed Control System
DG	:	Diesel Generating Set
DM	:	Demineralized Water

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EL	:	Slat Chain Elevator / Elevation
EOT	:	Electrical Operated Overhead Travelling
ESP	:	Electrostatic Precipitator
ETP	:	Effluent Treatment Plant
FD	:	Forced Draft
HHV	:	Gross Calorific Value
GHG	:	Green House Gas
GRPF	:	Grooved Roller Pressure Feeder
GSC	:	Gland Steam Condenser
HEI	:	Heat Exchange Institute
HI	:	Hydraulic Institute
HP	:	High Pressure
HVAC	:	Heating, Ventilation & Air Conditioning
HYSD	:	High Strength Deformed Steel
IBD	:	Intermittent Blow Down
ID	:	Induced Draft
IDC	:	Interest During Construction
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IRR	:	Internal Rate on Return
ISA	:	Instrument Society of America
IT	:	Income Tax
KA	:	Kilo Ampere
KLPD	:	Kilo Litres Per Day
KV	:	Kilo Volt
KW	:	Kilo Watt
LAVT	:	Lightning Arrestor & Voltage Transformer
LC	:	Letter of Credit
LOI	:	Letter Of Interest
LOS	:	Letter Of Support
LP	:	Low Pressure

LRSB	:	Long Retractable Soot Blower
LS	:	Lump Sum
LT	:	Low Tension
LV	:	Low Voltage
Max.	:	Maximum
MCC	:	Motor Control Centre
MCR	:	Maximum Continuous Rating
MDC	:	Mechanical Dust Collector
Min.	:	Minimum
MSS	:	Manufacturer's Standardisation Society
MT	:	Metric Tonnes
NEMA	:	National Electrical Manufacturers' Association
NEPRA	:	National Electric Power Regulatory Authority
NFPA	:	National Fire Protection Association
NGR	:	Neutral Grounding Resistor
NPSH	:	Net Positive Suction Head
PCC	:	Power Control Centre
PFI	:	Pipe Fabrication Institute
PLC	:	Programmable Logic Controller
PLF	:	Plant Load Factor
PPA	:	Power Purchase Agreement
PPIB	:	Private Power and Infra-structure Board
PPM	:	Parts per Million
PRDS	:	Pressure Reducing Desuperheating Station
PVC	:	Poly Vinyl Chloride
PT	:	Potential Transformer
RCC	:	Reinforced Cement Concrete
RM	:	Running Meter
RPM	:	Revolutions / Rotations Per

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		Minute
RSB	:	Rotary Soot Blower
ASML	:	Ashraf Sugar Mills Limited
RTD	:	Resistance Temperature Detector
SA	:	Secondary Air
SBC	:	Soil Bearing Capacity
SC	:	Slat Chain Conveyor
SCADA	:	Supervisory Control And Data Acquisition
SQ.M	:	Square Metre
TCD	:	Tonnes of Cane per Day
TCH	:	Tonnes of Cane per Hour
TEMA	:	Tubular Exchanger Manufacturer's Association
TPH	:	Tonnes Per Hour
TVM	:	Trivector Meter
WCM	:	Working Capital Margin
XLPE	:	Cross Linked Poly Ethylene

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18.0 Drawings & Annxures

S.No	Description	Drawing No.
01.	Overall Plant Layout	0-15308-600-0020
02.	Equipment Layout - TG Hall at EL 0.0 M level	1-15308-600-0035
03.	Equipment Layout - TG Hall at EL 5.0 M LVL	1-15308-600-0036
04.	Equipment Layout - TG Hall at EL 9 M level	1-15308-600-0037
05	Equipment Layout - TG Hall at EL 14 M level	1-15308-600-0038
06	Equipment Layout - Elevation View	1-15308-600-0039
07	Scheme of Steam generator Steam and Water System	1-15308-800-0041
08	Scheme of Steam generator Air and Flue Gas System	2-15308-800-0021
09.	Scheme of Fuel Handling System (Bagasse)	2-15308-300-0104
10.	Scheme of Ash Handling System	3-15308-300-0109
11.	Scheme of Cooling Water System	0-15308-800-0029

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S.No	Description	Drawing No.
12.	Control Instrument diagram	1-15308-800-0030
13.	Scheme of Plant Steam System	1-15308-800-0041
14.	Scheme of Raw Water, DM Water and Condensate System	0-15308-800-0028
15.	Organization Chart	4-15308-800-0046
16.	Electrical System Single Line Diagram	0-15308-900-0453
17.	Switchyard Layout	1-15308-900-0454
18.	DCS System Architecture	1-15308-800-0454
19.	Schemes	
	Cogeneration HMBD - Season Operation	3-15308-800-0018
	Cogeneration HMBD - Off-Season Operation	3-15308-800-0019
20.	Project Schedule	

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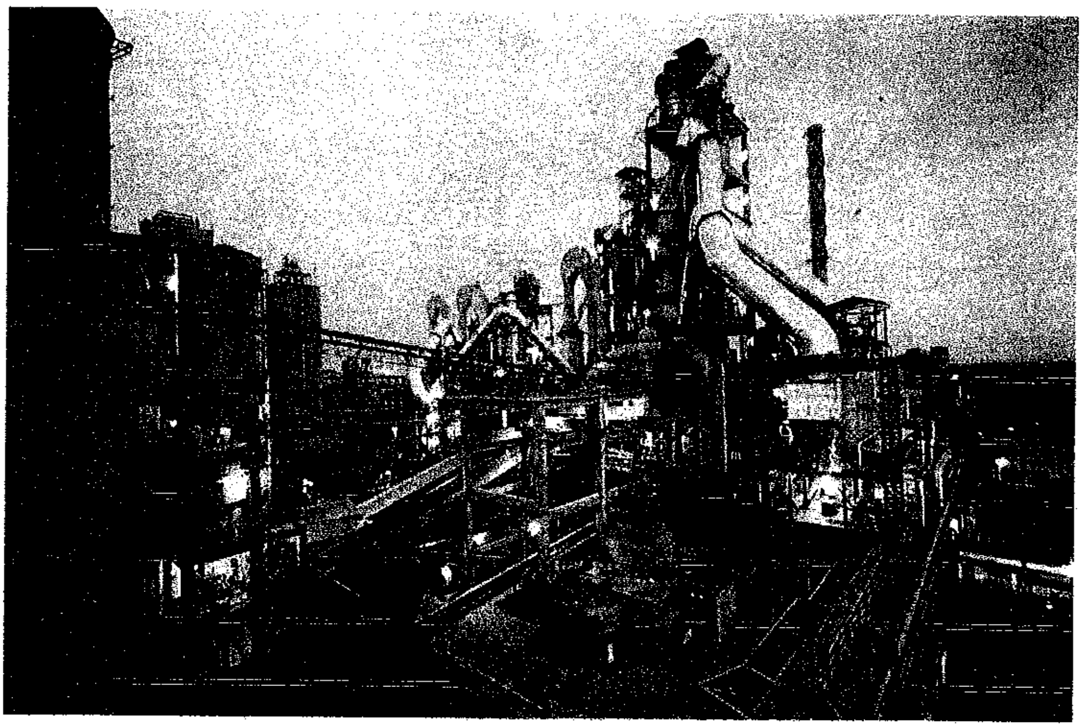
Report No. PPI-219.2-Final/16

PPI

INTERCONNECTION STUDY

For

31.2 MW Bahawalpur Energy Limited Power Plant near Bahawalpur, Punjab



Final Report
(December 2016)

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Executive Summary

- The Final Report of interconnection of the 31.2 MW Power Plant by Bahawalpur Energy Ltd. with MEPCO grid system is submitted herewith.
- Bahawalpur Energy Ltd. would like to go for high pressure cogeneration with the aim of exporting spillover power to the national grid during the crushing season (November to March) and Off-Season (April to October).
- The study objective, approach and methodology have been described and the plant's data received from the Client is validated. The network around Bahawalpur Energy Ltd. (referred to as Bahawalpur Energy PP in the remainder of the report) at 132 kV and 11 kV has been modeled as shown in Appendix-B (Sketch-1).
- As MEPCO has inherent problems of over loading and under voltages in the area under study, the following reinforcements were finalized in the meeting held in NTDC (Planning) office on 05-10-2016 and 06-10-2016 and are shown in Appendix-B (Sketch-2):
    - The double circuit, initially proposed from R. Y. Khan-New to Khanpur on Rail conductor should instead be laid from R. Y. Khan-New to Feroza. The length of this circuit would be 35 km.
    - A double circuit on Rail conductor from R. Y. Khan-New should be laid such that it is looped in-out at the R. Y. Khan-Old to R. Y. Khan Industrial Estate 132 kV circuit. The length of this circuit would be approximately 50 km and the looping point is 6 km from both R. Y. Khan-Old and R. Y. Khan Industrial Estate 132 kV Grid Station. It was further proposed that although the circuit from R. Y. Khan-Old to R. Y. Khan Industrial Estate is on Lynx conductor, the portion of the transmission from the looping point to R. Y. Khan-old should be replaced with Rail conductor.
- The nearest NTDC grid facility available for interconnection to Bahawalpur Energy PP is the Bahawalpur-New 220/132 kV Grid Station and the Samasata 132 kV Grid Station. A 132 kV circuit on lynx conductor between Bahawalpur-New and Samasata is being operated which passes about 8 km away from the location of Bahawalpur Energy PP.

- According to the interconnection scheme finalized in the meeting held in MEPCO Office on 6th September 2016, Bahawalpur Energy PP will be looped in-out at 132kV circuit between Bahawalpur-New and Samasata grids. The looping distance would be 8 km on Lynx conductor. The circuit length between Bahawalpur-New and Samasata Grids is 3.2 km and after the interconnection of Bahawalpur Energy PP it will become 19.2 km. The scheme is shown in Sketch-2 in Appendix-B.
- Bahawalpur Energy PP will generate at 11 kV voltage level from where it is stepped-up to 132 kV using two 30/40 MVA 132/11 kV transformers.
- The proposed scheme will require two breaker bays of 132 kV at Bahawalpur Energy PP to connect with the 132 kV circuits with Bahawalpur-New and Samasata and two transformer bays to connect two 30/40 MVA 132/11 kV transformers.
- With the gross capacity of 31.2 MW, the spillover from Bahawalpur Energy PP would be 28 MW in Crushing Season and 27 MW in the Off-Season.
- In view of planned COD of the Bahawalpur Energy PP in December 2018, the above proposed interconnection scheme has been tested for steady state conditions through detailed load flow studies for the peak conditions of
  - January 2019 for maximum thermal power dispatches in the grid during the crushing season of Bahawalpur Energy PP.
  - September 2019 for maximum hydropower dispatches in the grid during the Off-Season for Bahawalpur Energy PP.

  The system conditions of normal and N-1 contingency have been studied to meet the reliability criteria of NEPRA Grid Code.
- The proposed scheme of interconnection has also been tested for the extended term scenario of peak load conditions of the year 2021 for steady state conditions.
- Steady state analysis by load flow for all the scenarios described above reveals that the proposed scheme is adequate to evacuate the spillover of up to 28 MW power of the Plant under normal as well as contingency conditions.
- The short circuit analysis has been carried out to calculate maximum fault levels at Bahawalpur Energy PP and the substations of 132 kV in its vicinity. We find that the fault currents for the proposed scheme are within the rated short circuit

capacities of switchgear installed at these substations. There are no violations of exceeding the rating of the equipment due to contribution of fault current from Bahawalpur Energy PP.

- The maximum short circuit levels of Bahawalpur Energy PP 132 kV is 7.18 kA and 7.46 kA for 3-phase and 1-phase faults respectively for the Year 2019-20 and 7.36 kA and 7.65 kA for 3-phase and 1-phase faults respectively for the Year 2021. It would be advisable to go for standard size switchgear of short circuit rating of 40 kA. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out for January 2019 and extended term scenario (Summer 2021). The stability check for the worst case of three phase fault right on the 132 kV bus bar of Bahawalpur Energy PP substation followed by the final trip of one 132 kV circuit emanating from this substation, has been performed for fault clearing of 5 (100 ms) and 9 cycles (180 ms), in case of stuck breaker, as understood to be the normal fault clearing time of 132 kV protection system. The stability of system for far end faults of 3-phase occurring at 132 kV bus bar have also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far faults for the most stringent cases. The system is found strong enough to stay stable and recovered with fast damping.
- The proposed scheme of interconnection has no technical constraints or problems, it fulfills all the criteria of reliability and stability under steady state load flow, contingency load flows, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

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Report Contents

1. Introduction

1.1 Background

Bahawalpur Energy Ltd. would like to go for high pressure cogeneration with the aim of exporting spillover power to the National Grid. The electricity generated from this project would be supplied to the grid system of MEPCO through 132 kV grids available in the vicinity of this project. The nearest grid facility is a 220/132 kV Bahawalpur-New and 132 kV Samasata. A 132 kV circuit on lynx conductor between Bahawalpur-New and Samasata is being operated which passes about 8 km away from the location of Bahawalpur Energy PP, as shown in Sketch-2 in Appendix-B.

1.2 Objectives

The overall objective of the Study is to evolve an interconnection scheme between Bahawalpur Energy PP and MEPCO network, for stable and reliable evacuation of the electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives of this report are:

1. To develop scheme of interconnections at 132 kV for which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant 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 Bahawalpur Energy PP.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping.

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1.3 Planning Criteria

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

Steady State:

Voltage	± 5 %, Normal Operating Condition
	± 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

Short Circuit:

Substation Equipment Rating for 132 kV should be 31.5 kA or 40 kA.

Dynamic/Transient:

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

In case of failure of primary protection (stuck breaker case), the total fault clearing time from the instant of initiation of fault current to the complete interruption of current to isolate the faulted element, including the primary protection plus the backup protection to operate and isolate the fault, is equal to 180 ms (9 cycles) for 132 kV and higher voltage levels.

2. Assumptions of Data

The number of generating units at Bahawalpur Energy PP is one. The following data have been provided by the Client:

2.1 Bahawalpur Energy PP

Generator data:

Gross capacity of power plant	= 1x31.2 = 31.2 MW
Lump sum MVA capacity	= 1x39 = 39 MVA
Generating Voltage	= 11 kV
Power factor	= 0.80 lagging
Crushing Season:	
Auxiliary Consumption	= 3 MW
Spillover to the Grid	= 28 MW
Off-Season:	
Load	= 1 MW
Auxiliary Consumption	= 3 MW
Spillover to the Grid	= 27 MW
GSU Transformer	= 30/40 MVA (x2)
GSU Transformer reactance	= 12.49 %

2.2 Network data

The 132 kV network in the area near Bahawalpur Energy PP are as shown in Sketches in Appendix-B. The system data of MEPCO has been used as already available with PPI.

3. Study Approach and Methodology

3.1 Understanding of the Problem

Bahawalpur Energy Ltd. would like to go for high pressure cogeneration with the aim of exporting a maximum of 28 MW supply to the grid during the Crushing Season and 27 MW in Off Season. The proposed Power Project is going to be embedded in the transmission network of MEPCO through this nearest available 132 kV network. The adequacy of MEPCO network of 132 kV in and around the proposed site of Bahawalpur Energy PP has been investigated in this study for absorbing and transmitting this power fulfilling the reliability criteria.

3.2 Approach to the problem

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for January 2019 (for Crushing Season) and September 2019 (for Off Season) after the commissioning of Bahawalpur Energy PP in December 2018, comprising all 500 kV, 220 kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in MEPCO.
- Month of January 2019 and September 2019, while representing Crushing Season and Off-Season respectively, also represent low water and high water conditions respectively in the grid system. Thus both the high water and low water flow patterns can be observed allowing us to judge the maximum impact of the plant on the transmission system in its vicinity. In addition, case for extended term scenario of the year 2021 has also been studied.
- 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.

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- 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 132 kV network available around Bahawalpur Energy PP is shown in Sketch-2 in Appendix-B.

The system around Bahawalpur Energy PP has other co-generation power plants in the vicinity like Hamza Power Plant, Etihad Power, RYK Unit I and Unit II. The existing network of MEPCO in the vicinity of Bahawalpur Energy PP is notorious for low voltages and problems of circuit overloading in contingency conditions. A joint meeting was held in GM (Planning), NTDC office on 5th and 6th of October 2016 to address and resolve these issues. The reinforcements proposed in the meeting are:

- The double circuit, initially proposed from R. Y. Khan-New to Khanpur on Rail conductor should instead be laid from R. Y. Khan-New to Feroza. The length of this circuit would be 35 km.
- A double circuit on Rail conductor from R. Y. Khan-New should be laid such that it is looped in-out at the R. Y. Khan-Old to R. Y. Khan Industrial Estate 132 kV circuit. The length of this circuit would be approximately 50 km and the looping point is 6 km from both R. Y. Khan-Old and R. Y. Khan Industrial Estate 132 kV Grid Station. It was further proposed that although the circuit from R. Y. Khan-Old to R. Y. Khan Industrial Estate is on Lynx conductor, the portion of the transmission from the looping point to R. Y. Khan-old should be replaced with Rail conductor.

In addition, MEPCO has also taken steps to improve the voltage profile of this area by proposing capacitors at Ahmedpur-East (24 MVAR) and Uch-Sharif (12 MVAR).

4.2 The Scheme of Interconnection of Bahawalpur Energy PP

Keeping in view of the above mentioned 132 kV network available in the vicinity of the site of the Bahawalpur Energy PP and the reinforcements proposed in this area, the interconnection scheme for Bahawalpur Energy PP has been developed. According to the interconnection scheme finalized in the meeting held in MEPCO Office on 06-09-2016, Bahawalpur Energy PP will be looped in-out at 132kV circuit between Bahawalpur-New and Samasata. The looping distance would be 8 km. The scheme is shown in Sketch-2 in Appendix-B. The network of Bahawalpur Energy PP has been modeled at 132 kV and 11 kV.

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5. Detailed Load Flow Studies

5.1 Peak Case Load Flow January 2019, without Bahawalpur Energy PP

A base case has been developed for the peak load of January 2019 using the network data of NTDC and MEPCO available with PPI, after updating with latest load forecast and expansion plan of NTDC and MEPCO. The peak load of the year 2018-19 for MEPCO has been modeled as per the latest PMS Demand forecast obtained from NTDC.

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-C. The system plotted in this Exhibit comprises of 132 kV network feeding Bahawalpur-New, Samasata, Liaqatpur, Mubarakpur, Khanpur and the surrounding areas.

The load flow results show that the power flows on all the circuits are within their normal rating. The voltage profile of these surrounding substations is also within normal limits.

For N-1 contingency conditions we have performed the following cases

Exhibit-0.1	Samasata to Bahawalpur-New 132kV Single Circuit Out
Exhibit-0.2	Liaqatpur to Samasata 132kV Single Circuit Out
Exhibit-0.3	Hamza-PP to Liaqatpur 132kV Single Circuit Out
Exhibit-0.4	Khanpur to Hamza-PP 132kV Single Circuit Out
Exhibit-0.5	Bahawalpur-New to Mubarakpur 132 KV Single Circuit Out
Exhibit-0.6	Ahmadpur-East to Mubarakpur 132 KV Single Circuit Out

We see that in all the cases the power flows on all circuits remain within their rated limit. Also the bus voltages are within the acceptable operating range.

5.2 Peak Case Load Flow January 2019, with Bahawalpur Energy PP in Crushing Season

The scheme of interconnection modeled in the load flow for Bahawalpur Energy PP is as described in Chapter-4.

Load flow studies have been carried out for January 2019 because it represents the maximum thermal dispatch conditions in the grid during the crushing Season condition of Bahawalpur Energy PP. Thus the loading on the lines in the vicinity of Bahawalpur Energy PP will be maximum, allowing us to judge the maximum impact of the plant on the transmission system in its vicinity. The results of load flow with Bahawalpur Energy PP interconnected as per proposed scheme are shown in Appendix-C.

The results of Normal case of Peak January 2019 are plotted in Exhibit 1.0. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits. 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 ± 5 % off the nominal. N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – C as follows;

Exhibit-1.1	Bahawalpur Energy 132/11 kV Single Transformer Out
Exhibit-1.2	Bahawalpur Energy to BWP-New 132kV Single Circuit
Exhibit-1.3	Samasata to Bahawalpur Energy 132kV Single Circuit Out
Exhibit-1.4	Liaqatpur to Samasata 132kV Single Circuit Out
Exhibit-1.5	Hamza-PP to Liaqatpur 132kV Single Circuit Out
Exhibit-1.6	Hamza-PP to Khanpur 132kV Single Circuit Out
Exhibit-1.7	Bahawalpur-New to Mubarakpur 132 KV Single Circuit Out
Exhibit-1.8	Ahmadpur-East to Mubarakpur 132 KV Single Circuit Out

We see that in all the contingency cases, in the event of outage of any circuit, the intact circuits remain within the rated capacity.

Also the bus bar voltages are well within the permissible limits in all the contingency events.

5.3 Peak Case Load Flow September 2019, with Bahawalpur Energy PP in Off-Season

The scheme of interconnection modeled in the load flow for Bahawalpur Energy PP is as described in Chapter-4.

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Load flow studies have been carried out for September because it represents the maximum hydropower dispatch conditions in the grid during the off Season of Bahawalpur Energy PP. Thus the loading on the lines in the vicinity of Bahawalpur Energy PP will be maximum, allowing us to judge the maximum impact of the plant on the transmission system in its vicinity. The results of load flow with Bahawalpur Energy PP interconnected as per proposed scheme are shown in Appendix-C.

The results of Normal case of Peak September 2019 are plotted in Exhibit 2.0. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

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 ± 5 % off the nominal.

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

Exhibit-2.1	Bahawalpur Energy 132/11 kV Single Transformer Out
Exhibit-2.2	BWP-New to Bahawalpur Energy 132kV Single Circuit
Exhibit-2.3	Bahawalpur Energy to Samasata 132kV Single Circuit Out
Exhibit-2.4	Samasata to Liaqatpur 132kV Single Circuit Out
Exhibit-2.5	Hamza-PP to Liaqatpur 132kV Single Circuit Out
Exhibit-2.6	Hamza-PP to Khanpur 132kV Single Circuit Out
Exhibit-2.7	Bahawalpur-New to Mubarakpur 132 KV Single Circuit Out
Exhibit-2.8	Mubarakpur to Ahmadpur-East to 132 KV Single Circuit Out

We see that in all the contingency cases, in the event of outage of any circuit, the intact circuits remain within the rated capacity.

Also the bus bar voltages are well within the permissible limits in all the contingency events.

5.4 Peak Load Case 2021: Extended Term Scenario

Load flow studies have been carried out for the future scenario of Year 2021 to assess the impact of the plant in the extended term.

The results of Normal case of Peak 2021 are plotted in Exhibit 3.0. 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 ± 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	Bahawalpur Energy 132/11 kV Single Transformer Out
Exhibit-3.2	BWP-New to Bahawalpur Energy 132kV Single Circuit
Exhibit-3.3	Bahawalpur Energy to Samasata 132kV Single Circuit Out
Exhibit-3.4	Samasata to Liaqatpur 132kV Single Circuit Out
Exhibit-3.5	Liaqatpur to Hamza-PP 132kV Single Circuit Out
Exhibit-3.6	Hamza-PP to Khanpur 132kV Single Circuit Out
Exhibit-3.7	Bahawalpur-New to Mubarakpur 132 KV Single Circuit Out
Exhibit-3.8	Mubarakpur to Ahmadpur-East to 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 ± 10 % off the nominal for contingency conditions' criteria

We find that there are no capacity constraints in the proposed connectivity scheme of Bahawalpur Energy PP.

5.5 Analysis of Voltage Profile and Transmission Line Losses

a) Voltage Profile

The voltage profile on the buses near Bahawalpur Energy PP was analysed. The voltages on the bus bars in the vicinity of Bahawalpur Energy PP have been shown in Table 5.1 for comparison. These voltages are also shown in Exhibit 0.0 (without Bahawalpur Energy PP) and Exhibit 1.0 (with Bahawalpur Energy PP).

Table – 5.1

Bus Bars	Volatge (kV)	
	Without Bahawalpur Energy PP	With Bahawalpur Energy PP
Bahawalpur-New 132 kV	135.2	135.4
Samasata 132 kV	135.1	135.4
Liaqatpur 132 kV	135.2	135.3
Mubarakpur 132 kV	133.0	133.2
Hamza-PP 132 kV	136.5	136.6

It can be seen that the overall voltage profile of the area improves after the introduction of Bahawalpur Energy PP into the system.

b) Transmission Line Losses

The transmission line losses were evaluated for the normal case of peak load January 2019 for a sub-system comprising of all the 132 kV and 11 kV bus bars of Bahawalpur, Mubarakpur, Samasata, Liaqatpur, Hamza Power, Ahmedpur-East, Khanpur, Feroza, Khanbela, Uch Sharif, RYK PP Unit-I & II, R. Y. Khan-New, R. Y. Khan-Old and R.Y. Khan-2. These losses were evaluated for two scenarios; without Bahawalpur Energy PP and with Bahawalpur Energy PP. The PSS/E generated report of transmission line losses is shown in Report 5-A and Report 5-B in Appendix-C.

It can be seen that the overall transmission loss of the area reduces from 7.5 MW, when Bahawalpur Energy PP is not connected, to 7.0 MW, when Bahawalpur Energy PP comes into operation.

Hence the introduction of Bahawalpur Energy PP in MEPCO region reduces the overall transmission losses of the area due to availability of local generation as power does not have to flow from far-off generation points.

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5.6 Conclusion of Load Flow Analysis

The proposed interconnection scheme of Bahawalpur Energy PP is adequate to evacuate the spillover electrical power from Bahawalpur Energy PP under normal and contingency conditions tested for peak load conditions of January 2019, September 2019 and extended term scenario of the Year 2021. In all the normal and contingency cases, we find that the loading on the circuits remain within the rated capacity. Also the bus bar voltages are well within the permissible limits in all the normal and contingency events. Hence the proposed interconnection scheme of Bahawalpur Energy PP has no constraints according to the Load Flow Analysis.

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 hydro, thermal and nuclear plants in the system in the year 2018-19 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 Ch.2 of this report.

6.2 Fault Current Calculations without Bahawalpur Energy PP, 2018-19

In order to assess the short circuit strength of the network of 132 kV without Bahawalpur Energy PP for the grid of MEPCO in the vicinity of the site of the Plant, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will give us the idea of the fault levels without Bahawalpur Energy PP and later on how much the contribution of fault current from Bahawalpur Energy 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 i.e. Bahawalpur-New, Samasata, Liaqatpur, Hamza-PP, Khanpur, R.Y.Khan-New, Mubarakpur and surrounding bus bars 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 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 i.e. the substations connecting in the 132 kV circuits lying close to Bahawalpur-New, Khanpur and Ahmadpur. 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 20 kA, 25 kA or 31.5 kA for older substations and 40 kA for new substations.

Table-6.1
Maximum Short Circuit Levels without Bahawalpur Energy PP, 2018-19

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Bahawalpur-New-II 132kV	**8.14**	**8.19**
Samasata 132kV	**7.53**	**7.50**
Liaqatpur 132kV	**4.62**	**4.54**
Hamza-PP 132kV	**6.98**	**7.05**
Khanpur 132kV	**10.08**	**10.41**
R.Y.Khan-New 132kV	**16.16**	**15.58**
Mubarakpur 132kV	**4.79**	**4.92**
Ahmadpur-East 132kV	**4.43**	**5.26**

6.3 Fault Current Calculations with Bahawalpur Energy PP, – Year 2019-20

Fault currents have been calculated for the electrical interconnection of proposed scheme. Fault types applied are three phase and single-phase at 132 kV bus bars of Bahawalpur Energy PP itself and other bus bars of the 132 kV substations in the electrical vicinity of Bahawalpur-New, Samasata, Liaqatpur, Hamza-PP, Khanpur, R.Y.Khan-New and Mubarakpur. The graphic results showing maximum 3-phase and 1-phase fault levels are indicated in Exhibit 4.1. Both 3-phase and 1-phase fault currents are indicated in the Exhibit 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 Bahawalpur Energy PP 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 Bahawalpur Energy PP, – Year 2019-20

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Bahawalpur Energy 132kV	**7.18**	**7.46**
Bahawalpur-New-II 132kV	**8.70**	**8.83**
Samasata 132kV	**5.95**	**6.00**
Liaqatpur 132kV	**4.51**	**4.46**
Hamza-PP 132kV	**6.95**	**7.04**
Khanpur 132kV	**10.12**	**10.47**
R.Y.Khan-New 132kV	**16.33**	**15.79**
Mubarakpur 132kV	**4.92**	**5.03**
Ahmadpur-East 132kV	**4.52**	**5.36**

Comparison of Tables 6.1 and 6.2 show slight increase in short circuit levels for both three-phase and single – phase, on the 132 kV bus bars of Bahawalpur-New, Mubarakpur, Ahmadpur-East, Khanpur, and R.Y.Khan-New due to connection of Bahawalpur Energy PP. However, due to connection of Bahawalpur Energy PP the short circuit levels are slightly decreased on the 132 kV bus bars of Samasata, Liaqatpur, Hamza-PP. The short circuit levels are decreased due to the increase in circuit length between Bahawalpur-New and Samasata Grids. Before the interconnection of Bahawalpur Energy PP the circuit length was 3.2 km between Bahawalpur-New and Samasata Grids and after the interconnection it would become 19.2 km.

We find that even after some increase, these fault levels are below the rated short circuit values of the equipment installed on these substations. The maximum short circuit level of Bahawalpur Energy PP 132 kV is 7.18 kA and 7.46 kA for 3-phase and 1-phase faults respectively.

6.4 Fault Current Calculations with Bahawalpur Energy PP – Year 2021

Fault currents have been calculated for the electrical interconnection of proposed scheme in the year 2021. Fault types applied are three phase and single-phase at 132 kV bus bars of Bahawalpur Energy PP itself and other bus bars of the 132 kV substations in the electrical vicinity of Bahawalpur-New, Samasata, Liaqatpur, Hamza-PP, Khanpur, R.Y.Khan-New and Mubarakpur. 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 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 Bahawalpur Energy 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 Bahawalpur Energy PP – Year 2021

Substation	3-Phase fault current, kA	1-Phase fault current, kA
Bahawalpur Energy 132kV	7.36	7.65
Bahawalpur-New-II 132kV	8.99	9.26
Samasata 132kV	6.05	6.10
Liaqatpur 132kV	4.56	4.62
Hamza-PP 132kV	6.94	7.35
Khanpur 132kV	10.40	10.96
R.Y.Khan-New 132kV	17.19	16.30
Mubarakpur 132kV	4.99	5.38
Ahmadpur-East 132kV	4.58	5.49

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The short circuit levels have increased a little more in the future scenario but are still below the rated short circuit values of the equipment installed on these substations. The maximum short circuit level of Bahawalpur Energy PP 132 kV is 7.36 kA and 7.65 kA for 3-phase and 1-phase faults respectively. It would be advisable to go for standard size switchgear of short circuit rating of 40 kA. 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 Bahawalpur Energy PP there is no problem of violations of short circuit ratings of the already installed equipment on the 132 kV equipment of substations in the vicinity of Bahawalpur Energy 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 Bahawalpur Energy PP 132 kV is 7.18 kA and 7.46 kA for 3-phase and 1-phase faults respectively for the year 2019-20. The same values for the year 2021 are 7.36 kA and 7.65 kA. Therefore industry standard switchgear of the short circuit rating of 40 kA would be fine to be installed at 132 kV switchyard of Bahawalpur Energy PP 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 switchgear.

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 Ch.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 = 2.321 MW-sec/MVA

7.1.2 System Conditions

The proposed scheme as described in Chapter-4 has been modeled in the dynamic simulation.

All the power plants of WAPDA/PEPCO and IPPs 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 Bahawalpur Energy PP i.e. right at the 132 kV bus bar of Bahawalpur Energy PP substation, cleared in 5 cycles, as normal clearing time for 132 kV i.e. 100 ms, followed by a permanent trip of single 132 kV circuit emanating from this substation. Fault at the 132 kV bus bar of Bahawalpur Energy PP has also been simulated for 9 cycles.

7.2 Dynamic Stability Simulations' Results with Bahawalpur Energy PP in Crushing Season

Three-phase faults were applied 132 kV bus bars, followed by clearing of fault in 5 cycles (100 ms) or 9 cycles (180 ms) and then tripping of a circuit between the faulted bus and a nearby grid station. Different quantities were monitored for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and the results are plotted in Appendix – E. These fault locations and monitored quantities are discussed one by one as follows;

7.2.1

Fault Location: Bahawalpur Energy 132 kV bus bar

Fault Duration: 5 cycles (100 ms)

Line Tripping: Bahawalpur Energy to Bahawalpur-New 132 kV Single Circuit

Variable	Bus/Line	Response	Figure No.
Voltage	1. Bahawalpur Energy 132 kV 2. Samasata 132 kV 3. Liaqatpur 132 kV 4. Mubarakpur 132 kV 5. Bahawalpur-New 132 kV 6. Bahawalpur-New 220 kV	The voltages of all the bus bars recover after fault clearance	1.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	1.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	1.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	1.4
Line Flows (MW/MVAR)	Bahawalpur Energy to Samasata 132 kV intact single circuit	Attains steady state value after damping of oscillations	1.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	1.6

7.2.2

Fault Location: Bahawalpur Energy 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Bahawalpur Energy to Bahawalpur-New 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur Energy 132 kV 2. Samasata 132 kV 3. Liaqatpur 132 kV 4. Mubarakpur 132 kV 5. Bahawalpur-New 132 kV 6. Bahawalpur-New 220 kV	The voltages of all the bus bars recover after fault clearance	2.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	2.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	2.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	2.4
Line Flows (MW/MVAR)	Bahawalpur Energy to Samasata 132 kV intact single circuit	Attains steady state value after damping of oscillations	2.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	2.6

7.2.3

Fault Location: Bahawalpur-New 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Bahawalpur-New to Bahawalpur Energy 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur-New 132 kV 2. Bahawalpur-New 220 kV 3. Bahawalpur Energy 132 kV 4. Mubarakpur 132 kV 5. Samasata 132 kV 6. Liaqatpur 132 kV	The voltages of all the bus bars recover after fault clearance	3.1

Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	3.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	3.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	3.4
Line Flows (MW/MVAR)	Bahawalpur-New to Mubarakpur 132 kV intact single circuit	Attains steady state value after damping of oscillations	3.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	3.6

7.2.4

Fault Location: Samasata 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Samasata to Liaqatpur 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Samasata 132 kV 2. Bahawalpur Energy 132 kV 3. Liaqatpur 132 kV 4. Mubarakpur 132 kV 5. Bahawalpur-New 132 kV 6. Bahawalpur-New 220 kV	The voltages of all the bus bars recover after fault clearance	4.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	4.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	4.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	4.4
Line Flows (MW/MVAR)	Bahawalpur Energy to Samasata 132 kV intact single circuit	Attains steady state value after damping of oscillations	4.5
Rotor Angles	1. Bahawalpur Energy 11 kV	Damps down	4.6

	2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	quickly and attain a steady state value	

7.3 Dynamic Stability Simulations' Results with Bahawalpur Energy PP For Extended Term Scenario (Summer 2021)

Three-phase faults were applied on 132 kV bus bars, followed by clearing of fault in 5 cycles (100 ms) or 9 cycles (180 ms) and then tripping of a circuit between the faulted bus and a nearby grid station. Different quantities were monitored for one second pre-fault and nine secnd after clearance of fault (post-fault) conditions and the results are plotted in Appendix – E. These fault locations and monitored quantities are discussed one by one as follows;

7.3.1

Fault Location: Bahawalpur Energy 132 kV bus bar			
Fault Duration: 5 cycles (100 ms)			
Line Tripping: Bahawalpur Energy to Samasata 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur Energy 132 kV 2. Samasata 132 kV 3. Liaqatpur 132 kV 4. Mubarakpur 132 kV 5. Bahawalpur-New 132 kV 6. Bahawalpur-New 220 kV	The voltages of all the bus bars recover after fault clearance	5.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	5.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	5.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	5.4
Line Flows (MW/MVAR)	Bahawalpur Energy to Bahawalpur-New 132 kV intact single circuit	Attains steady state value after damping of oscillations	5.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV	Damps down quickly and	5.6

	3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	attain a steady state value	

7.3.2

Fault Location: Bahawalpur Energy 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Bahawalpur Energy to Samasata 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur Energy 132 kV 2. Samasata 132 kV 3. Liaqatpur 132 kV 4. Mubarakpur 132 kV 5. Bahawalpur-New 132 kV 6. Bahawalpur-New 220 kV	The voltages of all the bus bars recover after fault clearance	6.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	6.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	6.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	6.4
Line Flows (MW/MVAR)	Bahawalpur Energy to Bahawalpur-New 132 kV intact single circuit	Attains steady state value after damping of oscillations	6.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	6.6

7.3.3

Fault Location: Bahawalpur-New 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Bahawalpur-New to Mubarakpur 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur-New 132 kV 2. Bahawalpur-New 220 kV	The voltages of all the bus	7.1

	3. Bahawalpur Energy 132 kV 4. Mubarakpur 132 kV 5. Samasata 132 kV 6. Liaqatpur 132 kV	bars recover after fault clearance	
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	7.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	7.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	7.4
Line Flows (MW/MVAR)	Bahawalpur-New to Bahawalpur Energy 132 kV intact single circuit	Attains steady state value after damping of oscillations	7.5
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	7.6

7.3.4

Fault Location: Samasata 132 kV bus bar			
Fault Duration: 9 cycles (180 ms)			
Line Tripping: Samasata to Bahawalpur Energy 132 kV Single Circuit			
Variable	**Bus/Line**	**Response**	**Figure No.**
Voltage	1. Bahawalpur-New 132 kV 2. Bahawalpur-New 220 kV 3. Bahawalpur Energy 132 kV 4. Mubarakpur 132 kV 5. Samasata 132 kV 6. Liaqatpur 132 kV	The voltages of all the bus bars recover after fault clearance	8.1
Frequency	Bahawalpur Energy 132 kV	Recovers after fault clearance	8.2
MW/MVAR Output of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	8.3
Speed and $P_{mechanical}$ of the Plant	Bahawalpur Energy 11 kV	Recovers after damping down oscillations	8.4
Line Flows (MW/MVAR)	Samasata to Liaqatpur 132 kV intact single circuit	Attains steady state value after damping	8.5

		of oscillations	
Rotor Angles	1. Bahawalpur Energy 11 kV 2. Hamza-PP-2 11 kV 3. Etihad-PP 11 kV 4. R.Y.K Unit – II 11 kV 5. Ittefaq-PP 11 kV 6. Hub 500 kV (reference angle)	Damps down quickly and attain a steady state value	8.6

7.4 Conclusion of Dynamic Stability Analysis

The results of dynamic stability 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 Bahawalpur Energy PP. Therefore there is no problem of dynamic stability for interconnection of Bahawalpur Energy PP; it fulfills all the criteria of dynamic stability.

8. Conclusions

- Bahawalpur Energy Ltd. would like to go for high pressure cogeneration with the aim of exporting spillover power to the national grid during the crushing season (from Novermber to March) and Off-Season (from April to October).
- The nearest NTDC grid facility available for interconnection to Bahawalpur Energy PP are Bahawalpur-New 220/132 kV Grid Station and the Samasata 132 kV Grid Station. A 132 kV circuit on lynx conductor between Bahawalpur-New and Samasata is being operated which passes about 8 km away from the location of Bahawalpur Energy PP.
- According to the interconnection scheme finalized in the meeting held in MEPCO Office on 6th September 2016, Bahawalpur Energy PP will be looped in-out at 132kV circuit between Bahawalpur-New and Samasata. The looping distance would be 8 km on Lynx conductor. The circuit length between Bahawalpur-New and Samasata grid is 3.2 km and after the interconnection of Bahawalpur Energy PP it would become 19.2 km as shown in Sketch-2 in Appendix-B.
- Bahawalpur Energy PP will generate at 11 kV voltage level from where it is stepped-up to 132 kV using two 30/40 MVA 132/11 kV transformers.
- The proposed scheme will require two breaker bays of 132 kV at Bahawalpur Energy PP to connect with the 132 kV circuits with Bahawalpur-New and Samasata and two transformer bays to connect two 30/40 MVA 132/11 kV transformers.
- With the gross capacity of 31.2 MW, the spillover from Bahawalpur Energy PP would be 28 MW in Crushing Season and 27 MW in the Off-Season.
- In view of planned COD of the Bahawalpur Energy PP in December 2018, the above proposed interconnection scheme has been tested for steady state conditions through detailed load flow studies for the peak conditions of
  - January 2019 for maximum thermal power dispatches in the grid during the crushing season of Bahawalpur Energy PP.
  - September 2019 for maximum hydropower dispatches in the grid during the Off-Season for Bahawalpur Energy PP.

The system conditions of normal and N-1 contingency have been studied to meet the reliability criteria of NEPRA Grid Code.

- The proposed scheme of interconnection has also been tested for the extended term scenario of peak load conditions of the year 2021 for steady state conditions.
- Steady state analysis by load flow for all the scenarios described above reveals that the proposed scheme is adequate to evacuate the spillover up to 28 MW power of the Plant under normal as well as contingency conditions.
- Voltage profile of the bus bars in the vicinity of Bahawalpur Energy PP was analyzed which shows an improvement in overall voltage of the system after the introduction of Bahawalpur Energy PP. In addition, transmission line losses were evaluated on the subsystem comprising the 132 kV and 11 kV bus bars in the vicinity of Bahawalpur Energy PP, which show a reduction of 0.5 MW losses as a result of introduction of Bahawalpur Energy PP.
- The short circuit analysis has been carried out to calculate maximum fault levels at Bahawalpur Energy PP and the substations of 132 kV in its vicinity. We find that the fault currents for the proposed scheme are within the rated short circuit capacities of switchgear installed at these substations. There are no violations of exceeding the rating of the equipment due to contribution of fault current from Bahawalpur Energy PP.
- The maximum short circuit levels of Bahawalpur Energy PP 132 kV is 7.18 kA and 7.46 kA for 3-phase and 1-phase faults respectively for the Year 2019-20 and 7.36 kA and 7.65 kA for 3-phase and 1-phase faults respectively for the Year 2021. It would be advisable to go for standard size switchgear of short circuit rating of 40 kA. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out for January 2019 and Extended Term Scenario (Summer 2021). The stability check for the worst case of three phase fault right on the 132 kV bus bar of Bahawalpur Energy PP substation followed by the final trip of one 132 kV circuit emanating from this substation, has been performed for fault clearing of 5 (100 ms) and 9 cycles (180 ms), in case of stuck breaker, as understood to be the normal fault clearing time of 132 kV protection system. The stability of system for far end faults of 3-phase occurring at 132 kV bus bar have also been checked. The

proposed scheme successfully passed the dynamic stability checks for near and far faults for the most stringent cases. The system is found strong enough to stay stable and recovered with fast damping.

- The proposed scheme of interconnection has no technical constraints or problems, it fulfills all the criteria of reliability and stability under steady state load flow, contingency load flows, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.