ANNEXURE

VOLUME-1

ANNEXURE-1

105

POWER PURCHASE AGREEMENT

FOR

ALLOCATION OF CONTRACTED CAPACITY AND SALE OF POWER FROM UNIT-3 AND UNIT-4 (1320 MW) PROPOSED TO BE SET UP AT Ib THERMAL POWER STATION, BANHARPALLI, JHARSUGUDA DISTRICT, ORISSA

BETWEEN

ORISSA POWER GENERATION CORPORATION LIMITED

AND

GRIDCO LIMITED

Long Term PPA (25 years)

DATED : 4th January 2011

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

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ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

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ONE HUNDRED RUPEES

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POWER PURCHASE AGREEMENT

This **POWER PURCHASE AGREEMENT** hereinafter called the **"PPA 2"** or **"Agreement"** is entered into at Bhubaneswar on the 4th day of January, 2011:

BY AND BETWEEN

ORISSA POWER GENERATION CORPORATION LIMITED, a company incorporated under the Companies Act, 1956 and having its registered office at Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar - 751 023, District Khurda, Orissa, India (hereinafter called as **"OPGC"**), which expression shall unless repugnant to the context or meaning thereof includes its successors and permitted assigns as a party of the **FIRST PART**;

AND

GRIDCO LIMITED, a company incorporated under the provisions of the Companies Act, 1956 and having its registered office at Janpath, Bhubaneswar - 751 022, District Khurda, Orissa, India (hereinafter called as **"GRIDCO"**), formerly known as Grid Corporation of Orissa Limited, which expression shall unless repugnant to the context or meaning thereof includes its successors as a party of the **SECOND PART**.

WHEREAS:

A. OPGC, a generating company as defined in the Electricity Act 2003, has an existing coal based thermal power station comprised of Unit-1 and Unit-2 with 2 x 210 MW capacity, situated at Ib Thermal Power Station Complex, Banharpalli, under Jharsuguda District of Orissa (**"Unit-1 and Unit-2"**) and as part of its capacity addition program, OPGC is setting up two (2) more units, namely, Unit-3 and Unit-4, with Installed Capacity (as defined hereunder) of 660 MW each as a base load Power Plant, at the same Site (as defined hereunder) as that of the existing plant, to be owned, operated and maintained by OPGC.

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B. GRIDCO had entered into an Amended Restated Bulk Power Supply Agreement dated 13 August, 1996 (hereinafter referred to as **"PPA 1"**) with OPGC, for the purchase of power from Unit-1 and Unit-2 on the terms and conditions contained therein.

C. The Government of Orissa, which originally owned the entire stake holding in OPGC, had in the year 1998, in pursuance of the Industrial Development Policy and as a part of power sector reforms, disinvested forty nine percent (49%) of the equity in OPGC through competitive bidding.

D. In order to facilitate the aforesaid disinvestment process, GRIDCO, OPGC, and the Government of Orissa signed a Tripartite Agreement dated 18 October 1998 (hereinafter referred to as the **"Tripartite Agreement"**), providing for certain amendments to the PPA 1 and amongst other provisions including those concerning the establishment of Unit-3 and Unit-4 of Ib thermal Power Station by OPGC in accordance with the terms and conditions thereof.

E. Subsequently, OPGC, GRIDCO and the Government of Orissa agreed to amend the Tripartite Agreement keeping in view inter alia the notifications of Govt. of Orissa No:7216, dt: 21.6.2008 and No: 10081, dt: 12.10.2009, pursuant to which OPGC is to establish, operate and maintain Unit-3 and Unit-4, wherein fifty percent (50%) of the Installed Capacity (as defined here under) shall be allocated to GRIDCO in accordance with the terms and conditions of the Agreement.

F. The Parties (as defined hereunder) have agreed to sign this Agreement setting out the terms and conditions for the setting up and operation and maintenance of the Power Station and to sell the Contracted Capacity (as defined hereunder) by OPGC to GRIDCO from the Power Station. GRIDCO will enter into suitable arrangements with one or more purchasers for further sale of Contracted Capacity from OPGC.

NOW THEREFORE, IN CONSIDERATION OF THE PREMISES AND MUTUAL AGREEMENTS, COVENANTS AND CONDITIONS SET FORTH HEREIN, IT IS HEREBY AGREED BY AND BETWEEN THE PARTIES AS FOLLOWS:

ARTICLE 1: DEFINITIONS AND INTERPRETATION

1.1 *Definitions*

The terms used in this Agreement, unless as defined below or repugnant to the context, shall have the same meaning as assigned to them by the Electricity Act, 2003 and all rules and regulations made thereunder (as amended or re-enacted from time to time).

"ABT Order" means order dated 04 January, 2000 passed by Central Electricity Regulatory Commission defining and laying down the availability based tariff regime.

"Affected Party" shall have the meaning as ascribed to this term in Article 11.2;

"Affiliate" means, with respect to a Party, any person directly or indirectly Controlling, Controlled by or under common Control of that Party. For the purposes of this definition, **"Control"**, with respect to a person means – (a) ownership or control (whether directly or otherwise) of more than 26% or more of the equity share capital, voting capital, or the like of the controlled entity by contract or otherwise, (b) control of, or power to control the composition of the board of directors or other equivalent or analogous body of the controlled entity, or (c) the power to direct or cause the direction of the management and policies of such party by virtue of its constitutional documents or agreements or otherwise, and the terms **"Controlling"** and **"Controlled"** shall have corresponding meanings;

"Agreement" or "PPA 2"	means this document including its recitals and Schedules containing the terms and conditions of purchase of Contracted Capacity by GRIDCO from OPGC;
"Appellate Tribunal for Electricity"	means the appellate tribunal for electricity established under Section 110 of Electricity Act, 2003;
"Appropriate Commission"	means the Orissa Electricity Regulatory Commission or the Central Electricity Regulatory Commission, as the case may be, or such other succeeding authority or commission as may be notified by the Appropriate Government from time to time;
"Appropriate Government"	shall have the same meaning as ascribed to it in the Electricity Act, 2003;
"Arbitration"	shall mean the resolution of a dispute between the Parties in accordance with Article 17;
"Arbitration Act"	shall have the meaning ascribed to it in Article 17.2A.3;
"Auxiliary Energy Consumption" or "AUX"	shall have the meaning as ascribed to this term in Schedule 4;
"Availability Factor" or "Availability"	shall have the meaning as ascribed to it in ABT Order;
"Available Capacity"	shall, at any point of time mean the capacity available from the Contracted Capacity for dispatch of electricity which shall be computed by multiplying Contracted Capacity with Availability;
"Bill Disagreement Notice"	shall have the meaning ascribed to it in Article 9.6.4;
"Bill Dispute Notice"	shall have the meaning as ascribed to it in Article 9.6.2;
"Bill"	means either a Monthly Bill or a Supplementary Bill;
"Bureau of Indian Standards"	means the national standards organisation of India under the aegis of Ministry of Consumer Affairs, Food & Public Distribution, Government of India, constituted under the provisions of Bureau of Indian Standards Act, 1986;
"Business Day"	means a day other than a Sunday or any statutory holiday as per Negotiable Instruments Act 1881, on which the banks remain open for business in the State of Orissa;
"Capacity Charge(s)"	shall have the meaning as ascribed to it in Schedule 4;

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"Capital Cost"	shall have the meaning ascribed to this term under Schedule 4;
"Capital Structure Schedule"	shall have the meaning as ascribed to this term in Schedule 4;
"Captive Coal Mine(s)"	means the captive coal mines allotted to OPGC by Ministry of Coal, specifically Manoharpur & Dip Side of Manoharpur, District Sundergarh, Orissa;
"Captive Coal Mine Operator"	shall mean one (1) or more mine operator(s), engaged or to be engaged by OPGC from time to time for operation and supply of coal from its Captive Coal Mine(s);
"CERC"	shall mean the Central Electricity Regulatory Commission, constituted under sub-section (1) of Section 76 of the Electricity Act, 2003, and include its successors;
"Change in Law"	shall have the meaning as ascribed to it in Article 12;
"Check Meter(s)"	shall mean a Meter, which shall be connected to the same core of the current transformer and voltage transformer to which Main Meter is connected, and shall be used for accounting and billing of electricity in case of failure of Main Meter;
"Coal"	means coal to be supplied in accordance with the Fuel Supply Agreement(s) entered or to be entered with the applicable Fuel Supplier for supply of coal-whether the supply is premised on Coal Linkage, or imported coal, or coal procured directly from other market sources, or coal as will be received from the Captive Coal Mine(s);
"Coal Linkage"	means the coal supply permit provided to the Power Station by Government of India, Ministry of Coal;
"Commercial Operation Date" or "COD"	means, in relation to Unit-3 or Unit-4, as the case may be, the date one (1) day after the date when OPGC delivers to GRIDCO a Final Test Certificate of the Owner's Engineer pursuant to the Construction Contracts, and in relation to the Power Station, the date one (1) day after the date when OPGC delivers to GRIDCO a Final Test Certificate of the Owner's Engineer for the last unit of the Power Station to be commissioned, as provided in Article 5 and Schedule 2 of this Agreement, in conformity with CERC Tariff Regulations;
"Commissioning" or "Commissioned"	with its grammatical variations, in relation to a Unit, means that Unit or in relation to the Power Station, all the Units of the Power Station, that have passed the Performance Tests successfully
"Conciliation Task Force"	shall have the same meaning as ascribed to it in Article 17.2A.1;
"Conditions Precedent"	means all the conditions as specified in Article 2A.1 that are to be fulfilled or waived by the relevant Party;
"Consents"	shall mean to include the consents, permissions, licenses, clearances, permits, privileges, waivers, acknowledgements,

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agreements, registrations, approvals, no-objection certificates, concessions, right of way, or any other authorization required to be obtained from an Indian Governmental Instrumentality for construction, ownership, operation and maintenance of the Project, as required under the Laws to implement the Project;

"Consents Delay" shall have the same meaning as ascribed to it in Article 4.4.1(c);

"Consent Delay Period" shall have the same meaning as ascribed to it in Article 4.4.1(iii);

"Construction Contracts" means one or more contracts entered or to be entered into by OPGC to design, engineer, supply, construct and commission the Power Station in accordance with Article 4;

"Construction Contractor(s)" means one or more contractors, appointed by OPGC to design, engineer, supply, construct and commission the Power Station in accordance with Article 4;

"Construction Period" means the period from (and including) the date upon which the Construction Contractor is instructed or required to commence work under the Construction Contract up to (but not including) the Commercial Operation Date of (i) Unit-3 in relation to Unit-3, (ii) Unit-4 in relation to Unit-4, and (iii) all the Units in relation to the Power Station;

"Contract Year" means the period beginning on the COD of earlier of the Unit-3 or Unit-4 and ending on the immediately succeeding March 31 and thereafter each period of twelve (12) Months beginning on April 1 and ending on March 31, *provided that* in the financial year in which COD of the subsequently Commissioned Unit would have occurred, a Contract Year shall end on the date immediately before the COD of such subsequent Unit and a new Contract Year shall begin once again from that date and end on immediately succeeding March 31, and *provided further that* the last Contract Year of this Agreement shall end on the last day of the term of this Agreement;

"Contracted Capacity" means that portion of the Installed Capacity measured in MW which is allocated by OPGC to GRIDCO for supply of the Electrical Output in accordance with the terms and conditions of this Agreement, and more particularly in accordance with Article 7.2 read with Schedule 3;

"CTU" shall mean the Central Transmission Utility notified by the Central Government under Section 38 of the Electricity Act, 2003;

"Cut-off Date" shall have the meaning ascribed to this term under Schedule 4;

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"Debt Equity Ratio"	shall have the meaning ascribed to this term under Schedule 4;
"Debt Service"	means the amounts which are due and payable under the Financing Agreements by OPGC to the Lenders, and expressed in Rupees (with all amounts denominated in currencies other than Rupees being converted to Rupees at the reference exchange rate, the selling rate in Rupees for the foreign currency as notified by the State Bank of India as its TT Rate at 12:00 noon on the relevant day of payment);
"Declared Capacity"	shall have the meaning ascribed to this term under Schedule 4;
"Deed of Hypothecation"	shall mean the Deed of Hypothecation to be entered into by OPGC with GRIDCO, in the manner as provided in Schedule 6;
"Delivery Point"	means the point of delivery at Power Station bus for fulfilling the obligation of OPGC to deliver the Contracted Capacity to GRIDCO, as illustrated in Schedule 1;
"Dispatch Instruction(s)"	means any instruction issued by GRIDCO through the SLDC/RLDC to OPGC, in accordance with applicable Grid Code and this Agreement;
"Dispute"	means any dispute or difference of any kind between GRIDCO and OPGC in connection with or arising out of this Agreement including any issue on the interpretation and scope of the terms of this Agreement;
"Due Date"	means the thirtieth (30th) day after a Bill has been received by GRIDCO (or if such day is not a Business Day, the immediately succeeding Business Day) by which date such Bill is payable by GRIDCO;
"Effective Date"	shall have the same meaning as ascribed to it in Article 2A.3;
"Electrical Output"	means the net electrical output from the Contracted Capacity of the Power Station, at the Delivery Point, as expressed in kWh;
"Electricity Act, 2003"	shall mean the Electricity Act, 2003 and any rules, regulation, notifications, guidelines or policies issued thereunder along with amendments thereto and replacements thereof;
"Electricity Laws"	means the Electricity Act, 2003 and any other Law pertaining to electricity including rules and regulations framed and notified by the Appropriate Commission;
"Energy Account(s)"	means an energy account prepared by SLDC/ RLDC on a monthly basis or for such other period as maintained by the SLDC/ RLDC for the billing and settlement of Capacity Charge, Energy Charge, UI payments and transmission charges;
"Energy Charge(s)"	shall have the meaning as ascribed to it in Schedule 4;

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"Escrow Agreement" shall mean the Escrow Agreement dated 30 November, 1998 executed amongst the Escrow Bank, OPGC and GRIDCO;

"Escrow Bank" shall have the meaning as ascribed to it in the Supplemental Escrow Agreement, as annexed hereto in Schedule 5;

"Expenditure Incurred" shall have the meaning ascribed to this term under Schedule 4;

"Expiry Date" means the twenty fifth (25^{th}) anniversary of the Commercial Operation Date of the Power Station. For the avoidance of doubt, in case the COD of the Power Station occurs on 01 January, 2015, then the twenty fifth (25^{th}) anniversary of the Scheduled COD of the Power Station shall occur on 01 January, 2040, i.e. in the Contract Year 2039-40;

"Final Test Certificate" means –

(i) a certificate of the Owner's Engineer certifying and accepting the results of a Performance Test(s) in accordance with Article 5 of this Agreement; or

(ii) a certificate of the Owner's Engineer certifying the result of a repeat Performance Test;

"Financial Closure" or "Financial Close" means the execution of all the Financing Agreements required for the Project and fulfilment of conditions precedent and/ or waiver, if any, of any of the conditions precedent for the initial drawdown of funds thereunder;

"Financing Agreements" means all the loan agreements, notes, indentures, security agreements, letters of credit and other documents relating to the financing or refinancing of the Project, as may be amended, modified, or replaced from time to time;

"Force Majeure Event Period" shall mean the period commencing from the date of occurrence of a Force Majeure event until cessation of such Force Majeure event;

"Force Majeure" shall have the meaning as ascribed to it in Article 11.3;

"Fuel" means primary fuel Coal and Fuel Oil;

"Fuel Oil" means the secondary fuels light diesel oil or heavy fuel oil which will be used for start up and low load support in the steam generators, supplied under the Fuel Supply Agreement;

"Fuel Supplier(s)" is/ are the party(ies) which supplies(y) Fuel to the Power Station under the relevant Fuel Supply Agreement;

"Fuel Supply Agreement(s)" means the agreement(s) entered or to be entered into between OPGC and Fuel Supplier(s) for supply of Fuel for the Power Station, and shall include any arrangement for the supply of Fuel during the period in which Fuel is not available from the Captive Coal Mine, and shall also include the agreement to be entered into with the Captive Coal Mine Operator for operation of the Captive Coal Mine;

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"Functional Specification(s)"	means the technical requirements and parameters described in Schedule 1 of this Agreement and as provided in Grid Code relating to the operation, maintenance and dispatch of any Unit under the Power Station;
"Grid Code"	shall mean the Grid Code specified by the CERC under Clause (h) of Sub-section (1) of Section 79 of the Electricity Act, 2003 and/or the State Grid Code as specified by the concerned State Commission, referred under Clause (h) of Sub-section (1) of Section 86 of the Electricity Act, 2003, as applicable;
"Grid System"	means the Interconnection and Transmission Facilities and any other transmission or distribution facilities through which GRIDCO supplies electricity to its customers;
"GRIDCO Consultation Period"	shall mean the period of ninety (90) days or such other longer period as the Parties may agree, commencing from the date of issuance of a GRIDCO Preliminary Default Notice as provided in Article 13 of this Agreement, for consultation between the Parties to mitigate the consequence of the relevant event having regard to all the circumstances;
"GRIDCO Disputed Amount"	shall have the meaning as ascribed to it in Article 9.3.1.2(b);
"GRIDCO Escrow Account"	shall have the same meaning as ascribed to it in Schedule 5;
"GRIDCO Event of Default Period"	shall mean the period commencing from the occurrence of a GRIDCO Event of Default until the same is cured in accordance with the provisions of this PPA 2;
"GRIDCO Indemnifiable Losses"	shall have the meaning as ascribed to it in Article 14.1(b);
"GRIDCO Preliminary Default Notice"	shall have the meaning as ascribed to it in Article 13.3.1;
"Gross Calorific Value"	shall have the meaning as ascribed to this term in Schedule 4;
"Gross Station Heat Rate"	shall have the meaning as ascribed to this term in Schedule 4;
"Indemnifiable Losses"	shall mean either the GRIDCO Indemnifiable Losses or OPGC Indemnifiable Losses, as the case may be;
"Indemnified Party"	shall have the meaning as ascribed to it in Article 14.2;
"Indemnifying Party"	shall have the meaning as ascribed to it in Article 14.2;
"Indian Governmental Instrumentality"	means the Government of India, Government of Orissa and any Ministry or department or board or agency or other regulatory or quasi-judicial authority controlled by Government of India or Government of Orissa which have control or jurisdiction over the Project and includes the Appropriate Commission;

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"Indian Standard Time"	means the time observed throughout India with a time offset of GMT+05:30;
"Infirm Power"	shall mean the electricity injected by any Unit into the grid, prior to its COD;
"Installed Capacity"	shall mean the sum of nameplate capacities of 1320 MW, gross (i.e. 2 x 660 MW) of Unit-3 and Unit-4 of the Power Station reckoned at the generator terminals in terms of Article 5, and as determined through Performance Tests, as and when necessary and approved by the Appropriate Commission.
"Interconnection and Transmission Facilities"	means the facilities on GRIDCOs' side of the Delivery Point for receiving and metering Electrical Output in accordance with this Agreement and which shall include, without limitation, all other transmission lines and associated equipment, transformers and associated equipment, relay and switching equipment and protective devices, safety equipment, and subject to Article 7 and Article 8, the Meters required for the Power Station. The Interconnection and Transmission Facilities also includes the facilities for receiving power at the Delivery Point where the transmission line from the Power Station switchyard end is injecting power into the transmission network;
"Judicial Authority"	shall include the Appropriate Commission, Orissa High Court, Delhi High Court, Appellate Tribunal for Electricity, Supreme Court, the Arbitral Tribunal or any other civil court of appropriate jurisdiction at Bhubaneswar, Orissa;
"Late Payment Surcharge"	shall have the meaning as ascribed to such term in Article 9.5;
"Law(s)"	means, in relation to this Agreement, all laws including Electricity Laws, taxation and environmental laws in force in India and any statute, ordinance, regulation, notification or code, rule, treaties or any interpretation of any of them by any Indian Governmental Instrumentality and having force of Law and shall further include all applicable rules, regulations, orders, notifications by an Indian Governmental Instrumentality pursuant to or under any of them and shall include all rules, regulations, decisions and orders of the Appropriate Commission;
"Lenders"	means the banks, financial institutions, multilateral agencies, non banking financial companies registered with the RBI, mutual funds and agents or trustees of debenture/ bond holders, and includes their respective successors and assignees, who agree as on or before COD of the Power Station to provide OPGC with the debt financing described in Annexure B to Schedule 4 or refinancing and includes any such successor banks or financial institutions to whom their interests under the Financing Agreements may be transferred

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or assigned. For avoidance of doubt it is clarified that Lenders includes banks, financial institutions and such like agencies providing re-financing facilities in connection with the Project or part thereof;

"Letter of Credit" shall have the meaning as ascribed to it in Article 9.7.1;

"Load Dispatch Centre" means the RLDC or SLDC or such other load dispatch centre designated by GRIDCO from time to time through which GRIDCO shall issue Dispatch Instructions to OPGC for the Power Station;

"Main Meter" means a Meter, which would primarily be used for accounting and billing of electricity;

"Maintenance Outage" shall have the meaning as ascribed to this term in the applicable Grid Code;

"Maximum Continuous Rating" is the normal rated full load MW output capacity of a generating unit which can be sustained on a continuous basis at specified conditions as defined in the Grid Code / CERC Tariff Regulations;

"Meter(s)" means a device suitable for measuring, indicating and recording consumption of electricity or any other quantity related with electrical system and shall include, wherever applicable, other equipment such as current transformer, voltage transformer or capacitor voltage transformer necessary for such purpose;

"Month" means a period of thirty (30) days from (and excluding) the date of the event, where applicable, else a calendar month;

"Monthly Bill" means a monthly bill (applicable after COD of the Unit-3 or Unit-4, as the case may be) comprising Capacity Charges and Energy Charges, including incentive and penalty to be calculated as per Schedule 4 and as explained in Article 9 hereof;

"Monthly Tariff Payment(s)" shall have the meaning ascribed to it in Article 9.1;

"Normative Availability Factor" means the Availability equal to eighty five percent (85%) at the Delivery Point on the Contract Year basis, or as may be notified by CERC from time to time;

"OERC" means the Orissa Electricity Regulatory Commission, or its successors, constituted in accordance with the provisions of Electricity Act, 2003 or any amendment thereof;

"Operating Period" in relation to the Unit or Power Station, means the period from its COD, until the Expiry Date or the date of earlier termination of this Agreement in accordance with Article 2A.4;

"OPGC Consultation Period" shall mean the period of ninety (90) days or such other longer period as the Parties may agree, commencing from the date of issuance of a OPGC Preliminary Default Notice as provided in Article 13 of this Agreement, for consultation between the Parties to mitigate the consequence of the relevant event having regard to all the circumstances;

"Operation and Maintenance Expenses"	shall mean the expenses incurred by OPGC for operation and maintenance of the Power Station and calculated as per the mechanism provided in Schedule 4;
"OPGC Event of Default"	shall mean the events of default as listed under Article 13.1;
"OPGC Indemnifiable Losses"	shall have the meaning ascribed to it in Article 14.1.2(b);
"OPGC Account 2"	shall have the meaning as ascribed to it in Supplemental Escrow Agreement;
"OPGC Preliminary Default Notice"	shall have the meaning ascribed to it in Article 13.4.2;
"OPTCL"	means Orissa Power Transmission Corporation Limited, a company wholly owned by Orissa Government and designated as the State Transmission Utility (**"STU"**), and the transmission licensee, in accordance with the provisions of the Electricity Act, 2003;
"Owner's Engineer"	means an engineer appointed by OPGC for providing engineering consultation, and also for overseeing construction and commissioning of the Power Station;
"Party" or "Parties"	means OPGC or GRIDCO individually as a Party or jointly as Parties, as the context may require;
"Payment Mechanism"	shall mean the mechanism provided in Article 9.3;
"Performance Test(s)"	means the test carried out in accordance with Schedule 2;
"Plant Availability Factor"	shall have the meaning as ascribed to this term under Schedule 4;
"Power Station"	means the Unit-3 and Unit-4 coal fired power generation facility, with each Unit having an Installed Capacity of 660 MW (gross), and located at the Ib Thermal Power Station Complex in Banharpalli, District Jharsuguda, Orissa and includes the following-

(i) above referred Unit-3 and Unit-4 and auxiliaries such as associated fuel handling, treatment or storage facilities of the power generation facility referred to above;

(ii) water conductor system and water supply, treatment or storage or discharge facilities required for the operation of the power generation facility referred to above;

(iii) the ash extraction, handling and disposal system including ash dyke and ash transportation;

(iv) township area for the staff colony;

(v) bay(s) for transmission system in the switchyard of the Power Station, all electrical equipment including transformers, switchgears, cable and cable facilities, complete control and instrumentation system;

(vi) all the other assets, buildings/ structures, equipments, plant and machinery, facilities and related assets required for the efficient and economic operation of the power generation facility; and

(vii) Coal transportation facility ("**MGR**" or "**Merry Go Round**") from the loading point at Captive Coal Mine till the unloading point at Unit-3 and Unit-4;

whether completed or at any stage of development and construction or intended to be developed and constructed as per the provisions of this Agreement and the Project Documents;

"PPA 1" shall mean and refer to the power purchase agreement executed between OPGC and GRIDCO on 13 August, 1996, for supply of power from Unit-1 and Unit-2 of OPGC for a period of thirty (30) years being currently in force;

"Project" means the Power Station and Captive Coal Mine(s) undertaken for design, financing, engineering, procurement, construction, operation, maintenance, repair, refurbishment, development and insurance by OPGC;

"Project Consents" shall mean the consents listed in Schedule 1A;

"Project Documents" shall mean the following documents to be entered into in respect of the Power Station, by the parties to the respective agreements -

(i) PPA 2;

(ii) Supplemental Escrow Agreement;

(iii) Deed of Hypothecation;

(iv) Financing Agreements;

(v) Construction Contracts; and

(vi) Fuel Supply Agreement(s);

"Prudent Utility Practices" means -

(a) where used with reference for the Power Station, the practices, methods and standards which are generally accepted internationally from time to time by electric utilities for the purpose of ensuring the safe, efficient and economic design, construction, commissioning, operation

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and maintenance of power generation equipment of the type specified in this Agreement and which practices, methods and standards shall be adjusted as necessary, to take account of -

(i) operation and maintenance guidelines recommended by the manufacturers of the plant and equipment to be incorporated in the Power Station;

(ii) the requirements of Law; and

(iii) the physical conditions at the Site;

(b) where used with reference for the Captive Coal Mine(s), the practices, methods and standards which are generally accepted internationally from time to time by the coal mining entities including without limitation, those engaged in mine mouth production, for the purpose of ensuring the safe, efficient and economic design, construction, commissioning, operation and maintenance of coal mines of the type as specified in this Agreement and which practices, methods and standards shall be adjusted as necessary to take account of –

(i) the requirements of Law; and

(ii) the physical conditions at the Site;

"RBI" means Reserve Bank of India;

"Rebate" shall have the same meaning as ascribed to it in Article 9.4;

"Receivables" shall mean to include all payments and monies payable by GRIDCO to OPGC under or in relation to this Agreement;

"RLDC" means the Regional Load Dispatch Centre as defined in the Electricity Act, 2003, in the eastern region, in which region, the Power Station is located;

"Rupees" or "Rs." means the lawful currency of India;

"Schedule" shall mean the various schedules as annexed to this Agreement, and shall be read as an integral part of this Agreement;

"Scheduled COD" or "Scheduled Commercial Operation Date" means (i) for the Unit-3, forty-eight (48) months from Financial Close; (ii) for the Unit-4, fifty-four (54) months from Financial Close or such other dates from time to time, specified in accordance with the provisions of this Agreement;

"Scheduled Connection Date" shall mean the date falling three sixty five (365) days before the Scheduled COD of the Unit-3;

"Scheduled Energy" means the quantum of energy scheduled by the SLDC/ RLDC to be injected into the Grid System by Units of the Power Station over a day;

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"Selectee"	means a new company (i) proposed by the Lenders pursuant to Schedule 7 for substituting OPGC in accordance with the terms and conditions contained in Schedule 7 and the Direct Agreements;
"Settlement Period"	means the time block for issue of daily generation and drawdown schedules as provided in Availability Based Tariff;
"Shareholders Agreement"	means the Subscription and Shareholders Agreement dated 06 October, 1998 between the Government of Orissa, AES Corporation and OPGC;
"Site"	means the (i) location of Unit-1 and Unit-2 of OPGC at Banharpalli, District Jharsuguda, Orissa, where the proposed Power Station is being set up, (ii) Manoharpur coal block District Sundergarh, Orissa, from where Coal is proposed to be mined and supplied to the Power Station, (iii) the corridor on which the MGR is to be constructed, and (iv) ash pond where ash from the Power Station will be disposed. A schematic depiction of the Site is set forth in Schedule 1;
"SLDC"	shall mean the State Load Dispatch Centre established under sub-section (1) of Section 31 of the Electricity Act, 2003;
"STU"	shall mean the State Transmission Utility as defined under the Electricity Act, 2003;
"Substitution Notice"	shall have the meaning as ascribed to it in Clause 3 of Schedule 7;
"Supplementary Bill"	means a bill other than a Monthly Bill raised by OPGC in accordance with Article 9;
"Supplemental Escrow Agreement"	shall mean the escrow agreement to be entered in accordance with Article 9.8.1 and Schedule 5;
"Tariff"	means the tariff as computed in accordance with Schedule 4;
"Tariff Payment"	means the payments under Monthly Bills and the relevant Supplementary Bills as referred to in Schedule 4;
"Tariff Regulations"	shall have the meaning as ascribed to it under Schedule 4;
"Tax"	means to include any form of tax, duty, cess, fee, surcharges, impost or levy of any nature howsoever called charged, levied or imposed by an Indian Governmental Instrumentality whether Central, State or local, whether in present or in future, and is having an impact on the Project in any manner;
"Term of Agreement"	shall have the meaning as ascribed to it in Article 2;
"Tested Capacity"	in relation to any Unit or the Power Station (if both Unit-3 and Unit-4 have been Commissioned) means the capacity demonstrated as a result of the most recent Performance Test or repeat Performance Test carried out in relation to any Unit or the Power Station in accordance with Article 5 and Schedule 2;

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"Testing Laboratory" or "National Accredited Testing Laboratory"	means (a) in respect of Meters an accredited reputed testing laboratory for testing and calibration of Main Meters and Check Meters; and (b) in respect of Coal, a reputed, testing laboratory to determine Coal characteristics;
"Testing"	means testing of meters in accordance with Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006;
"Unit"	means one (1) steam generator, steam turbine, generator and associated auxiliaries of the Power Station based on super-critical technology as applicable and includes - (i) **"Unit-3"**, which shall mean the new unit of 660 MW incorporating super critical technology, to be constructed immediately adjacent to Unit-2 of existing power plant of OPGC; and (ii) **"Unit-4"**, which shall mean the new unit of 660 MW incorporating super critical technology, to be constructed immediately adjacent to Unit-3, as described above;
"Unit-1 and Unit-2"	shall have the meaning ascribed to it in Recital A; and
"Unscheduled Interchange" or "UI"	shall have the meaning as ascribed to it under Regulation 24 of the Tariff Regulations.

1.2 *Interpretation*

Save where the contrary is indicated, any reference in this Agreement to -

1.2.1. a **"Recital"**, an **"Article"**, a **"Schedule"** and a **"paragraph/ Clause"** shall be construed as a reference to a Recital, an Article, a Schedule and a paragraph/clause respectively of this Agreement;

1.2.2. a **"crore"** means a reference to ten million (10,000,000) and a **"lakh"** means a reference to one tenth of a million (100,000);

1.2.3. an **"encumbrance"** shall be construed as a reference to a mortgage, charge, pledge, lien or other encumbrance securing any obligation of any person or any other type of preferential arrangement (including, without limitation, title transfer and retention arrangements) having a similar effect;

1.2.4. **"indebtedness"** shall be construed so as to include any obligation (whether incurred as principal or surety) for the payment or repayment of money, whether present or future, actual or contingent;

1.2.5. a **"person"** shall be construed as a reference to any person, firm, company, corporation, society, trust, government, state or agency of a state or any association or partnership (whether or not having separate legal personality) of two (2) or more of the above and a person shall be construed as including a reference to its successors, permitted transferees and permitted assigns in accordance with their respective interests;

1.2.6. the **"winding-up"**, **"dissolution"**, **"insolvency"**, or **"reorganization"** of a company or corporation shall be construed so as to include any equivalent or analogous proceedings under the Law of the jurisdiction in which such company or corporation

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is incorporated or any jurisdiction in which such company or corporation carries on business including the seeking of liquidation, winding-up, reorganization, dissolution, arrangement, protection or relief of debtors;

1.2.7. words importing the singular shall include the plural and vice versa;

1.2.8. capitalised terms used in the main part of the Agreement and not defined in Article 1.1 above, shall mean to have the same meaning as ascribed to such term in the Schedules forming part of this Agreement;

1.2.9. this Agreement itself or any other agreement or document shall be construed as a reference to this or to such other agreement or document as it may have been, or may from time to time be, amended, varied, novated, replaced or supplemented;

1.2.10. a Law shall be construed as a reference to such Law including its amendments or re-enactments from time to time;

1.2.11. a time of day shall, save as otherwise provided in any agreement or document be construed as a reference to Indian Standard Time;

1.2.12. different parts of this Agreement are to be taken as mutually explanatory and supplementary to each other and if there is any inconsistency between or among the parts of this Agreement, they shall be interpreted in a harmonious manner so as to give effect to each part;

1.2.13. the tables of contents and any headings or sub-headings in this Agreement have been inserted for ease of reference only and shall not affect the interpretation of this Agreement;

1.2.14. all interest payable under this Agreement shall accrue from day to day and be calculated on the basis of a year of three hundred and sixty five (365) days, except in the case of leap years, where the number of days shall be considered as three hundred and sixty six (366) days;

1.2.15. the words **"hereof"** or **"herein"**, if and when used in this Agreement shall mean a reference to this Agreement;

1.2.16. whenever a provision of the Agreement requires an approval or consent by a Party and notification of such approval or consent is not delivered within the applicable time limit, then, unless otherwise specified, the Party whose consent or approval is required shall be conclusively deemed to have withheld its consent or approval; and

1.2.17. terms defined in this Agreement by reference to any other agreement, document or instrument shall have the same meaning as assigned to them respectively in such agreement, document or instrument, whether or not such agreement, document or instrument is then in effect.

1.2.18. The words/expressions used in this Agreement shall have the same meaning as assigned to them in the context in which these have been used in this Agreement provided that their respective meaning, if any, assigned to such undefined word/expression in the Electricity Act, 2003 shall also be taken into consideration for harmonious interpretation of the Agreement.

Alan Mellis

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ARTICLE 2: TERM OF AGREEMENT

2.1 *Term of Agreement*

2.1.1 Save and except as expressly provided in Article 2A (*Conditions Precedent*), Article 11 (*Force Majeure*), Article 14 (*Liability and Indemnification*), Article 15 (*Representation and Warranties*), Article 16 (*Assignment and Charges*), Article 17 (*Governing Law and Dispute Resolution*), and Article 18 (*Miscellaneous*), the respective rights and obligations of the Parties under this Agreement shall be subject to the satisfaction or waiver of the Conditions Precedent as specified in Article 2A.

2.1.2 For the avoidance of doubt, the provisions of Article 2A (*Conditions Precedent*), Article 11 (*Force Majeure*), Article 14 (*Liability and Indemnification*), Article 15 (*Representation and Warranties*), Article 16 (*Assignment and Charges*), Article 17 (*Governing Law and Dispute Resolution*), and Article 18 (*Miscellaneous*), shall come into effect and force from the date of execution of the PPA 2 and shall not be subject to any condition.

2.1.3 This Agreement shall be valid for a term commencing from the Effective Date until the Expiry Date ("**Term of Agreement**") unless terminated earlier pursuant to Article 2A or Article 13. Upon the occurrence of the Expiry Date, this Agreement shall, subject to Article 2.2, automatically terminate, unless extended by the Parties on mutually agreed terms and conditions, at least one hundred and eighty (180) days prior to the Expiry Date.

2.2 *Survival*

2.2.1 Except as provided herein the expiry or termination of this Agreement shall not affect –

(a) rights and obligations of the Parties which may have accrued in accordance with the terms of this Agreement prior to such expiry or termination, and

(b) any continuing obligations, which expressly or by necessary implication will survive the expiry or termination of this Agreement.

Notwithstanding anything to the contrary herein, the provisions of Article 10 (*Insurances*), Article 11 (*Force Majeure*), Article 13 (*Events of Default and Termination*), Article 14 (*Liability and Indemnification*), Article 15 (*Representation and Warranties*), Article 16 (*Assignment and Charges*), Article 17 (*Governing Law and Dispute Resolution*), Article 18 (*Miscellaneous*), and other Articles and Schedules of this Agreement, which expressly or by their nature survive the Term of Agreement or termination of this Agreement, shall continue and survive any expiry or termination of this Agreement.

ARTICLE 2A: CONDITIONS PRECEDENT

2A.1 *Effectiveness of the Agreement*

Except as provided in Article 2.1, this Agreement shall come into full force and effect on the Effective Date and upon the following conditions precedent (**"Conditions Precedent"**) having been duly fulfilled or waived

(a) OPGC shall have received forest clearance from Ministry of Environment and Forest for Captive Coal Mine and MGR.

(b) OPGC shall have received interim Coal Linkage and have executed the Fuel Supply Agreement;

(c) OPGC shall have achieved Financial Closure;

(d) OPGC shall have received all Project Consents as per Schedule 1A.

(e) Approval of GoO to provisions under Annexure D to Schedule 4 should have been received,

2A.2 *Notification of fulfilment of Conditions Precedent*

OPGC shall notify GRIDCO within seven (7) days of its fulfilment of all the Conditions Precedent other than those that have been waived by OPGC in accordance with Article 18.3.

2A.3 *The Effective Date*

The Effective Date shall be the date upon which OPGC shall have notified to GRIDCO, the fulfilment or waiver, as the case may be, of each of the Conditions Precedent,

2A.4 *Right to terminate*

2A.4.1 If the Conditions Precedent listed in Article 2A.1 are not duly satisfied or waived within eighteen (18) Months from the date of execution of this Agreement, either Party shall have the right to terminate this Agreement with a notice of fifteen (15) days, unless it is mutually agreed between the Parties in writing during such notice period, to further extend such period for satisfaction of the Conditions Precedent.

2A.4.2 Neither Party shall have any liability whatsoever to the other Party as a result of the termination of this Agreement pursuant to this Article.

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ARTICLE 3: DEVELOPMENT OF THE POWER STATION

3.1 *OPGC's obligations*

Subject to the terms and conditions of this Agreement, OPGC undertakes to -

(a) take expeditious steps within its power and control to implement the Power Station as a base load Power Plant so as to achieve Commissioning by the Scheduled Commercial Operation Date;

(b) procure the requirement of electricity at the Site for the purpose of the Project (including for construction, Commissioning and start-up power) and to meet in a timely manner all formalities for getting such a supply of electricity and pay for such electricity to the applicable entities;

(c) file application before the Appropriate Commission for tariff determination under the Electricity Act;

(d) provide on a timely basis relevant information on Power Station specifications which may be required for Interconnection and Transmission Facilities; and

(e) Make available the Contracted Capacity with the operating characteristics of each Unit to GRIDCO, in accordance with the terms of this Agreement.

(f) fulfilling all other obligations as undertaken by OPGC under this Agreement.

3.2 *GRIDCO's Obligations*

Subject to the terms and conditions of this Agreement, GRIDCO agrees and undertakes that it-

(a) shall be responsible for evacuation of its Contracted Capacity by signing Bulk Power Transmission Agreement with STU / CTU, for the Interconnection and Transmission Facilities, to enable the Power Station to be connected to the Grid System not later than the Scheduled Connection Date;

(b) shall extend reasonable assistance for the grant of an electrical connection to OPGC at the Site by Western Electricity Supply Company of Orissa Limited, the distribution licensee, on the then prevalent terms and conditions as applicable to such consumers as required for the construction, start-up and commissioning of the Project;

(c) shall make all reasonable arrangements for the evacuation of the Infirm Power from the Power Station;

(d) shall be responsible for payment of the transmission charges and all other charges as may be payable for evacuation of power;

(e) shall be responsible for the due and timely payment of the amounts payable under Monthly Bills and Supplementary Bills in accordance with this Agreement;

(f) shall render all reasonable assistance with respect to Interconnection and Transmission Facilities as may be required in connection with the Financial Close and to execute such necessary documents as required to achieve Financial Closure, including PPA 2, Escrow Agreement and Deed of Hypothecation(if applicable). and if required by the Lenders provide letters to the Lenders accepting Lender's Substitution Rights under the Finance Agreement;

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(g) shall maintain at all times the required licenses that is required under Law to purchase and further sell the power output of the Power Station;

(h) shall open and maintain the Letter of Credit as required under the terms and conditions specified in Article 9 of this Agreement;

(i) provide support for execution of Project Documents;

(j) file petition with OERC for approval of this PPA 2 under section 86 of the Electricity Act;

(k) shall not take any action or inaction to interfere with or inhibit OPGC's sale to third parties of any Installed Capacity that it is permitted to sell under this Agreement; and

(l) fulfill all other obligations as undertaken by GRIDCO under this Agreement.

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ARTICLE 4: CONSTRUCTION

4.1 OPGC's Obligations

4.1.1 OPGC shall be responsible for designing, constructing, erecting, testing and Commissioning, the Power Station in accordance with the -

(a) Grid Code;

(b) Functional Specifications;

(c) terms and conditions of this PPA 2; and

(d) Prudent Utility Practices.

4.1.2 Notwithstanding anything to the contrary contained in this PPA 2, OPGC shall ensure that the technical parameters or equipment limits of the Power Station shall -

(a) always be subject to the requirements as specified in points (a) to (d) of Article 4.1.1;

(b) not contradict the provisions of this Agreement; and

(c) not excuse OPGC from the performance of its obligations under this Agreement.

4.1.3 Performance Test Reports

OPGC shall retain at the Site, and make available for inspection by GRIDCO at all reasonable times, copies of the results of Performance Test(s) specified in Schedule 2.

4.1.4 Quality of Workmanship

OPGC shall ensure that the Power Station is designed, built and completed in accordance with Prudent Utility Practices and the design, construction and testing of all equipment, facilities, components and systems of the Power Station are in accordance with the Indian standards and codes issued by the Bureau of Indian Standards and/ or by the internationally recognized standards and codes.

4.2 GRIDCO's Obligations

4.2.1 Information regarding Interconnection and Transmission Facilities

GRIDCO shall provide OPGC, on a timely basis, all information with regard to the Interconnection and Transmission Facilities as is necessary, to enable OPGC to design, install and operate all interconnection plant and apparatus on OPGC's side of the Delivery Point.

4.3 Co-ordination of Construction Activities

4.3.1 During the Construction Period, both OPGC and GRIDCO shall co-ordinate with each other and inform each other of the progress of the Project and the Interconnection and Transmission Facilities respectively.

4.3.2 OPGC and GRIDCO shall designate from time to time, by giving a written notice to the other Party, its personnel who shall be responsible for coordinating all construction activities relating to the Power Station and Interconnection and Transmission

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Facilities. Such designated personnel shall have access to the Site, at all reasonable times, for the purpose of apprising the progress of the abovementioned activities, upon giving reasonable notice to the other Party of such visit and subject to their complying with all reasonable safety procedures.

4.4 *Extension of time*

4.4.1 In the event that OPGC is not likely to achieve the Scheduled Commercial Operation Date for a Unit or the Power Station because of -

(a) any GRIDCO Event of Default; or

(b) a Force Majeure event;

(c) delay in grant of any of the Project Consents as provided in Schedule 1A or any other Consent ("**Consent Delay**");

then such Scheduled Commercial Operation Date shall be deferred for a period which shall not be less than the -

(i) Force Majeure Event Period in case the Scheduled Commercial Operation Date of a Unit or the Power Station is delayed due to a Force Majeure Event; or

(ii) GRIDCO Event of Default Period in case the Scheduled Commercial Operation Date of a Unit or the Power Station is delayed due to a GRIDCO Event of Default; or

(iii) period of Consent Delay in case Scheduled Commercial Operation Date of the Unit or the Power Station is delayed due to Consent Delay ("**Consent Delay Period**").

In case of extension occurring due to reasons specified herein above, the original Scheduled Commercial Operation Date of any Unit or the original Scheduled Commercial Operation Date of the Power Station as a whole shall not be extended by more than two (2) years or for such other time periods as may be mutually agreed between the Parties.

4.4.2 If the Parties do not agree on the revised Scheduled Commercial Operation Date within thirty (30) days after the expiry of the Force Majeure Event Period or GRIDCO Event of Default Period or the Consent Delay Period, as the case may be, either Party may raise the Dispute to be resolved in accordance with Article 17.

4.4.3 As a result of such extension, the date newly determined shall be deemed to be the Scheduled Commercial Operation Date for the purposes of this Agreement.

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ARTICLE 5: SYNCHRONISATION, COMMISSIONING AND COMMERCIAL OPERATION

5.1 Synchronization

5.1.1 OPGC shall give GRIDCO and SLDC/ RLDC at least sixty (60) days advance preliminary written notice and at least thirty (30) days advance final written notice, of the date on which it intends to synchronize a Unit to the Grid System.

5.1.2 Subject to Article 5.1.1, a Unit may be synchronized by OPGC to the Grid System when it meets all the connection conditions prescribed in the Grid Code then in effect, and otherwise meets all statutory requirements for synchronization to the Grid System.

5.2 Commissioning

5.2.1 OPGC shall be responsible for ensuring that each Unit is Commissioned in accordance with Schedule 2 at its own cost, risk, and expense.

5.2.2 Testing and measuring procedures applied during each Performance Test, shall be in accordance with the codes, practices and procedures mentioned in Schedule 2 of this Agreement.

5.2.3 Within five (5) days of a Performance Test, OPGC shall provide GRIDCO with copies of the detailed Performance Test result.

5.3 Commercial Operation

5.3.1 A Unit shall be Commissioned on the day after the date when OPGC provides a Final Test Certificate of the Owner's Engineer stating that -

(a) the Performance Tests have been carried out in accordance with Schedule 2 and are acceptable to it; and

(b) the results of the Performance Test show that the Unit's Tested Capacity, has been demonstrated to be not less than the MCR or Installed Capacity for each of the Units, through a successful trial run after notice to GRIDCO, from 00.00 hours of which, scheduling process as per the Grid Code is fully implemented.

5.3.2 If a Unit fails the Performance Test, OPGC may retake the relevant test, within a reasonable period after the end of the previous test, with five (5) days prior written notice to GRIDCO.

Provided however, GRIDCO shall have a right to require deferment of any such re-tests for a period not exceeding fifteen (15) days, without incurring any liability for such deferment, only if GRIDCO is unable to provide evacuation of power to be generated due to reasons outside its reasonable control or due to inadequate demand in the Grid System. However, any further delay beyond the fifteen (15) days shall be only with the prior written consent of OPGC.

5.3.3 OPGC may retake the Performance Test by giving at least five (5) days advance notice in writing to GRIDCO, up to eight (8) times, during a period of one hundred and eighty (180) days from a Unit's COD in order to demonstrate an increased Tested Capacity over and above as provided in Article 5.3.1 (b). *Provided however that*, GRIDCO shall have a right to require deferment of any such re-tests for a period not exceeding fifteen (15) days, without incurring any liability for such deferment,

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only if GRIDCO is unable to provide evacuation of power to be generated, due to reasons outside its reasonable control or due to inadequate demand in the Grid System. However, any further delay beyond the fifteen (15) days shall be only with the prior written consent of OPGC.

5.4 ***Costs Incurred***

OPGC expressly agrees that all costs incurred by it in synchronizing, connecting, Commissioning and/ or testing or retesting a Unit shall be solely and completely to OPGC's account; provided, however, that any Infirm Power injected by OPGC will be deemed to be sold to GRIDCO at the applicable and prevalent UI rate.

Alam Mallick

ARTICLE 6: OPERATION AND MAINTENANCE

6.1 *Operation and Maintenance of Power Station*

OPGC shall comply with the provisions of the applicable Law including, in particular, Grid Code regarding operation and maintenance of the Power Station and all matters incidental thereto. GRIDCO shall co-ordinate through the STU and CTU, to comply with the provisions of applicable Law, in operating and maintaining the Interconnection and Transmission Facilities, and all matters incidental thereto. Notwithstanding the foregoing, the Parties acknowledge and agree that OPGC shall not be obligated to operate the Power Station outside of the parameters set forth in Article 4.1.1.

Provided however that OPGC shall not schedule the Maintenance Outage of a Unit, when another Unit of the Power Station is shut down or expected to be shut down except due to Force Majeure or when the operation of a Unit is not permissible due to technical considerations, an emergency outage, or Prudent Utility Practices.

6.2 *Inability to off-take Available Capacity*

GRIDCO shall not schedule and dispatch power relatable to the Available Capacity from the Power Station, which would require OPGC to operate any Unit at a level below the limit specified by the equipment manufacturer, leading to operation of any Unit under oil support.

ARTICLE 6A: AVAILABILITY, DISPATCH AND SCHEDULING

6A.1 Availability

OPGC shall comply with the provisions of the applicable Law regarding Availability including, in particular, to the provisions of the ABT Regulations and the Grid Code relating to intimation of Availability and the matters incidental thereto.

6A.2 Dispatch

OPGC shall comply with the provisions of the applicable Law regarding Dispatch Instructions, in particular, to the provisions of the ABT Regulations and the Grid Code and the matters incidental thereto.

6A.3 Scheduling

Methodology of generation and scheduling of power to be sold to the GRIDCO shall be as per Grid Code.

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ARTICLE 7: SALE AND PURCHASE OF POWER

7.1 *Purchase and sale of Available Capacity and Electrical Output*

7.1.1 Subject to the terms and conditions of this Agreement –

(a) OPGC undertakes to allocate to GRIDCO, the Available Capacity up to the Contracted Capacity and sell the Electrical Output as a base load Power Plant, throughout the term of this Agreement.

(b) GRIDCO undertakes to pay to OPGC the Tariff for the Available Capacity up to the Contracted Capacity and the Electrical Output as a base load Power Plant supplied throughout the term of this Agreement.

7.1.2 Unless otherwise instructed by GRIDCO, OPGC shall sell all power generated from the Available Capacity up to the Contracted Capacity to GRIDCO, pursuant to Dispatch Instructions.

7.1.3 The risk and title in respect of the Contracted Capacity as delineated by OPGC shall pass on and transfer to GRIDCO at the Delivery Point.

7.2 *GRIDCO's Entitlement to Available Capacity and Electrical Output*

7.2.1 GRIDCO's entitlement to the power generation from the Power Station shall at all times be proportionate to its Contracted Capacity of fifty percent (50%) of the Installed Capacity.

Provided that, if Commissioning of Unit-3 or Unit-4 of the Power Station, whichever occurs later, is delayed beyond six (6) Months of Commissioning of the earlier Unit of the Power Station, GRIDCO's Contracted Capacity shall be 450 MW out of 660 MW, i.e., sixty eight point one eight percent (68.18%) of the Installed Capacity of such earlier Commissioned Unit, until the subsequent Unit of the Power Station is Commissioned.

By way of illustration, assuming that the Installed Capacity of the Power Station is 1320 (2x660) MW and after Commissioning of both the Units -

(a) If the Availability Factor is at seventy five percent (75%) on any time block and therefore the Available Capacity in millions unit is equivalent to 990 MW, then if the Contracted Capacity of GRIDCO is fifty percent (50%), GRIDCO shall be entitled to Available Capacity of 495 MW.

(b) If the Availability Factor is at fifty percent (50%) on any time block, and the Available Capacity in million units is equivalent to 660 MW, and the Contracted Capacity of GRIDCO is fifty percent (50%), then GRIDCO shall be entitled to Available Capacity of 330 MW.

The above allocation principle shall also apply during the six (6) Month period from Commissioning of Unit-3 or Unit-4 of the Power Station (whichever occurs earlier) up to Commissioning of the subsequent Unit of the Power Station and therefore, during this period GRIDCO's share in the Installed Capacity from the earlier Commissioned Unit of the Power Station shall be fifty percent (50%) i.e. 330 MW. The power allocation principles set out in Article 7.2.1 are further explained in the table as provided in Schedule 3.

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It is hereby clarified that OPGC shall be free to sell the fifty percent (50%) of the Installed Capacity not allocated to GRIDCO to any other party.

7.2.2 Subject to other provisions of this Agreement, the entire Available Capacity out of the Contracted Capacity from the Power Station shall at all times be for the exclusive benefit of GRIDCO, and GRIDCO shall have the exclusive right to purchase the entire Available Capacity out of the Contracted Capacity from OPGC. OPGC shall not grant to any third party or allow any third party to obtain any entitlement to the Available Capacity and/ or Electrical Output, except in accordance with the terms of this Agreement.

7.2.3 For avoidance of doubt, GRIDCO's obligations under this Agreement shall always be construed in proportion to its Contracted Capacity and in all circumstances be limited to the extent of its Contracted Capacity.

7.3 OPGC's right to Sell Power to third party if GRIDCO does not off-take the Electrical Output

7.3.1 If GRIDCO does not off-take the Electrical Output relatable to the Available Capacity corresponding to the Contracted Capacity provided by OPGC, OPGC shall be entitled to sell such Available Capacity not scheduled, to any person without losing the right to receive the Capacity Charges from GRIDCO for such unavailed Available Capacity. In such a case, the sale realization in excess of Energy Charges after taking into account such other costs including, transmission charges, transmission losses, open access charges, incidental costs, and trading margin (as per CERC Regulations), incurred for such third party sale, shall be first utilised to extinguish any dues payable by GRIDCO towards corresponding Capacity Charges and surplus if any, beyond this, shall be shared by OPGC and GRIDCO in the ratio of 60:40.

By way of the following illustrations the working of this Article 7.3.1 is explained herein below: Regulated tariff for sale to GRIDCO

Capacity Charge	: Rs.1.50
Energy charge	: Rs.1.00
Total tariff	: Rs.2.50

Scenario 1

Realization from third party sale	: Rs. 2.70
Retained energy charges by OPGC	: Rs. 1.00
Retained additional cost & trading margin for power sale by OPGC	: Rs. 0.10 (say)
Capacity Charge adjustment towards GRIDCO	: Rs. 1.50
Excess earnings to be shared	: Rs. 0.10
Surplus retention by OPGC	: Rs. 0.06
Surplus used to extinguish GRIDCO dues	; Rs. 0.04

Scenario 2

Realization from third party sale	: Rs. 2.30
Retained energy charges by OPGC	: Rs. 1.00
Retained additional cost & trading margin for power sale by OPGC	: Rs. 0.10 (say)
Capacity Charge adjustment towards GRIDCO	: Rs. 1.20
Excess earnings to be shared	: Nil
Surplus retention by OPGC	: Nil
Surplus used to extinguish GRIDCO dues	; Nil
Capacity Charge to be paid by GRIDCO	: Rs. 0.30

Scenario 3

Third party sale could not be made by OPGC

Capacity Charge to be paid by GRIDCO	: Rs. 1.50

7.3.2 In the event GRIDCO does not avail of the Available Capacity and OPGC sells such Available Capacity to the shareholders of OPGC or any Affiliate of OPGC, without obtaining the prior written consent of GRIDCO, then OPGC shall be liable to sell such Available Capacity at a rate being not less than the Tariff payable by GRIDCO to OPGC.

For the avoidance of doubt it is clarified that subject to applicable Law, OPGC may sell such un-availed Available Capacity to its shareholders or any Affiliate at such rate as it may deem fit, if such sale is with the prior written consent of GRIDCO.

7.3.3 If following GRIDCO's decision not to avail itself of Available Capacity pursuant to this Article 7.3 for a specified period exceeding two (2) days, it subsequently notifies OPGC of its intention and willingness to off-take a portion of Electrical Output relatable to the Available Capacity (which was to be sold to a third party), OPGC shall, notwithstanding anything contained in the arrangement between OPGC and such third party, commence scheduling of such capacity to GRIDCO from the later of two (2) days from receipt of notice in this regard from GRIDCO, or the time for commencement of supply specified in the period notified by GRIDCO and subject to the provisions regarding scheduling as per the Grid Code.

For avoidance of doubt, supply of such capacity would be proportionate to the Available Capacity at such point in time and as allocated to GRIDCO.

7.4 OPGC's Own Consumption of Power

7.4.1 In respect of the Contracted Capacity, OPGC shall not itself use any of the electricity generated by the Power Station during the term of this Agreement except for the purpose of meeting the Power Station's Auxiliary Energy Consumption of the Project as per applicable Law and the consumption of the housing colony for the staff.

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7.5 Sale under UI excluded

7.5.1 The sale under Unscheduled Interchange shall not be considered as sale to third party for the purposes of this Agreement.

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ARTICLE 8: METERING AND ENERGY ACCOUNTING

8.1 Metering

8.1.1 Installation of Meters

(a) All interface Meters at the point of interconnection, for purpose of electricity accounting and billing, shall be installed by OPGC or STU / CTU at its own cost, as applicable. Each Meter shall be of static type, Availability Based Tariff Regulations compliant, zero point two percent (0.2%) accuracy class conforming to latest IEC-687 and shall meet the requirements of the Grid Code/ Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, as applicable. The recording of each such Meter shall include, as a minimum -

(i) Energy output in kWh during each Settlement Period;

(ii) Average power output in MW during each Settlement Period;

(iii) Frequency during each Settlement Period; and

(iv) Year, Month, day, hour and minute and start and end of each Settlement Period;

(b) One set of Meters comprising –

(i) a set of Main Meters, and

(ii) a set of Check Meters,

shall be installed by OPGC on each circuit of the transmission lines at interconnection point(s) so as to record both (A) energy exported by OPGC to the Grid and (B) energy imported by OPGC from the Grid;

(c) One complete spare set of tested, calibrated, and sealed Meters shall be kept in safe custody of OPGC. All such Meters shall be sealed in presence of CTU / STU, GRIDCO and OPGC and such seal shall remain intact unless the Testing Laboratory breaks it for Testing and calibration; and

(d) Authorized representative(s) of CTU / STU, GRIDCO, RLDC and SLDC shall have the unrestricted free entry into the metering points. Provided that they shall be accompanied by an OPGC representative when accessing the relevant metering points.

8.1.2 Testing and Calibration of Meters -

(a) All the Main Meters, Check Meters, including spare set of Meters shall be tested and calibrated by National Accredited Testing Laboratory. The Meters (and associated circuits, if necessary) shall be tested and calibrated in accordance with the provisions set out in the Grid Code, at least once in two (2) Contract Years, or at any time when the difference between the readings of the Main Meter and the corresponding Check Meter is found to exceed zero point four percent (0.4%). OPGC shall bear the cost of Testing and calibration of Meters.

(b) The Meters shall be sealed in the presence of authorized representative(s) of CTU/ STU, GRIDCO and OPGC. The parties witnessing the calibration shall jointly sign the Meter calibration report of Testing Laboratory and the Meter calibration report shall be furnished to all the parties concerned. The Party, which requests for any additional Testing and calibration of the Meters shall bear the cost of such Testing and calibration. A notice of seven (7) Business Days shall be issued by the Party, which arranges for such Testing and calibration, to enable authorized representatives of the other Parties to witness the Testing and calibration of Meters.

(c) If during any Testing and calibration, a Main Meter is found to be within zero point two percent (0.2%) permissible limit of error and the corresponding Check Meter is found to be beyond such limit of error, the monthly billing shall be as per the reading of the Main Meter. The corresponding Check Meter shall be replaced forthwith with the spare tested Check Meter and the defective Check Meter shall be repaired and calibrated by the Testing Laboratory or replaced by a new and tested Check Meter.

(d) Normally the reading of the Main Meter shall be used for accounting and billing purpose. If during any Testing and calibration, a Main Meter is found to be beyond zero point two percent (0.2%) permissible limit of error, but the corresponding Check Meter is found to be within limit of error, the monthly billing shall, for that Month and till the date and time of the repair and calibration or replacement of the defective Main Meter, be as per the reading of the Check Meter. The corresponding Main Meter shall be replaced forthwith, with the spare tested and calibrated Main Meter and the defective Main Meter shall be repaired and calibrated by the Testing Laboratory or replaced by the new and tested Main Meter, so as to be kept as spare. In an event of failure of CT or PT of main meter and check meter, the reading of the Stand By meter shall be used for accounting and billing as per CEA Metering Regulations 2006.

(e) If during any Testing and calibration, a Main Meter and the corresponding Check Meter are found to be beyond zero point two percent (0.2%) permissible limit of error, both the Meters or at least the Main Meter shall be replaced forthwith with a spare tested calibrated meter. The energy accounting shall be done on a mutually agreed basis between OPGC, GRIDCO and OPTCL / SLDC/ RLDC for that period of defect.

(f) Data shall be downloaded from the Meters at regular intervals as decided by SLDC/ RLDC for preparation of Energy Accounts.

(g) The Main Meter and Check Meter shall be checked on a monthly basis by comparing the readings between the Main Meter and Check Meter and in case the readings of these Meters differ by more than double the value of the accuracy class in use, both the Main Meter and Check Meter will be checked separately with respect to another reference Meter and defective Meter shall be replaced. The energy metered during the period of defect would be revised by applying a correction factor on the energy metered by the defective Meter.

8.2 Energy Accounting

8.2.1 Both Parties agree to facilitate issue of Energy Accounts by the first five (5) Business Days of every Month.

B.2.2 OPGC shall prepare and submit Bills to GRIDCO on the basis of such Energy Accounts.

8.2.3 Energy Account issued by SLDC/RLDC shall be binding on all the Parties for billing and payment purposes. In case of any Dispute, Parties can follow the Dispute resolution mechanism as set out in this Agreement.

8.2.4 Any change in the methodology of Energy Accounting shall be done only as per the Grid Code.

8.3 RLDC / SLDC Charges

8.3.1 All scheduling and RLDC/ SLDC charges applicable shall be borne by GRIDCO.

ARTICLE 9: BILLING AND PAYMENT

9.1 *General*

From the COD of the earlier of Unit-3 or Unit-4 of the Power Station, GRIDCO shall pay OPGC the Monthly Bill on or before the Due Date, comprising of monthly tariff payment ("**Monthly Tariff Payment**"), based on Tariff for every Contract Year, determined in accordance with Schedule 4. All Tariff Payments by GRIDCO shall be in Indian Rupees and will be paid in accordance with this Article 9 and Schedule 4 of this Agreement.

If GRIDCO avails of any Infirm Power from OPGC prior to the Commercial Operation Date of any Unit, the same shall be charged as per the applicable UI rates in accordance with Schedule 4.

9.2 *Billing*

9.2.1 Monthly Bills

OPGC shall issue to GRIDCO a signed Monthly Bill for the immediate preceding Month any time from the first day of the current Month, subsequent to SLDC/ RLDC providing the information to OPGC required pursuant to Article 9.2.1(a) below.

Each Monthly Bill shall include -

(a) Availability for the relevant Month for Monthly Bill and Energy Account as provided by SLDC/ RLDC;

(b) OPGC's computation of various components of the Monthly Tariff Payment in accordance with Schedule 4; and

(c) supporting data, documents, and calculations in accordance with this Agreement.

9.2.2 Supplementary Bills

OPGC may raise a bill on GRIDCO ("**Supplementary Bill**") as and when applicable, for payment on account of -

(a) Adjustments required by the Energy Account issued by SLDC/ RLDC;

(b) Adjustments on account of quarterly reconciliations including Fuel price adjustments in respect of Coal at the end of second and fourth quarter as per Clause 6(b)(vii) of Schedule 4;

(c) Adjustments on account of annual reconciliation including Fuel price adjustment in respect of secondary Fuel Oil as per Clause 4(f)(iii) of Schedule 4;

(d) Tariff Payment for change in parameters, pursuant to provisions in Schedule 4;

(e) Claims arising out of any Change in Law as provided in Article 12; or

(f) Claims arising out of any of the parameters in Clause 7 of Schedule 4;

The Supplementary Bills shall be raised as and when applicable due to occurrence of one or more of the events outlined in this Article 9.2.2 provided approval of Appropriate Commission shall be applicable on matters related to (d) and (e) above.

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The Supplementary Bill should contain -

(a) OPGC's computation of claims and amount payable by / to GRIDCO due to changes as a result of events as stated in this Article 9.2.2 (a) to (f) above; and

(b) data and documents reflecting such changes.

9.2.3 OPGC shall have the right to raise an Infirm Power bill(s) pursuant to Article 5.4, commencing from the Month in which such Infirm Power is injected into the grid by OPGC. GRIDCO shall have an obligation to pay the amounts due under the Infirm Power bill(s) within thirty (30) Days from the date of issuance of the Infirm Power bill(s) by OPGC. If GRIDCO fails to pay such Infirm Power bill(s), within thirty (30) Business Days from the date of issuance of the Infirm Power bill(s) by OPGC, then OPGC may recover the amount(s) due under such Infirm Power bill(s) as part of Monthly Bill or Supplementary Bill. OPGC may exercise such right as available to OPGC under this Agreement, including but not limited to exercising its rights under this Article 9 of this Agreement to recover the amounts due under the Infirm Power bill(s). In the event of coming into effect of Intra State ABT, the relevant regulation shall be followed, if applicable.

9.3 Payment Mechanism

9.3.1 Payment of Monthly Bills

9.3.1.1 GRIDCO shall pay the amount payable under Monthly Bill to 'OPGC Account 2' on or before the Due Date, as shall have been previously notified by OPGC to GRIDCO in accordance with this Agreement and notify OPGC of such payment on the same day.

9.3.1.2 All payments required to be made under this Agreement shall include any deduction or set off for -

(a) deductions required under Law; and

(b) any amounts disputed by GRIDCO (**"GRIDCO Disputed Amount"**) provided that each of the following are satisfied:

(i) GRIDCO Disputed Amount is payable by OPGC; and

(ii) OPGC has not disputed the GRIDCO Disputed Amount within thirty (30) days of raising of such Dispute by GRIDCO; and

(iii) a period of thirty (30) days has lapsed from the date on which such Dispute has been raised by GRIDCO.

Provided that neither Party shall make any withholdings, deductions or set-offs against payments due to the other Party under this Agreement till such time as the avenues for amicable resolution of Dispute under Articles 17.2 and 17.2A have been exhausted without a successful resolution of the Dispute.

Any deduction or set-off with respect to a GRIDCO Disputed Amount shall be made by GRIDCO only to the extent of the amounts not disputed by OPGC.

The maximum amounts that can be deducted or set-off by GRIDCO as a GRIDCO Disputed Amount in a Contract Year shall not exceed 3% of the

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aggregate of Monthly Bills in Contract Year and shall not include any amount relating to PPA 1.

The Illustration below explains the working of this Article 9.3.1.2(b):

If a Monthly Bill or a Supplementary Bill is raised on 07 April, 2011 for a sum of Rupees One Lakh (Rs. 100,000/-) and the same is received by GRIDCO on 09 April, 2011 and the Due Date for payment of such Monthly Bill or Supplementary Bill is 09 May, 2011. GRIDCO intends to set off an amount of Rupees Thirty Thousand (Rs. 30,000) (which is the GRIDCO Disputed Amount). The said sum of Rupees Thirty Thousand may be set off by GRIDCO whilst paying the sum of Rupees One Lakh (Rs. 100,000) by the Due Date only if OPGC has not disputed the GRIDCO Disputed Amount within thirty (30) days of raising of such a Dispute by GRIDCO.

9.3.2 Payment of Supplementary Bills

9.3.2.1 GRIDCO shall remit all amounts due under a Supplementary Bill raised by OPGC to OPGC Account 2 on or before the Due Date for payment of the succeeding month's bill and notify OPGC of such remittance on the same day, provided that if a Supplementary Bill is raised along with the current Monthly Bill, it shall be payable by the Due Date of the current Bill. OPGC shall pay all amounts due under a Supplementary Bill to GRIDCO by adjusting such amount in the next Monthly Bill/ Supplementary Bill raised by OPGC.

9.3.2.2 In the event of delay in payment/adjustment of a Supplementary Bill by OPGC beyond its Due Date, a Late Payment Surcharge shall be payable by OPGC at the same terms applicable to the Monthly Bill as in Article 9.5.

9.4 Rebate

For the payment of any Bill before Due Date, the rebate (**"Rebate"**) shall be paid by OPGC to GRIDCO in the following manner -

9.4.1 Two percent (2%) Rebate shall be allowed on payment of Bills through Letter of Credit (or directly) from GRIDCO on the full amount of the Bill, paid within seven (7) days of presentation of the Bills. If payment is made after seven (7) but within thirty (30) days of presentation of the Bills then one percent (1%) Rebate will be allowed.

9.4.2 The above Rebate will be allowed only if GRIDCO pays the full Monthly Bill or the full Supplementary Bill to OPGC Account 2. In case of Disputed Bill, Rebate shall be payable as per provisions in Article 9.6.2.

9.4.3 The rate/ percentage of Rebate shall be in line with the Tariff Regulations.

9.4.4 No such Rebate shall be payable on the Bills raised on any statutory levy.

9.4.5 No such Rebate shall be payable on account of Change in Law unless it is determined to the contrary by the Appropriate Commission.

9.4.6 No such Rebate shall be payable on Late Payment Surcharge.

9.5 Late Payment Surcharge

9.5.1 In the event of delay in payment of any Bill by GRIDCO beyond sixty (60) days from the date of billing, a surcharge for late payment (**"Late Payment Surcharge"**) shall be payable by GRIDCO to OPGC at the rate of one point two five percent (1.25%) per

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Month or as per the Tariff Regulations on the amount of outstanding payment. The Late Payment Surcharge shall be claimed by OPGC through succeeding Monthly Bills.

9.6 *Disputed Bill*

9.6.1 If GRIDCO does not dispute a Bill raised by OPGC within twenty one (21) days of receipt of Bill, such Bill shall be taken as conclusive.

9.6.2 If GRIDCO disputes the amount payable under a Bill, GRIDCO shall, within twenty one (21) days of receiving such Bill, issue a bill dispute notice (**"Bill Dispute Notice"**) to OPGC setting out -

(a) the details of the disputed amount;

(b) its estimate of what the correct amount should be; and

(c) all written material in support of its claim.

Wherever GRIDCO disputes a Bill, it shall make payment of ninety five percent (95%) of such Bill or hundred percent (100%) of the undisputed portion of the Bill, which ever is higher, as per the provisions of this Article. However, in the event of such payment, as an exception to provisions in Art.9.4.1 and Art.9.4.2, two percent (2%) Rebate shall be allowed on payment of Bills through Letter of Credit (or directly) from GRIDCO on such amount of the Bill, paid within seven (7) days of presentation of the Bills. If payment is made after seven (7) days, but within thirty (30) days of presentation of the Bills, then one percent (1%) Rebate will be allowed. Other provisions as set out in Art.9.4 shall apply mutatis-mutandis.

Provided that, Late Payment Surcharge shall be applicable on the amount not paid due to such Bill dispute.

9.6.3 If OPGC agrees to the claim raised in the Bill Dispute Notice issued pursuant to Article 9.6.2, OPGC shall revise such Bill within seven (7) days of receiving such notice.

9.6.4 If OPGC does not agree to the claim raised in the Bill Dispute Notice issued pursuant to Article 9.6.2, it shall within seven (7) days of receiving the Bill Dispute Notice, furnish a bill disagreement notice (**"Bill Disagreement Notice"**) to GRIDCO providing -

(a) reasons for its disagreement with the Bill Dispute Notice;

(b) its estimate of what the correct amount should be; and

(c) its counter-claim and all material in support of such counter-claim.

9.6.5 In case of Disputed Bills, after exhausting settlement of the matter mutually as per Article 17.2 and 17.2A of this Agreement, it shall be open to the aggrieved Party to approach the Appropriate Commission for Dispute resolution in accordance with Article 17 and also for interim orders protecting its interest including for orders for interim payment pending Dispute resolution and the Parties shall be bound by the decision of the Appropriate Commission, including in regard to interest or Late Payment Surcharge, if any directed to be paid by the Appropriate Commission.

9.6.6 If a Dispute regarding a Bill is settled pursuant to this Article 9.6 or by Dispute resolution mechanism provided in this Agreement in favour of either Party, either Party shall refund the amount, if any incorrectly charged and collected, within five (5) days of the Dispute, either being amicably resolved by the Parties or settled by

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Dispute resolution mechanism, along with the interest at the same rate as Late Payment Surcharge from the date when such payment was received by the other Party.

9.7 *Letter of Credit*

9.7.1 GRIDCO shall provide to OPGC, in respect of payment of its Monthly Bills, a monthly unconditional, revolving and irrevocable letter of credit (**"Letter of Credit"**), opened and maintained by GRIDCO, which may be drawn upon by OPGC in accordance with Articles 9.7.1 through Article 9.7.8. GRIDCO shall provide OPGC draft of the Letter of Credit proposed to be provided within four (4) Months before the Sheduled COD which shall be in a form reasonably satisfactory to OPGC. Further, the Letter of Credit shall be provided from the bank which is appointed as the Escrow Bank under the Supplemental Escrow Agreement, and which can be assigned to the lenders and be in a form acceptable to OPGC.

9.7.2 Not later than one (1) Month prior to the Scheduled COD of the Unit-3 or Unit-4 (whichever occurs earlier), GRIDCO shall through a scheduled bank at Bhubaneswar open a Letter of Credit in favour of OPGC, to be made operative from a date prior to the Due Date of its first (1st) Monthly Bill under this Agreement. The Letter of Credit shall have a term of twelve (12) Months and shall be renewed annually, for an amount equal to

(a) for the first (1st) Contract Year, equal to one point zero five (1.05) times the estimated average monthly billing based on Normative Availability Factor; and

(b) for each subsequent Contract Year, equal to the one point zero five (1.05) times the average of the Monthly Tariff Payments of the previous Contract Year plus the estimated monthly billing during the current Contract Year from any additional unit(s) expected to be put on COD during the current Contract Year based on Normative Availability Factor.

Provided that OPGC shall not drawdown upon such Letter of Credit prior to the Due Date of the relevant Monthly Bill, or if payment is not made directly by GRIDCO by the Due Date. For avoidance of doubt it is clarified that OPGC will not make more than one (1) drawdown in a Month.

Provided further that the Letter of Credit amount shall be revised once in every six (6) months during a Contract Year (April and October), based on previous year's corresponding six (6) months energy pattern, calculated at the rate of current year's Tariff

9.7.3 GRIDCO shall cause the scheduled bank issuing the Letter of Credit to intimate OPGC, in writing regarding establishing of such irrevocable Letter of Credit.

9.7.4 In case of a drawdown of the Letter of Credit by OPGC in accordance with the terms of this Article 9.7, the amount of the Letter of Credit shall be replenished by GRIDCO within fifteen (15) days of such a draw.

9.7.5 If GRIDCO fails to pay a Monthly Bill or part thereof by the Due Date, then, subject to Article 9.7.2, OPGC may draw upon the Letter of Credit, and accordingly the bank shall pay without any reference or instructions from GRIDCO, an amount equal to such Monthly Bill or part thereof plus Supplementary Bill, if applicable, in accordance with Article 9.2.2 above, by presenting to the scheduled bank issuing the Letter of Credit, the following documents -

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(a) a copy of the Monthly Bill which has remained unpaid by GRIDCO;

(b) a certificate from OPGC to the effect that the Bill at item (a) above, or specified part thereof, is in accordance with the Agreement and has remained unpaid beyond the Due Date; and

Further, on the occurrence of such an event set forth in Article 9.7.5 (a) and (b) above, OPGC shall immediately inform GRIDCO of the said failure of GRIDCO to pay the Monthly Bill or part thereof. For the avoidance of doubt it is clarified that OPGC shall also be entitled to drawdown on the Letter of Credit for any failure of GRIDCO to pay a Supplementary Bill.

9.7.6 GRIDCO shall ensure that the Letter of Credit shall be renewed not later than fifteen (15) days prior to its expiry. If the Letter of Credit is not renewed within such agreed period, then OPGC shall be entitled to draw upon the Letter of Credit against any outstanding Bill, before such expiry.

9.7.7 All costs relating to opening and maintenance of the Letter of Credit shall be borne by GRIDCO. If payment is made through Letter of Credit, negotiation charges shall also be borne and paid by GRIDCO.

9.7.8 Where necessary, the Letter of Credit may also be substituted by an unconditional and irrevocable bank guarantee or an equivalent instrument as mutually agreed by the Parties.

9.8 *Escrow and Security Arrangement*

9.8.1 To secure the due discharge by GRIDCO of its obligations under this Agreement, GRIDCO and OPGC shall contemporaneously with the execution of this Agreement enter into a Supplemental Escrow Agreement.

9.8.2 GRIDCO and OPGC shall contemporaneously with the execution of the Supplemental Escrow Agreement, enter into a separate Deed of Hypothecation in the form and format as provided in Schedule 6. The minimum revenue flow in any Month in the GRIDCO Escrow Account shall be at least equal to the amount required for servicing payment obligations for the PPA 1, and the Receivables under this PPA 2.

9.8.3 Subject to the Escrow Agreement, GRIDCO shall ensure that OPGC has first ranking charge on the GRIDCO Escrow Account and the Receivables in accordance with the terms of the Deed of Hypothecation.

9.8.4 In the event that GRIDCO fails to make complete payment of any Bill to OPGC in accordance with this Agreement, OPGC shall be entitled to draw down the shortfall in payment from OPGC Account 2 without any delay or demur.

9.9 *Third Party Sales on default*

9.9.1 Notwithstanding anything to the contrary contained in this Agreement, upon the occurrence of an event where GRIDCO has not made payment by the Due Date of a Bill through the Payment Mechanism as provided in Article 9.3 of this Agreement, OPGC shall first follow the steps as enumerated in Articles 9.7 and 9.8, failing which OPGC may resort to the provisions of Article 9.9.2 below.

9.9.2 On occurrence of the event mentioned in Article 9.9.1 and after giving a notice of at least fifteen (15) days to GRIDCO, OPGC shall have the right to offer twenty five percent (25%) of the Contracted Capacity for sale to third-parties.

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9.9.3 If the GRIDCO Escrow Account is not fully restored by GRIDCO within thirty (30) days of the non-payment of a Monthly Bill by its Due Date, the provisions of Article 9.9.2 shall apply with respect to one hundred percent (100%) of the Contracted Capacity.

9.9.4 In case of third party sales as permitted by this Article 9.9, the adjustment of the surplus revenue over Energy Charge (applicable to GRIDCO) attributable to such electricity sold, shall be adjusted as under -

(a) the surplus up to the Capacity Charge shall be used towards the extinguishment of the subsisting payment liability of GRIDCO towards OPGC; and

(b) the sale realization in excess of Energy Charges after taking into account such other costs including, transmission charges, transmission losses, open access charges, incidental costs, and trading margin (as per CERC Regulation), incurred for such third party sale, shall be first utilised to extinguish any dues payable by GRIDCO towards corresponding Capacity Charges and surplus if any, beyond this, shall be shared by OPGC and GRIDCO in the ratio of 60:40.

The liability of GRIDCO towards making Capacity Charge payments to OPGC even for electricity sold to third party(s) or remaining unsold during such periods will remain unaffected.

Provided such Capacity Charge payment liability shall cease on the expiry date of a period of three (3) years and hundred (100) days from the date of occurrence of a GRIDCO Event of Default under Article 13 if prior to such date, such GRIDCO Event of Default has not ceased and regular supply of electricity for a period of at least ninety (90) continuous days has not occurred.

GRIDCO covenants that it shall co-operate and facilitate any such sales to third parties.

9.9.5 Sales to any person or Party, other than GRIDCO under Article 9.9, shall cease and regular supply of electricity to GRIDCO in accordance with all the provisions of this Agreement shall commence and be restored on the later of the two (2) following dates or any date before this date at the option of OPGC -

(a) the day on which GRIDCO pays the amount due to OPGC and renews the Letter of Credit and restores GRIDCO Escrow Account as mentioned in Articles 9.7 and 9.8; or

(b) the date being thirty (30) days from the date on which GRIDCO pays the amount due to OPGC.

By way of the following illustrations the working of this Article 9.9.4 is explained herein below:

Regulated tariff for sale to GRIDCO

Capacity Charge	: Rs.1.50
Energy charge	: Rs.1.00
Total tariff	: Rs.2.50

Scenario 1

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Realization from third party sale	: Rs. 2.70
Retained energy charges by OPGC	: Rs. 1.00
Retained additional cost & trading margin for power sale by OPGC	: Rs. 0.10 (say)
Capacity Charge adjustment towards GRIDCO	: Rs. 1.50
Excess earnings to be shared	: Rs. 0.10
Surplus retention by OPGC	: Rs. 0.06
Surplus used to extinguish GRIDCO dues	; Rs. 0.04

Scenario 2

Realization from third party sale	: Rs. 2.30
Retained energy charges by OPGC	: Rs. 1.00
Retained additional cost & trading margin for power sale by OPGC	: Rs. 0.10 (say)
Capacity Charge adjustment towards GRIDCO	: Rs. 1.20
Excess earnings to be shared	: Nil
Surplus retention by OPGC	: Nil
Surplus used to extinguish GRIDCO dues	; Nil
Capacity Charge to be paid by GRIDCO	: Rs. 0.30

Scenario 3

Third party sale could not be made by OPGC	
Capacity Charge to be paid by GRIDCO	: Rs. 1.50

9.10 Quarterly and Annual Reconciliation

9.10.1 The Parties agree that –

(a) all payments made against Monthly Bills and Supplementary Bills shall be subject to quarterly reconciliation at the beginning of the following quarter of each Contract Year and annual reconciliation at the end of each Contract Year to take into account Energy Account provided by SLDC/ RLDC, Tariff adjustment payments, Rebate payments, Late Payment Surcharge, or any other reasonable circumstance provided under this Agreement.

(b) upon all data in respect of any quarter of a Contract Year or a full Contract Year as the case may be being finally verified and adjusted, OPGC and GRIDCO shall jointly sign such reconciliation statement.

9.10.2 Within fifteen (15) days of signing of a reconciliation statement, OPGC, if required, shall raise a Supplementary Bill for the adjustments for the relevant quarter/

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Contract Year and shall make/ receive payment of such Supplementary Bill for the adjustments for the relevant quarter/ Contract Year.

9.10.3 Any Dispute with regard to the above reconciliation shall be dealt with in accordance with the provisions of Article 17.

ARTICLE 10: INSURANCES

10.1 *Insurance*

OPGC shall effect and maintain or cause to be effected and maintained during the Construction Period and Operating Period, insurances against such risks, with such deductibles and with such endorsements and co-insured(s), as per Prudent Utility Practices and also as per the requirements under the Financing Agreements.

10.2 *Application of Insurance Proceeds*

Save as expressly provided in this Agreement or as required pursuant to any of the Financing Agreements or the insurances effected and maintained as above, the proceeds of any insurance claim made due to loss or damage to the Power Station or any part of the Power Station shall be first applied for reinstatement, replacement, or renewal of such loss or damage.

10.3 *Effect on liability of GRIDCO*

Notwithstanding any liability or obligation that may arise under this Agreement, any loss, damage, liability, payment, obligation or expense which is insured or for which OPGC can claim compensation under any Insurance, shall not be charged to or be payable by GRIDCO.

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ARTICLE 11: FORCE MAJEURE

11.1. *Definitions*

In this Article 11, the terms "**Affected Party**" and "**Force Majeure**" shall have the meanings as ascribed to it in Article 11.2 and 11.3 respectively.

11.2 *Affected Party*

An "**Affected Party**" means GRIDCO or OPGC whose performance has been affected by an event of Force Majeure.

An event of Force Majeure affecting the CTU/ STU or any other agent of GRIDCO, which has affected the Interconnection and Transmission Facilities, shall be deemed to be an event of Force Majeure affecting GRIDCO.

Further, any event of Force Majeure affecting the performance of GRIDCOs' contractor or sub-contractor for the setting up or operating Interconnection and Transmission Facilities shall be deemed to be an event of Force Majeure affecting GRIDCO, only if the Force Majeure event is resulting in a delay in the performance of GRIDCO's contractors or sub-contractors.

Any event of Force Majeure affecting the performance of OPGC's contractors or sub-contractors shall be deemed to be an event of Force Majeure affecting OPGC, if the Force Majeure event is affecting and resulting in -

(a) late delivery of plant, machinery, equipment, materials, spare parts, Fuel, water or consumables for the Project; or

(b) a delay in the performance of any of OPGC's contractors or sub-contractors.

11.3 *Force Majeure*

A "**Force Majeure**" means any event or circumstance or combination of events and circumstances including those stated below that wholly or partly prevents or unavoidably delays an Affected Party in the performance of its obligations under this Agreement, but only if and to the extent that such events or circumstances are not within the reasonable control, directly or indirectly of the Affected Party and could not have been avoided if the Affected Party had taken reasonable care or complied with Prudent Utility Practices.

11.3.1 Natural Force Majeure Events

Act of God, including, but not limited to lightning, drought, fire and explosion (to the extent originating from a source external to the Site), earthquake, volcanic eruption, landslide, flood, inundation, cyclone, typhoon, tornado, epidemic, plague or quarantine, or exceptionally adverse weather conditions which are in excess of the statistical measures for the last ten (10) years or any event analogous to the foregoing.

11.3.2 Non-Natural Force Majeure Events

11.3.2.1 Direct Non - Natural Force Majeure Events

(a) Nationalization or compulsory acquisition by any Indian Governmental Instrumentality of any material assets or rights of OPGC or OPGC's contractors or sub-contractors or GRIDCO or GRIDCO's contractors or sub-contractors; or

(b) the, unreasonable or discriminatory revocation or suspension of, or refusal to renew any Consents required by OPGC or any of OPGC's contractors or sub-contractors to perform their respective obligations under the Project Documents or any unreasonable or discriminatory refusal to grant any other Consents required for the development/ operation of the Project, subject to mutual agreement of both Parties; or

(c) Disruption in supply of Fuel due to any un-anticipated and unforeseen events in the normal course of business, which is not within the control of OPGC, leading to loss or complete disruption of power generation; or

(d) Any act of Indian Government Instrumentality or compliance with such acts which affects such Party's ability to perform its obligations herein including directions issued under Laws; or

(e) any event or circumstance of a nature analogous to any of the foregoing.

11.3.2.2 Indirect Non - Natural Force Majeure Events

(a) any act of war (whether declared or undeclared), invasion, armed conflict or act of foreign enemy, blockade, embargo, revolution, riot, insurrection, or military action, acts of terrorism, civil commotion, religious strife, communal violence, extremist action or politically motivated sabotage or sabotage or abductions; or

(b) radioactive contamination or ionizing radiation originating from a source in India or resulting from another Indirect Non Natural Force Majeure event excluding circumstances where the source or cause of contamination or radiation is brought or has been brought into or near the Site by the Affected Party or those employed or engaged by the Affected Party; or

(c) industry wide strikes and labour disturbances having a nationwide impact in India, or go slows or industrial disputes at the Project or Power Station; or

(d) an event, where on account of failure on the part of Fuel Supplier, the supply of Fuel is disrupted due to any un-anticipated and unforeseen events in the normal course of business, which is not within the control of the Fuel Supplier, leading to loss or complete disruption of power generation; or

(e) any event or circumstance of a nature analogous to any of the foregoing.

11.4 Force Majeure Exclusions

Force Majeure shall not include (i) any event or circumstance which is within the reasonable control of the Parties, and (ii) the following conditions except to the extent that they are consequences of an event of Force Majeure:

(a) unavailability, late delivery, or changes in cost of the plant, machinery, equipment, materials, spare parts, Fuel or consumables for the Project;

(b) delay in the performance of any contractor, sub-contractors or their agents excluding the conditions as mentioned in Article 11.3;

(c) non-performance resulting from normal wear and tear typically experienced in power generation materials and equipment;

(d) insufficiency of finances or funds or the agreement becoming onerous to perform; and

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(e) non-performance caused by, or connected with, the Affected Party's -

(i) negligent or intentional acts, errors or omissions;

(ii) failure to comply with Law; or

(iii) breach of, or default under this Agreement or any Project Documents.

11.5 *Notification of Force Majeure Event*

The Affected Party shall give notice to the other Party of any event of Force Majeure as soon as reasonably practicable, preferably not later than seven (7) days after the date on which such Party knew or should have reasonably known of the commencement of the event of Force Majeure. If an event of Force Majeure results in a breakdown of communications rendering it unreasonable to give notice within the applicable time limit specified herein, then the Party claiming Force Majeure shall give such notice as soon as reasonably practicable after reinstatement of communications, preferably not later than seven (7) days after such reinstatement.

Such notice shall

(a) be a pre-condition to either Party's entitlement to claim relief with respect to the event Force Majeure under this Agreement; and

(b) include full particulars of the event of Force Majeure, its effects on the Party claiming relief and the remedial measures proposed.

The Affected Party shall give the other Party regular (and not less than monthly) reports on the progress of those remedial measures and such other information as the other Party may reasonably request about the situation.

The Affected Party shall give notice to the other Party of (i) the cessation of the relevant event of Force Majeure; and (ii) the cessation of the effects of such event of Force Majeure on the performance of its rights or obligations under this Agreement, as soon as practicable after becoming aware of each of these cessations.

11.6 *Duty to perform and duty to mitigate*

To the extent not prevented by an event of Force Majeure pursuant to Article 11.3, the Affected Party shall continue to perform its obligations pursuant to this Agreement. The Affected Party shall use its reasonable efforts to mitigate the effect of any event of Force Majeure as soon as practicable and will not be required to settle any strike or labour dispute it considers to be unjustified to it.

11.7 *Available Relief for a Force Majeure Event*

Subject to this Article 11 -

(a) no Party shall be in breach of its obligations pursuant to this Agreement to the extent that the performance of its obligations was prevented, hindered or delayed due to a Force Majeure event;

(b) every Party shall be entitled to claim relief in relation to a Force Majeure event in regard to its obligations, including but not limited to those specified under Article 4.4;

(c) no Tariff shall be paid by GRIDCO for the part of Contracted Capacity which is not available to GRIDCO due to a Natural Force Majeure event affecting OPGC, for the

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duration of such non-availability. For the balance part of the Contracted Capacity available to it, GRIDCO shall pay the Tariff to OPGC, provided that during such period of Natural Force Majeure event, the balance part of the Power Station is declared to be Available for scheduling and dispatch as per Availability Based Tariff for supply of power by OPGC to GRIDCO;

(d) if the average Availability of the Power Station is reduced (i) below sixty percent (60%) for over two (2) consecutive Months, or (ii) for any non consecutive period of four (4) Months both (i) and (ii) being within any continuous period of sixty (60) Months, as a result of an Indirect Non Natural Force Majeure, then, with effect from the end of the period during which an Indirect Non Natural Force Majeure was subsisting and for so long as the daily average Availability of the Power Station continues to be below sixty percent (60%) as a result of an Indirect Non Natural Force Majeure of any kind, GRIDCO shall make payments for Debt Service, subject to a maximum of Capacity Charge based on Normative Availability Factor, relatable to such Unit.

Such amounts shall be paid to OPGC in the form of an increase in Capacity Charge. These amounts will be paid from the date, of cessation of such Indirect Non Natural Force Majeure event. Such Capacity Charge increase shall be subject to determination by Appropriate Commission on the basis of putting OPGC in the same economic position as OPGC would have been in case OPGC had been paid Debt Service in a situation where the Indirect Non Natural Force Majeure had not occurred. Provided that OPGC shall make all efforts to re-structure the Debt Service in a manner for GRIDCO to be able to pay in a convenient manner..

For avoidance of doubt it is clarified that GRIDCO will have the above obligation to make payment for the Debt Service only after the Unit(s) affected by such Indirect Non Natural Force Majeure event has been Commissioned.

(e) if the average Availability of the Power Station is reduced (i) below eighty five percent (85%) for over two (2) consecutive Months or (ii) for any non consecutive period of four (4) Months, both (i) and (ii) being within any continuous period of sixty (60) Months, as a result of a Direct Non Natural Force Majeure, then, with effect from the end of that period and for so long as the daily average Availability of the Power Station continues to be reduced below eighty five percent (85%) as a result of a Direct Non Natural Force Majeure of any kind, OPGC may elect in a written notice to GRIDCO, to deem the Availability of the Power Station to be eighty five percent (85%) from the end of such period, regardless of its actual Available Capacity.

In such a case, GRIDCO shall be liable to make payment to OPGC of Capacity Charge calculated on such deemed Normative Availability Factor, after the cessation of the effects of the Direct Non Natural Force Majeure, in the form of an increase in Capacity Charge. Such Capacity Charge increase shall be subject to determination by Appropriate Commission on the basis of putting OPGC in the same economic position as OPGC would have been in case OPGC had been paid Capacity Charges in a situation where the Direct Non Natural Force Majeure had not occurred. Provided that OPGC shall make all efforts to re-structure the Debt Service in a manner for GRIDCO to be able to pay in a convenient manner.

(f) for so long as OPGC is claiming relief due to any Natural Force Majeure event or Non Natural Force Majeure event under this Agreement, GRIDCO may from time to time on one (1) day's notice inspect the Power Station and OPGC shall provide GRIDCO's personnel access to the Power Station to carry out such inspections. GRIDCO's personnel shall comply with all safety precautions and standards during such inspections.

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GRIDCO shall be entitled at all times to request repeat Performance Test of the Unit(s) Commissioned earlier, if testing is possible to be undertaken in respect of the Units affected by Direct or Indirect Non Natural Force Majeure event or GRIDCO being affected by a Natural Force Majeure event. In such an event, GRIDCO shall bear the cost for the Performance Test.

GRIDCO shall make pro-rata payment of Debt Service with respect to reduced Availability as established pursuant to a repeat Performance Test of a Unit(s), demonstrated to GRIDCO through a trial run.

For the avoidance of doubt, if Debt Service would have been payable at an Availability of the Power Station of sixty percent (60%) and pursuant to a repeat Performance Test it is established that the Availability of the Power Station-would have been forty percent (40%), then GRIDCO shall make payment equal to Debt Service multiplied by forty percent (40%) and divided by sixty percent (60%). Similarly, the payments in case of Direct Non Natural Force Majeure event (and Natural Force Majeure event affecting GRIDCO) shall also be adjusted pro-rata for reduction in Available Capacity.

(g) for the avoidance of doubt, it is specified that the charges payable under this Article 11 shall be paid by GRIDCO in proportion to their then existing Contracted Capacity.

11.8 Failure or delay caused by Force Majeure

So long as the Parties are in compliance of the requirements of this Article 11, neither Party shall be liable for any failure or delay in complying with its obligations pursuant to this PPA-2 to the extent that such failure or delay has been caused or contributed to, by one or more events of Force Majeure or their effects or by any combination thereof subject to Article 13.1 or Article 13.2, as applicable. The period allowed for the performance by the Affected Party of its obligations herein shall be extended by one (1) day for each day of continuation of the effect of an event or events of Force Majeure. The said extension will be for such additional duration as may be required to compensate for any delay or failure resulting from the time spent on demobilization and remobilization of personnel and restoration of the Project, as the case may be, after cessation of an event or events of Force Majeure, to the pre-delay condition, factoring in diligent and reasonable conduct by the Affected Party consistent with Prudent Utility Practices.

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ARTICLE 12: CHANGE IN LAW

12.1 *Definition*

In this Article 12, the term **"Change in Law"** shall have the meanings ascribed to it in Article 12.2 below.

12.2 *Change in Law*

"Change in Law" means the occurrence of any of the following events after the Effective Date -

(a) the enactment, bringing into effect, adoption, promulgation, amendment, modification or repeal, of any Law, or

(b) a change in interpretation of any Law by a Judicial Authority, tribunal or Indian Governmental Instrumentality which is the final authority under Law for such interpretation; or

(c) change by any competent statutory authority in any consents available or obtained for the Project, or imposition by an Indian Governmental Instrumentality of any material condition in connection with the issuance, renewal, modification, revocation or non-renewal of any consent, which may result in any additional cost to OPGC; or the enactment bringing into effect, adoption, promulgation, amendment, modification or repeal, of any Law with respect to carbon-di-oxide or other green house gas emissions.

12.3 *Application and Principles for computing impact of Change in Law*

While determining the consequence of Change in Law under this Article 12, the Parties shall have due regard to the principle that the purpose of compensating the Party affected by such Change in Law, is to restore, to the extent contemplated in this Article 12, as may be determined by the Appropriate Commission.

12.4 *Notification of Change in Law*

12.4.1 If OPGC is affected by a Change in Law in accordance with Article 12.2 and seeks to claim a Change in Law under this Article, it shall give notice to GRIDCO of such Change in Law as soon as reasonably practicable after becoming aware of the same or should reasonably have known of the Change in Law.

12.4.2 Notwithstanding Article 12.4.1, OPGC shall be obliged to serve a notice to GRIDCO under this Article 12.4.2 if OPGC is beneficially affected by a Change in Law. Without prejudice to the factor of materiality or other provisions contained in this Agreement, the obligation to inform GRIDCO contained herein shall be material. In case OPGC has not provided such notice, GRIDCO shall have the right to issue such notice to OPGC.

12.4.3 Any notice served pursuant to Article 12.4.2 shall provide, amongst other things, precise details of -

(a) the Change in Law; and

(b) the effects on OPGC of the matters referred to in Article 12.2.

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12.5 *Tariff Adjustment Payment on account of Change in Law*

12.5.1 Subject to Article 12.4, the adjustment in Monthly Tariff Payment shall be effective from -

(a) the date of adoption, promulgation, amendment, re-enactment or repeal of the Law or Change in Law; or

(b) the date of order/judgment of any Judicial Authority or tribunal or Indian Governmental Instrumentality, if the Change in Law is on account of a change in interpretation of Law; or

(c) the date of impact resulting from the occurrence of Article 12.2.

12.5.2 For any one-time event, the payment for Changes in Law shall be through Supplementary Bill as mentioned in Article 9. However, in case of any change in Tariff by reason of Change in Law, as determined in accordance with this Agreement, the Monthly Bill to be raised by OPGC after such change in Tariff shall appropriately reflect the changed Tariff.

Provided that, payments arising out of this Article 12.5, is subject to approval of the Appropriate Commission.

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ARTICLE 13: EVENTS OF DEFAULT AND TERMINATION

13.1 *OPGC Event of Default*

The occurrence and continuation of any of the following events, unless any such event occurs as a result of a Force Majeure event or a breach by GRIDCO of its obligations under this Agreement, shall constitute an OPGC Event of Default:

(a) the failure to Commission any Unit by the date falling twelve (12) Months after its Scheduled Commercial Operation Date; or

(b) failure to make any payment of an amount exceeding Rupees One (1) Crore required to be made to GRIDCO under this Agreement, within three (3) Months after the date when such amount is due to paid to GRIDCO; or

(c) any of the representations and warranties made by OPGC under this Agreement, being found to be untrue or inaccurate in all material respects. Provided however that, prior to considering any event specified under this sub-article to be an OPGC Event of Default, GRIDCO shall give a notice to OPGC in writing of occurrence of such OPGC Event of Default at least thirty (30) days and unless within which OPGC has cured the same; or

(d) if OPGC is in material breach of any of its obligations under the Agreement; or

(e) if OPGC:

(i) assigns any of its rights under this Agreement or in violation of this Agreement; or

(ii) transfers or novates any of its rights and/or obligations under this agreement, in violation of this Agreement; or

(f) if:

(i) OPGC becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of thirty (30) days; or

(ii) any winding up or bankruptcy or insolvency order is passed against OPGC; or

(iii) OPGC goes into liquidation or dissolution or has a receiver or any similar officer appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs, pursuant to Law, except where such a dissolution or liquidation of OPGC is for the purpose of a merger, consolidation or reorganization, and where the resulting entity has the financial standing to perform its obligations under this Agreement and has the creditworthiness similar to OPGC and expressly assumes all obligations of OPGC under this Agreement and is in a position to perform them.

13.2 *GRIDCO Event of Default*

The occurrence and the continuation of any of the following events, unless any such event occurs as a result of a Force Majeure event or a breach by OPGC of its obligations under this Agreement, shall constitute the GRIDCO Event of Default -

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(a) GRIDCO's failure to make any payment with respect to a Bill or any part of the Bill for a period of thirty (30) days after the Due Date in case OPGC is unable to recover the amount outstanding to OPGC through the Supplemental Escrow Agreement and Letter of Credit; or

(b) If GRIDCO fails to renew the Letter of Credit in accordance with Article 9.7.6; or

(c) any representation and warranties made by GRIDCO in this Agreement. being found to be untrue or inaccurate in all material respect. Provided however, that prior to considering any event specified under this sub-article to be a GRIDCO Event of Default, OPGC shall give a notice to GRIDCO in writing of occurrence of such GRIDCO Event of Default of at least thirty (30) days;; or

(d) if GRIDCO is in material breach of any of its obligations under the Agreement including timely replenishment of payment security mechanism under Article 9. or

(e) if GRIDCO-

(i) assigns or purports to assign any of its assets or rights in violation of this Agreement; or

(ii) transfers or novates any of its rights and/or obligations under this agreement, in violation of this Agreement; or

(f) if:

(i) GRIDCO becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of thirty (30) days; or

(ii) any winding up or bankruptcy or insolvency order is passed against GRIDCO; or

(iii) GRIDCO goes into liquidation or dissolution or has a receiver or any similar officer appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs, pursuant to Law, except where such dissolution or liquidation of GRIDCO is for the purpose of a merger, consolidation or reorganization and where the resulting entity has the financial standing to perform its obligations under this Agreement and has the creditworthiness similar to GRIDCO and expressly assumes all obligations of such GRIDCO under this Agreement and is in a position to perform them.

13.3. *Procedure for cases of OPGC Event of Default*

13.3.1 Upon the occurrence and continuation of any OPGC Event of Default under Article 13.1, GRIDCO shall have the right to deliver to OPGC a preliminary default notice ("**GRIDCO Preliminary Default Notice**"), which shall specify in reasonable detail, the circumstances giving rise to the issue of such notice.

13.3.2 Following the issue of GRIDCO Preliminary Default Notice, the GRIDCO Consultation Period of ninety (90) days or such longer period as the Parties may agree, shall apply.

13.3.3 During the GRIDCO Consultation Period, the Parties shall continue to perform their respective obligations under this Agreement.

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13.3.4 Within a period of seven (7) days following the expiry of the GRIDCO Consultation Period, unless the Parties shall have otherwise agreed to the contrary, or OPGC Event of Default giving rise to the GRIDCO Consultation Period shall have been remedied, the Lenders may exercise their substitution rights and other rights as provided to them, if any, under the Financing Agreements in accordance with the terms and conditions contained in Schedule 7 of this Agreement, and GRIDCO would have no objection to the Lenders exercising their rights. Alternatively, in case the Lenders do not exercise their rights as mentioned herein above, OPGC Event of Default continues for three (3) years, then GRIDCO will have the right to terminate this Agreement with no liabilities except for the ones that have actually accrued.

13.4 Procedure for GRIDCO Event of Default

13.4.1 Upon the occurrence and continuation of any GRIDCO Event of Default pursuant to Article 13.2(a), OPGC shall follow the remedies provided under Articles 9.9.

13.4.2 Without in any manner affecting the rights of OPGC under Article 13.4.1, on the occurrence of any GRIDCO Event of Default specified in Article 13.2, OPGC shall have the right to deliver to GRIDCO a preliminary default notice (**"OPGC Preliminary Default Notice"**), which notice shall specify in reasonable detail the circumstances giving rise to its issue.

13.4.3 Following the issue of an OPGC Preliminary Default Notice, the OPGC Consultation Period of ninety (90) days or such longer period as the Parties may agree, shall apply.

13.4.4 During the OPGC Consultation Period, the Parties shall continue to perform their respective obligations under this Agreement.

13.4.5 Within a period of seven (7) days following the expiry of the OPGC Consultation Period, unless the Parties shall have otherwise agreed to the contrary or GRIDCO Event of Default giving rise to the OPGC Consultation Period shall have been remedied, OPGC shall be free to sell the then existing Contracted Capacity and associated Available Capacity of GRIDCO to any third party of its choice.

Provided that GRIDCO shall have the liability to make payments for Capacity Charges based on Normative Availability Factor to OPGC for the period three (3) years from the eighth (8th) day after the expiry of the OPGC Consultation Period.

Provided further that in such three (3) year period, in case OPGC is able to sell electricity to any third party at a price which is in excess of the Energy Charges, then such excess realization up to Capacity Charge will reduce the Capacity Charge payments due from GRIDCO. Excess realization beyond the Tariff shall be retained by OPGC.

For the avoidance of doubt, the above excess adjustment would be applied on a cumulative basis for the three (3) year period. During such period, OPGC shall use its commercially reasonable efforts to sell the Contracted Capacity to such third parties at the most commercially reasonable terms available in the market, having due regard to the circumstances and the pricing of electricity in the market, at all such time. OPGC shall ensure that sale of power to the shareholders of OPGC or to any Affiliate of OPGC/shareholders of OPGC, is not at a price less than the Tariff, without obtaining the prior written consent of GRIDCO. Such request for consent would be responded to within a maximum period of three (3) days, failing which it would be deemed that GRIDCO has given its consent. Further, at the end of the three (3) year period from the expiry of this Agreement shall automatically terminate and

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period, after OPGC has used commercially reasonable efforts to consult with GRIDCO to remedy the default, provided on such termination, the future Capacity Charge liability of GRIDCO shall cease immediately.

By way of the following illustrations the working of this Article 13.4.5 is explained herein below:

Regulated tariff for sale to GRIDCO	
Capacity Charge	: Rs.1.50
Energy charge	: Rs.1.00
Total tariff	: Rs.2.50
Scenario 1	
Realization from third party sale	: Rs. 2.70
Energy charges to be retained by OPGC	: Rs. 1.00
Excess realization by OPGC	: Rs. 1.70
Less: adjustment towards GRIDCO dues	*: Rs. 1.50*
Excess realization by OPGC	: Rs. 0.20
Capacity Charge payment by GRIDCO	: Rs. 1.50 (this will accrue)
Scenario 2	
Realization from third party sale	: Rs. 2.20
Energy charges to be retained by OPGC	: Rs. 1.00
Excess realization by OPGC	: Rs. 1.20
Less: adjustment towards GRIDCO dues	*: Rs. 1.20*
Excess realization by OPGC	: Rs. 0.00
Capacity Charge payment by GRIDCO	: Rs. 1.50 (this will accrue)
Scenario 3	
Third party sale could not be made by OPGC	
Capacity Charge payment by GRIDCO	: Rs. 1.50 (this will accrue)

ARTICLE 14: LIABILITY AND INDEMNIFICATION

14.1 *Indemnity*

14.1.1 OPGC shall indemnify, defend, and hold GRIDCO harmless against -

(a) any and all third party claims, actions, suits or proceedings against GRIDCO for any loss of or damage to property of such third party, or death or injury to such third party, arising out of a breach by OPGC of any of its obligations under this Agreement, except to the extent that any such claim, action, suit or proceeding has arisen due to a negligent act or omission, breach of this Agreement or breach of statutory duty on the part of GRIDCO, its contractors, servants or agents; and

(b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest (together to constitute "**GRIDCO Indemnifiable Losses**") actually suffered or incurred by GRIDCO from third party claims arising by reason of –

(i) breach by OPGC of any of its obligations under this Agreement, (provided that this Article 14 shall not apply to such breaches by OPGC, for which specific remedies have been provided for under this Agreement) except to the extent that any such GRIDCO Indemnifiable Losses, has arisen due to a negligent act or omission, breach of this Agreement or breach of statutory duty on the part of GRIDCO, its servants or agents; or

(ii) any of the representations or warranties of OPGC under this Agreement being found to be inaccurate or untrue.

14.1.2 GRIDCO shall indemnify, defend, and hold OPGC harmless against -

(a) any and all third party claims, actions, suits or proceedings against OPGC, for any loss of or damage to property of such third party, or death or injury to such third party, arising out of a breach by GRIDCO of any of its obligations under this Agreement except to the extent that any such claim, action, suit or proceeding has arisen due to a negligent act or omission, breach of this Agreement or breach of statutory duty on the part of OPGC, its contractors, servants or agents; and

(b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest (together to constitute "**OPGC Indemnifiable Losses**") actually suffered or incurred by OPGC from third party claims arising by reason of –

(i) a breach by GRIDCO of any of its obligations under this Agreement (Provided that this Article 14 shall not apply to such breaches by GRIDCO, for which specific remedies have been provided for under this Agreement), except to the extent that any such OPGC Indemnifiable Losses have arisen due to a negligent act or omission, a breach of this Agreement or breach of statutory duty on the part of OPGC, its servants or agents; or

(ii) any of the representations or warranties of GRIDCO under this Agreement being found to be inaccurate or untrue.

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14.2 *Monetary Limitation of liability*

A Party who is indemnifying (**"Indemnifying Party"**) shall be liable to indemnify the other Party (**"Indemnified Party"**) under this Article 14 for any indemnity claims made in a Year only upto an amount of Rupees Two crore fifty lakh (Rs. 25,000,000/-).

14.3 *Procedure for claiming indemnity*

14.3.1 Third party claims

(a) Where the Indemnified Party is entitled to indemnification from the Indemnifying Party pursuant to Article 14.1.1(a) or 14.1.2(a), the Indemnified Party shall promptly notify the Indemnifying Party of such claim, proceeding, action or suit referred to in Article 14.1.1(a) or 14.1.2(a) in respect of which it is entitled to be indemnified. Such notice shall be given as soon as reasonably practicable after the Indemnified Party becomes aware of such claim, proceeding, action, or suit. The Indemnifying Party shall be liable to settle the indemnification claim within thirty (30) days of receipt of the above notice. Provided however that, if -

(i) the Parties choose to contest, defend or litigate such claim, action, suit or proceedings in accordance with Article 14.3.1(b) below; and

(ii) the claim amount is not required to be paid/deposited to such third party pending the resolution of the Dispute;

the Indemnifying Party shall become liable to pay the claim amount to the Indemnified Party or to the third party, as the case may be, promptly following the resolution of the Dispute, if such Dispute is not settled in favour of the Indemnifying Party;

(b) The Indemnified Party may contest, defend and litigate a claim, action, suit or proceeding for which it is entitled to be indemnified under Article 14.1.1(a) or 14.1.2(a) and the Indemnifying Party shall reimburse to the Indemnified Party all reasonable costs and expenses incurred by the Indemnified party. However, such Indemnified Party shall not settle or compromise such claim, action, suit or proceedings without first getting the consent of the Indemnifying Party, which consent shall not be unreasonably withheld or delayed; and

(c) An Indemnifying Party may, at its own expense, assume control of the defence of any proceedings brought against the Indemnified Party if it acknowledges its obligation to indemnify such Indemnified Party, and gives such Indemnified Party prompt notice of its intention to assume control of the defence, and employs an independent legal counsel at its own cost that is reasonably satisfactory to the Indemnified Party.

14.4 *Indemnifiable Losses*

Where an Indemnified Party is entitled to Indemnifiable Losses from the Indemnifying Party pursuant to Article 14.1.1(b) or 14.1.2(b), the Indemnified Party shall promptly notify the Indemnifying Party of the Indemnifiable Losses actually incurred by the Indemnified Party. The Indemnifiable Losses shall be reimbursed by the Indemnifying Party within thirty (30) days of receipt of the notice seeking Indemnifiable Losses by the Indemnified Party. In case of non-payment of such losses after a valid notice under this Article 14.4, such event shall constitute a payment default under Article 13.

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14.5 *Limitation on Liability*

Except as expressly provided in this Agreement, neither OPGC nor GRIDCO nor their respective officers, directors, agents, employees or Affiliates (or their officers, directors, agents or employees), shall be liable or responsible to the other Party or their respective Affiliates, officers, directors, agents, employees, successors or permitted assigns (or their respective insurers) for incidental, indirect or consequential damages, connected with or resulting from performance or non-performance of this Agreement, or anything done in connection herewith, including claims in the nature of lost revenues, income or profits (other than payments expressly required and properly due under this Agreement), any increased expense of, reduction in or loss of power generation, production, or equipment used therefore, irrespective of whether such claims are based upon breach of warranty, tort (including negligence, whether of GRIDCO, OPGC or others), strict liability, contract, breach of statutory duty, operation of Law or otherwise. GRIDCO shall have no recourse against any officer, director, or shareholder of OPGC or any Affiliate of OPGC or any of its officers, directors, or shareholders for such claims excluded under this Article 14.5. OPGC shall have no recourse against any officer, director, or shareholder of GRIDCO, or any Affiliate of GRIDCO or any of its officers, directors, or shareholders for such claims excluded under this Article.

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ARTICLE 15: REPRESENTATION AND WARRANTIES

15.1 *Representations and Warranties by GRIDCO*

GRIDCO hereby represents and warrants to and agrees with OPGC as follows and acknowledges and confirms that OPGC is relying on such representations and warranties in connection with the transactions described in this Agreement -

15.1.1 GRIDCO has all requisite powers authorizing and has been duly authorized to execute and consummate this Agreement.

15.1.2 This Agreement is enforceable against GRIDCO in accordance with its terms.

15.1.3 The consummation of the transactions contemplated by this Agreement on the part of GRIDCO will not violate any provision of nor constitute a default under, nor give rise to a power to cancel any charter, mortgage, deed of trust or lien, lease, agreement, license, permit, evidence of indebtedness, restriction, or other contract to which GRIDCO is a party or to which GRIDCO is bound, which violation, default has not been waived and power has been allowed.

15.1.4 GRIDCO is not insolvent and no insolvency proceedings have been instituted, nor threatened or pending by or against GRIDCO.

15.1.5 There are no actions, suits, claims, proceedings or investigations pending or, to the best of GRIDCO's knowledge, threatened in writing against GRIDCO at Law, in equity, or otherwise, and whether civil or criminal in nature, before or by, any court, commission, arbitrator or governmental agency or authority, and there are no outstanding judgments, decrees or orders of any such courts, commission, arbitrator or governmental agencies or authorities, which materially adversely affect its ability to comply with its obligations under this Agreement.

GRIDCO makes all the above representations and warranties to be valid as on the date of execution of this Agreement.

15.2 *Representation and Warranties of OPGC*

OPGC hereby represents and warrants to and agrees with GRIDCO as follows and acknowledges and confirms that GRIDCO is relying on such representations and warranties in connection with the transactions described in this Agreement -

15.2.1 OPGC has all requisite power authorizing and has been duly authorized to execute and consummate this Agreement.

15.2.2 This Agreement is enforceable against OPGC in accordance with its terms.

15.2.3 The consummation of the transactions contemplated by this Agreement on the part of OPGC will not violate any provision of nor constitute a default under, nor give rise to a power to cancel any charter, mortgage, deed of trust or lien, lease, agreement, license, permit, evidence of indebtedness, restriction, or other contract to which OPGC is a party or to which OPGC is bound which violation, default has not been waived and power has been allowed.

15.2.4 OPGC is not insolvent and no insolvency proceedings have been instituted, or not threatened or pending by or against OPGC.

15.2.5 There are no actions, suits, claims, proceedings or investigations pending or, to the best of OPGC's knowledge, threatened in writing against OPGC at Law, in equity, or

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otherwise, and whether civil or criminal in nature, before or by, any court, commission, arbitrator or governmental agency or authority, and there are no outstanding judgments, decrees or orders of any such courts, commission, arbitrator or governmental agencies or authorities, which materially adversely affect its ability to implement the Project or to comply with its obligations under this Agreement.

OPGC makes all the above representations and warranties to be valid as on the date of execution of this Agreement.

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

ARTICLE 16: ASSIGNMENT AND CHARGES

16.1 *Assignment*

This Agreement shall be binding upon, and inure to the benefit of the Parties and their respective successors and assigns. Subject to Article 16.2, this Agreement shall not be assigned by any Party (and no Party shall create or permit to subsist any encumbrance over all or any of its rights and benefits under this Agreement) other than by mutual consent between the Parties to be evidenced in writing.

Subject to Art.18.12 of this Agreement, such consent shall not be withheld, if GRIDCO seeks to transfer to any transferee, all of its rights and obligations under this Agreement; and

(a) such transferee is either the owner(s) or operator(s) of one or more of the distribution system of Orissa and/ or such transferee is a successor entity of GRIDCO; and

(b) this Agreement shall continue to remain valid and binding on such successor.

16.2 *Permitted Charges*

16.2.1 Notwithstanding anything contained in Article 16.1, OPGC may create any encumbrance over all or part of the Receivables, Payment Mechanism or the other assets of the Project in favour of the Lenders on their behalf as security for -

(a) amounts payable under the Financing Agreements; and

(b) any other amounts agreed by the Parties.

16.2.2 OPGC shall be entitled to assign its rights and obligations under this Agreement in favour of (i) the Lenders or (ii) a Selectee appointed in accordance with the provisions of Schedule 7. However, such assignment shall become effective only upon Lenders exercising their right of appointing a Selectee on the occurrence of an OPGC Event of Default.

16.3 *Direct Agreements*

GRIDCO agrees that it shall execute any direct agreement reasonably requested by the Lenders as part of their security package in accordance with the provisions set forth in Schedule 7.

Alum Mallis

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

ARTICLE 17: GOVERNING LAW AND DISPUTE RESOLUTION

17.1 Governing Law

This Agreement shall be governed by and construed in accordance with the Laws of India.

17.2 Amicable Settlement

17.2.1 Either Party is entitled to raise any claim or dispute or difference of whatever nature arising under, out of, or in connection with this Agreement including its existence or validity, billing process or termination (collectively "**Dispute**") by giving a written notice to the other Party, which shall contain -

(a) a description of the Dispute;

(b) the grounds for such Dispute; and

(c) all written material in support of its claim.

17.2.2 The other Party shall, within twenty (20) days of receipt of Dispute notice issued under Article 17.2.1, furnish -

(a) defences and counter-claim, if any, regarding the Dispute; and

(b) all written material in support of its defences and counter-claim.

17.2.3 Within forty (40) days of receipt of notice by any Party pursuant to Article 17.2.1 or 17.2.2, the Parties shall meet to attempt to settle such Dispute amicably.

17.2.4 In the event the Parties fail to resolve the Dispute amicably within seventy five (75) Business Days of receipt of the notice issued under Article 17.2.1, the Dispute shall be referred for resolution in accordance with Article 17.2A by either Party.

17.2A Conciliation Task Force

17.2A.1 There shall be a Conciliation Task Force ("**Conciliation Task Force**") comprising of the following members , with the consent of GoO:-

(a) Chief Secretary, Government of Orissa – Chairman;

(b) Secretary, Energy Department, Government of Orissa, - Member;

(c) Chairman-cum-Managing Director, GRIDCO - Member;

(d) Managing Director, OPGC - Member;

17.2A.2 Upon receipt of reference of a Dispute in terms of 17.2.4, the Conciliation Task Force shall notify the other Party of the reference and initiate a conciliation process, to resolve the Dispute amicably within seventy five (75) days of the receipt of the reference.

17.2A.3 The Conciliation Task Force shall be free to adopt appropriate procedure consistent with Law.

17.2A.4 In the event that the Dispute is not resolved amicably under the aegis of the Conciliation Task Force within sixty (60) days of receipt of the reference of dispute, either Party shall be entitled to refer the Dispute for adjudication/resolution in accordance with Article 17.3.

Allen Mollis

17.3 Dispute Resolution

17.3.1 Where any Dispute arises out of or with respect to determination of Tariff or any matter related to Tariff or claims made by any Party (which partly or wholly relate to Tariff) or any other matter, then such Dispute shall be referred for adjudication by the Appropriate Commission in accordance with the applicable Law.

Provided that any appeal against the decisions of the Appropriate Commission shall be preferred in terms of the Electricity Act, 2003.

17.3.2 It is however clarified that if subsequently due to a change in applicable Law, Disputes are permitted by Law to be resolved by referring the same to arbitration as per Arbitration and Conciliation Act 1996, then the provisions of Article 17.3.3 will be applicable and binding on the Parties other than in terms of Sections 79, 86 and 158 of the Electricity Act, 2003.

17.3.3 Subject to Articles 17.3.1 and 17.3.2, where any dispute arising out of or in connection with this Agreement outside the purview of the Electricity Act, 2003, then the following provisions shall apply:

(a) such Dispute shall be submitted to arbitration in accordance with the Arbitration Act at the request of either Party upon written notice to that effect to the other Party and be finally determined by arbitration;

(b) the place of arbitration shall be New Delhi;

(c) the language of the arbitration shall be English;

(d) any Dispute submitted to arbitration shall be considered by three (3) arbitrators, such that –

(i) Two (2) arbitrators shall be nominated - one (1) each by OPGC and GRIDCO;

(ii) If within thirty (30) days of the receipt of a Party's notification of the appointment of an arbitrator, the other Party has not notified the first Party of the arbitrator it has appointed, the first Party may apply for the appointment of the second arbitrator in accordance with the Arbitration Act;

(iii) The third arbitrator will be nominated by the two (2) existing arbitrators, or failing such nomination within thirty (30) days of the appointment of the second arbitrator, shall be appointed in accordance with the Arbitration Act.

The Parties shall endeavour to appoint reputed individuals who are well versed with the Indian electricity sector as arbitrators.

17.3.4 Parties undertake to carry out any decision or award of the arbitrator relating to Dispute without delay. Awards relating to the Dispute shall be final and binding on the Parties to such Dispute as from the date they are made. The arbitrators shall give a reasoned decision or award in writing. The arbitrators shall have power to grant interim relief and pass an interim award.

17.4 Parties to Perform Obligations

Notwithstanding the existence of any Dispute and difference referred for adjudication under Article 17.2 or 17.3, and save as the Appropriate Commission or the Arbitral Tribunal may otherwise direct by a final or interim order, the Parties shall continue to perform their respective obligations (which are not in dispute) under this Agreement.

ARTICLE 18: MISCELLANEOUS PROVISIONS

18.1 *Effectiveness of the Agreement*

Notwithstanding anything herein to the contrary, the Effective Date will not occur, before the internal approval of the terms of this PPA 2 by respective Boards of OPGC and GRIDCO have been accorded, and informed to the other Party.

18.2 *Amendment*

This Agreement may only be amended, modified, or supplemented by a written agreement between the Parties and duly approved by the Appropriate Commission, where necessary.

18.3 *No Third Party Beneficiaries*

This Agreement is solely for the benefit of the Parties and their respective successors and assigns and shall not be construed as creating any duty, standard of care or any liability to, any person not a party to this Agreement.

18.4 *No Waiver*

A valid waiver by a Party shall be in writing and executed by an authorized representative of that Party. Neither the failure by any Party to insist on the performance of the terms, conditions, and provisions of this Agreement, nor time or other indulgence granted by one Party to the other Party, shall act as a waiver of such breach or acceptance of any variation or the relinquishment of any such right or any other right under this Agreement, which shall remain in full force and effect.

18.5 *Entirety*

18.5.1 This Agreement is intended by the Parties as the final expression of their agreement and is also as a complete and exclusive statement of the terms of their agreement on the subject matter contained herein.

18.5.2 Except as provided in this Agreement, all prior written or oral understandings, offers or other communications of every kind pertaining to this Agreement, or the sale or purchase of Electrical Output and Contracted Capacity under this Agreement to GRIDCO by OPGC shall stand superseded and abrogated.

18.6 *Confidentiality*

The Parties undertake to hold in confidence this Agreement and not to disclose the terms and conditions of the transaction contemplated hereby to third parties, except -

(a) to their professional advisors;

(b) to their officers, contractors, employees, agents or representatives, financiers, shareholders and lenders, who need to have access to such information for the proper performance of their activities in the normal due course; or

(c) disclosures required under Law.

without the prior written consent of the other Party.

18.7 *Affirmation*

OPGC and GRIDCO, each affirm that -

(a) neither it nor its respective directors, employees, or agents has paid or undertaken to pay or shall in the future pay, any unlawful commission, bribe, pay-off or kick-back; and

(b) it has not in any other manner paid any sums, whether in Indian currency or foreign currency and whether in India or abroad to the other Party to procure this Agreement, and OPGC and GRIDCO hereby undertake not to engage in any similar acts during the Term of Agreement.

18.8 *Severability*

The invalidity or enforceability, for any reason, of any part of this Agreement shall not prejudice or affect the validity or enforceability of the remainder of this Agreement, unless the part held invalid or unenforceable is fundamental to this Agreement.

18.9 *No Partnership*

None of the provisions of this Agreement shall constitute a partnership or agency or any such similar relationship between the Parties.

18.10 *Counterparts*

This Agreement may be executed in one or more counterparts, each of which shall be deemed an original and all of which collectively shall be deemed one and the same instrument.

18.11 *Notices*

All notices to be given under this Agreement shall be in writing and in the English Language.

All notices must be delivered personally, by registered or certified mail post or any method duly acknowledged or facsimile to the addresses below –

OPGC:	Head of Commercial 7th Floor, Fortune Towers Chandrasekharpur Bhubaneswar-751023 Tel: 0674-2303765/66 Fax: 0674-2303755
GRIDCO:	Sr. General Manager (PP) GRIDCO Janpath Bhubaneswar Tel: 0674-2542840 Fax: 0674-2547180

Alem Mallik

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

All notices or communications given by facsimile shall be confirmed by sending a copy of the same via post in an envelope properly addressed to the appropriate Party for delivery by registered post. All notices shall be deemed validly delivered upon receipt evidenced by an acknowledgement of the recipient, unless the Party delivering the notice can prove in case of delivery by hand or through the registered post that the recipient refused to acknowledge the receipt of the notice despite efforts of the post authorities.

Any Party may by notice of at least fifteen (15) days to the other Party change the address and/ or addresses to which such notices and communications to it are to be delivered or mailed.

18.12 *Language*

The language of this Agreement and all written communications between the Parties, relating to this Agreement, shall be in English language.

18.13 *Nomination Restriction*

Notwithstanding anything contained to the contrary in this Agreement, wherever a reference is made to the right of GRIDCO to nominate a third party to receive benefits under this Agreement, such third party shall have adequate financial standing to meet the obligations under this Agreement, as reasonably determined by OPGC.

18.14 *Commercial Acts*

GRIDCO and OPGC unconditionally and irrevocably agree that the execution, delivery and performance by each of them of this Agreement and those agreements included in the collateral arrangement to which it is a Party, constitute commercial acts.

18.15 *Restriction of Shareholders/Owners Liability*

The Parties expressly agree and acknowledge that none of the shareholders of the Parties shall be liable to the other Party for any of the contractual obligations of the concerned Party under this Agreement. Further, the financial liabilities of the shareholder(s) of each Party to this Agreement, in such Party, shall be restricted to the extent provided in Section 426 of the (Indian) Companies Act, 1956.

The provisions of this Article shall supersede any other prior agreement or understanding, whether oral or written, that may be existing between GRIDCO, OPGC, shareholders/ owners of OPGC, shareholders/ owners of GRIDCO before the date of this Agreement, regarding the subject matter of this Agreement.

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18.16 *No Consequential or Indirect Losses*

The liability of the Parties shall be limited to that explicitly provided in this Agreement. To the extent permitted by applicable law, neither Party shall assert, and each Party hereto waives, any claim against the other Party, on any theory of liability, for special, indirect, consequential or punitive damages (as opposed to direct or actual damages) arising out of, in connection with, or as result of, this Agreement or any agreement, instrument or transaction contemplated by this Agreement.

IN WITNESS WHEREOF the Parties have executed these presents through their authorized representatives at Bhubaneswar.

For and on behalf of [GRIDCO]

Alem Mallik

Signature with seal

Director (Commercial)
GRIDCO Ltd.
Bhubaneswar

GRID CORPORATION OF ORISSA LIMITED BHUBANESWAR

Witness:

1.

2.

For and on behalf of [OPGC]

Signature with seal

Managing Director
Orissa Power Generation Corporation Ltd.
Bhubaneswar

Orissa Power Generation Corporation Ltd. BBSR.

Witness:

1. Manoranjan Mishra

2.

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

SCHEDULE 1: PROJECT DESCRIPTION AND FUNCTIONAL SPECIFICATIONS

1.1 **SITE**

Map highlighting the Delivery Point will be annexed here on the finalisation of the Construction Contracts.

1.2 **PROJECT DESCRIPTION**

Project means the Power Station and Captive Coal Mine(s) undertaken for design, financing, engineering, procurement, construction, operation, maintenance, repair, refurbishment, development and insurance by OPGC

1.3 **INTERCONNECTIVITY DETAILS WITH TRANSMISSION FACILITY**

S No.	Description	Unit	Particulars
1.3.1	Grid Conditions at Delivery Point		
(i)	Voltage: Nominal	kV	400
	Variation	%	10
(ii)	Frequency: Nominal	Hz.	50
	Variation	%	-5 to + 3
(iii)	Combined Voltage and Frequency variation for Contracted Capacity	%	+/- 10
(iv)	Power Factor: Nominal		0.85 lag
	Variation		0.85 lag to 0.90 lead
(v)	Basic Impulse Level (Peak)	Kv	1050
1.3.2	Fault Levels:		
(i)	3 Phase Maximum	kA	40
(ii)	Clearance time Maximum	ms	1000
1.3.3	Ramp Rates		

All Units of the Power Station shall be capable of increasing or decreasing their output (generation level) by not less than one percent (1%) per minute. Such capability shall be demonstrated during the Unit load of more than fifty percent (50%).

For the avoidance of doubt, it is clarified that the parameters provided in clause 1.3 above are indicative only, and is subject to finalization (and any change, if required) pursuant to the conclusion of Construction Contracts. In any event, OPGC will determine and finally confirm the said parameters upon the conclusion of the Construction Contracts, even if there are no changes in the said parameters.

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SCHEDULE 1A: PROJECT CONSENTS

(a) Clearance of National Airport Authority/ Ministry of Defence for chimney height.

(b) Grant of Coal Linkage for Unit-3 and Unit-4 by the Standing Linkage Committee (SLC) of the Ministry of Coal and execution FSA.

(c) Environment clearance from Ministry of Environment and Forests being granted to the Power Station and Consent to Establish by the State Pollution Control Board.

(d) Electricity Connection for construction being granted to the Power Station.

(e) Possession of all private, Govt. and forest land for Captive Coal Mine by OPGC.

(f) Forest clearance from Ministry of Environment and Forests ("**MoEF**") for all forest land for Captive Coal Mine.

(g) Environmental approval from Ministry of Environment and Forests for the development of the Captive Coal Mine and MGR and Consent to establish by the State Pollution Control Board.

(h) Approval of Mine Lease.

(i) Water allocation being granted by the State Govt. for Captive Coal Mine.

(j) Construction & operation power being made available by distribution licensee for Captive Coal Mine.

(k) Possession of all private, Govt. and forest land for MGR by OPGC.

(l) Forest clearance from Ministry of Environment and Forests ("**MoEF**") for all forest land for MGR/ rail linkage lands.

(m) Railway clearance for rail over bridge construction

(n) National Highway Authority of India (NHAI) clearance for construction of road over bridge.

(o) Rail Transportation Clearance from Railways

(p) Any other Consent as may be required under Law.

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1.1 **Performance Test**

(i) (a) The Performance Test shall be conducted under any and all ambient conditions (temperature, humidity etc.) and Fuel quality as per the applicable test code.

(b) The Performance Test shall be deemed to have demonstrated the Installed Capacity of the Unit under all designed conditions, as per the applicable test codes.

(c) OPGC shall perform in respect of each Unit a Performance Test, which such Unit shall be deemed to have passed if the maximum continuous output at the generator terminals, guaranteed by the manufacturer at rated parameters, has been established.

(ii) For the purposes of any Performance Test pursuant to this sub-article 1.1, the electrical system limits to be achieved shall be as follows -

(a) Voltage

The Unit must operate within the voltage levels described in the Functional Specification for the duration of the Performance Test. If, during the Performance Test, voltage tests cannot be performed due to Grid System, data supplied from tests of the generator step-up transformers and generators supplied by the manufacturers shall be used to establish the ability of the Unit to operate within the specified voltage limits.

(b) Grid System Frequency

The Unit shall operate within the Grid System frequency levels described in the Functional Specification for the duration of the Performance Test.

(c) Power Factor

The Unit shall operate within the power factor range described in the Functional Specification for the duration of the Performance Test. If, during the Performance Test, power factor tests cannot be performed due to the Grid System, data supplied from tests of the generators and the generator step-up transformers supplied by the manufacturers, shall be used to establish the ability of the Unit to operate within the specified power factor range.

(d) Fuel Quality and Cooling Water Temperature

The Unit must operate to its Installed Capacity with Fuel quality and water temperature available at the time of testing and no adjustment shall be allowed for any variation in these parameters.

(iii) As a part of the Performance Test, OPGC shall demonstrate that the Unit meets the Functional Specifications for ramping rate as mentioned in Schedule 1. For this purpose, representative samples of ramp rates shall be taken, by ramping up or down the gross turbine load while maintaining the required temperatures and temperature differences associated with each ramp rate within the turbine while maintaining all other operational parameters within equipment limits;

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(iv) Further, as a part of the Performance Test, the Unit shall be tested for compliance with parameters of super- critical technology; and

(v) Testing and measurement procedures applied during Performance Test shall be in accordance with the codes, practices or procedures as generally/normally applied for the Performance Tests.

Table - A – Reference Site Conditions

The Reference Site Conditions corresponding to the Installed Capacity are as under and corrections are allowed if actual conditions differ from those set forth below:

Parameter	Unit	Value
Ambient air dry bulb temperature	Degree Celsius	[*]
Ambient air relative humidity	%	[*]
Barometric pressure	bar	[*]
Interconnection Voltage	kV	[*]
Electrical output Power Factor (at generator terminal)		[*]
Interconnection Frequency	Hz	[*]
Coal Quality	As given in Table YY	[*]

TABLE - B - ANALYSIS OF COAL

S. No.	Characteristics	Unit	Design Coal	Worst Coal	Best Coal
1.	**Proximate Analysis (As received basis) :-**				
	Total Moisture	%	13.1	13.7	12.4
	Ash	%	41.0	43.7	38.1
	Volatile Matter	%	20.2	22.2	17.7
	Fixed Carbon	%	25.8	23.7	28.2
2.	**Ultimate Analysis (As received basis) :-**				
	Carbon	%	37.87	33.74	42.52
	Hydrogen	%	1.74	2.09	1.09
	Nitrogen	%	0.92	0.45	1.84
	Oxygen	%	5.19	5.92	3.96

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	Sulphur	%	0.18	0.40	0.09
	Carbonates	%	-	-	-
	Phosphorous	%	-	-	-
	Total Moisture	%	13.1	13.7	12.4
	Ash	%	41.0	43.7	38.1
	Gross Calorific Value	Kcal/Kg	3200	3000	3400
	Hard Grove Index		62.6	70.0	52.0
	YGP Index	mg/kg	-	-	-

For the avoidance of doubt, it is clarified that the above parameters are indicative only, and is subject to finalization (and any change, if required) pursuant to the conclusion of Construction Contracts. In any event, OPGC will determine and finally confirm the said parameters upon the conclusion of the Construction Contracts, even if there are no changes in the said parameters.

Alan Mallis

GENERATION CORPORATION LTD. BHUBANESWAR

SCHEDULE 3: POWER SHARE TABLE

GRIDCO's entitlement to the power to be generated from the Power Station as delineated in Article 7.2.1 is further explained in the following table.

	Scenarios	Installed capacity (MW)	Availability of the Power Station (%)	Total Generation of the Power Station equivalent to Availability (MW)	GRIDCO's share in terms of Availability (MW)	OPGC's share in terms of Availability (MW)
A.	On Commissioning of Unit-3 or Unit-4 (whichever occurs earlier) and six (6) Months thereafter till commissioning of the subsequent Unit.	660	100	660	330	330
			80	528	264	264
B	Commissioning of Unit-3 or Unit-4 (whichever occurs later) and delayed beyond six (6) Months from Commissioning of the earlier Unit.	660	100	660	450	210
			80	528	360 (528x450/660)	168 (528x210/660)
C	Both Unit-3 and Unit-4 Commissioned and operational.	1320	100	1320	660	660
			75	990	495	495
			60	792	396	396
D	Both Unit-3 and Unit-4 Commissioned but one unit operational and the other under outage.	660	100	660	330	330
			80	528	264	264

GRIDCO's entitlement shall be the Electrical Output corresponding to above "generation equivalent to Availability" (net of AUX).

1. Tariff basis

Tariff under this Agreement shall be based on tariff norms and parameters of the Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2009 ("**Tariff Regulations**"). Accordingly the Tariff norms and parameters stated hereunder have been included in this schedule based on the tariff norms and parameters outlined in the Tariff Regulations.

As and when any amendment to the Tariff norms and parameters are made in the Tariff Regulations, the said norms and parameters in this Schedule shall be applied to reflect the said amendments from time to time.

While the tariff provisions given herein are considered for the Power Station as a whole, while computing tariff for sale to GRIDCO, the provisions shall be considered in proportion to the 50% Contracted Capacity for GRIDCO.

2. Definitions

Capitalized terms used in this Schedule which are not defined herein below shall have the same meaning as ascribed to it in the PPA 2 -

"Auxiliary Energy Consumption" or "AUX" in relation to a period, means the quantum of energy consumed by auxiliary equipment of the Power Station, and transformer losses within the Power Station, expressed as a percentage of the sum of gross energy generated at the generator terminals of both the Units of the Power Station;

"Capacity Charge(s)" shall mean the charges to be calculated in accordance with the Clause 5 of this Schedule.

"Capital Cost" for the Power Station shall include -

(a) the Expenditure Incurred or projected to be incurred, including interest during Construction Period and financing charges, any gain or loss on account of foreign exchange risk variation during Construction Period on the loan (i) being equal to 70% of the funds deployed, in the event of the actual equity being in excess of 30% of the funds deployed, by treating the excess equity as normative loan, or (ii) being equal to the actual amount of loan in the event of the actual equity less than 30% of the funds deployed, up to the Commercial Operation Date of the Power Station as admitted by the Appropriate Commission after prudence check.

(b) capitalized initial spares at the rate of two point five percent (2.5%) of the capital cost.

(c) Additional capital Expenditure Incurred or projected to be incurred, on the following counts within the original scope of work, after the Commercial Operation Date and

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ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

up to the Cut-Off Date including -

(i) undischarged liabilities;

(ii) works deferred for execution;

(iii) procurement of initial capital spares within the original scope of work;

(iv) liabilities to meet award of arbitration or for compliance of the order or decree of a court; and

(v) Change in Law.

Provided that the details of works included in the original scope of work along with estimates of expenditure, undischarged liabilities and the works deferred for execution shall be submitted along with the application for determination of Tariff.

(d) The capital Expenditure Incurred on the following counts after the Cut-Off Date may, in its discretion, be admitted by the Commission, subject to prudence check -

(i) liabilities to meet award of arbitration or for compliance of the order or decree of a court;

(ii) Change in Law;

(iii) deferred works relating to ash pond or ash handling system or ash utilization in the original scope of work:

(e) Inclusion of Rupees Seventy Five Crore (Rs. 750,000,000) incurred during construction of Unit-1 and Unit-2 of OPGC and in terms with Clause No. 9 of the Tripartite Agreement; and

(f) as reduced by proceeds from sale of Infirm Power-

Supply of Infirm Power shall be accounted as Unscheduled Interchange and paid for from the regional or State UI pool account at the applicable frequency-linked UI rate.

Provided that any revenue earned from sale of Infirm Power after accounting for the Fuel expenses shall be applied for reduction in Capital Cost.

For the purpose of determination of Tariff, the Capital Cost of the Unit-3 until the Unit-4 COD is achieved shall be considered on the basis of the capital cost broken up into stages and distinct units or blocks forming part of the Project. Provided that where break-up of the capital cost of the project for different stages or units or blocks is not available, the common

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facilities shall be apportioned on the basis of the installed capacity of the units. The applicable capital structure shall be as at Annexure B to Schedule 4.

"Capital Structure Schedule"	means the sources of finance used to finance the Capital Cost as provided in the Financing Agreements and as reproduced at Annexure B to this Schedule;
"Cut-off Date"	means March 31 of the year closing after two (2) years of the Contract Year in which Commercial Operation Date of the Power Station occurs, and in case Commercial Operation Date of the Power Station occurs in the last quarter of a financial year, the Cut-off Date shall be March 31 of the year closing three (3) years after the financial year in which Commercial Operation Date of Power Station occurs;
"Debt Equity Ratio"	for the Power Station shall mean funding of debt and equity in the ratio as per the financing agreements, which shall not fall below 70:30. If the equity actually deployed is more than 30% of the Capital Cost, equity in excess of 30% shall be treated as normative loan. Provided that where equity actually deployed is less than 30% of the Capital Cost, the actual equity shall be considered for determination of tariff. Equity invested in foreign currency shall be designated in Indian Rupees on the date of each investment. The premium, if any raised, while issuing share capital and investment of internal resources created out of its free reserve, for the funding of the Power Station, shall be reckoned as paid-up capital for the purpose of computing return on equity, provided such premium amount and internal resources are actually utilized for meeting the capital expenditure of the Power Station.
"Declared Capacity"	means, the capability to deliver ex-bus electricity in MW declared by OPGC in relation to any time-block of the day or whole of the day, duly taking into account the availability of Fuel or water, and subject to further qualification in the relevant Tariff Regulation;
"Energy Charge(s)"	shall have the meaning as ascribed to it in Clause 6(a) of this Schedule;
"Expenditure Incurred"	means the fund, whether the equity or debt or both, actually deployed and paid in cash or cash equivalent, for creation or acquisition of a useful asset and does not include commitments or liabilities for which no payment has been released;
"Gross Calorific Value"	means the heat produced in kCal by complete combustion of one (1) kilogram of Coal or one (1) litre of Fuel Oil;
"Gross Station Heat Rate"	means the heat energy input in kCal required to generate one (1) kWh of electrical energy at generator terminals;

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"Normative Auxiliary Consumption" in relation to a period in case of a Unit means the quantum of energy consumed by auxiliary equipment of the Unit, and transformer losses within the generating station, and expressed as a percentage of the sum of gross energy generated at the generator terminals of all the Units as notified by the Appropriate Commission from time to time;

"Operation and Maintenance Expenses" means the Expenditure Incurred on operation and maintenance of the Power Station, or part thereof, and includes the expenditure on manpower, repairs, spares, consumables, insurance and overheads;

"Plant Availability Factor" in relation to the Power Station for any period means the average of the daily declared capacities for all the days during that period expressed as a percentage of the Installed Capacity in MW reduced by the normative Auxiliary Energy Consumption.

3. **Annual Tariff**

The Tariff for supply of electricity shall comprise of two (2) parts, namely, firstly, Capacity Charge for recovery of annual fixed cost, and secondly, Energy Charge for recovery of Fuel. The annual fixed cost shall be computed based on the applicable Contracted Capacity as per Annexure B to Schedule 4. The Energy Charge for recovery of Coal cost shall be computed based on the Coal procured for the Power Station capacity as per Annexure C to Schedule 4.

4. **Annual fixed cost**

The annual fixed cost (AFC) shall consist of the following components and shall be proportionate to the Contracted Capacity-

(a) Return on equity

(i) Return on equity shall be computed in rupee terms, on the equity base determined for the Power Station.

(ii) Return on equity shall be computed on pre-Tax basis at the base rate of fifteen point five percent (15.5%) to be grossed up as per applicable Tax rate for the applicable year.

Provided that an additional return of zero point five percent (0.5%) shall be allowed if the Power Station is completed within specified number of Months, as per Construction Contract and subject to ceiling norms as per CERC Regulations.

Provided further that the additional return of zero point five percent (0.5%) shall not be admissible if the Power Station is not completed within the timeline specified above for reasons whatsoever.

(iii) The rate of return on equity shall be computed by grossing up the base rate with the normal Tax rate for the year in which the Commercial Operation Date of Power Station occurs.

Provided that return on equity with respect to the actual Tax rate applicable in line with the provisions of the relevant Finance Acts of the Contract Year

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shall be trued up separately for each Contract Year along with the Tariff computation for next Contract Year.

(iv) Rate of return on equity shall be rounded off to three (3) decimal points and be computed as per the formula given below:

Rate of pre-Tax return on equity = Base rate / (1-t).

Where (t) is the applicable Tax rate in accordance with clause (iii) above.

(b) Interest on loan capital

(i) The loans arrived at as per the Debt Equity Ratio shall be considered as gross normative loan for calculation of interest on loan.

(ii) The normative loan outstanding for a Contract Year shall be worked out by deducting the cumulative repayment from the gross normative loan.

(iii) The repayment for a Contract Year shall be deemed to be equal to the depreciation allowed for that Contract Year.

(iv) Notwithstanding any moratorium period availed by OPGC, the repayment of loan shall be considered from the first year in which the Commercial Operation Date of the Power Station occurs and shall be equal to the annual depreciation allowed.

(v) The rate of interest shall be the weighted average rate of interest calculated on the basis of the actual loan portfolio at the beginning of each year applicable to the Power Station.

Provided that if there is no actual loan for a particular year but normative loan is still outstanding, the last available weighted average rate of interest shall be considered.

(vi) The interest on loan shall be calculated on the normative average loan of the year by applying the weighted average rate of interest.

(c) Depreciation

(i) The value base for the purpose of depreciation shall be the Capital Cost of the asset as admitted by the CERC;

(ii) The salvage value of the asset shall be considered as ten percent (10%) and depreciation shall be allowed up to maximum of ninety percent (90%) of the Capital Cost of the asset;

(iii) Land other than the land held under lease, shall not be a depreciable asset and its cost shall be excluded from the Capital Cost while computing depreciable value of the asset;

(iv) Depreciation shall be calculated annually based on straight line method and at rates specified in Annexure A to Schedule 4.

Provided that, the remaining depreciable value as on March 31 of the year closing after a period of twelve (12) years from date of commercial operation shall be spread over the balance useful life of the assets;

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(v) Depreciation shall be chargeable from the first year of Commercial Operation. In case of commercial operation of the asset for part of the year, depreciation shall be charged on pro rata basis.

(d) Interest on working capital

The working capital base shall cover the following -

(i) Cost of Coal for one and a half (1½) Months for supplies from pit-head locations and two (2) Months for supplies from non-pit-head locations, for generation corresponding to the Normative Availability Factor;

(ii) Cost of secondary Fuel Oil for two (2) Months for generation corresponding to the Normative Availability Factor, and in case of use of more than one secondary Fuel Oil, cost of Fuel Oil stock for the main secondary Fuel Oil. The cost of Fuel shall be based on the landed cost incurred (taking into account normative transit and handling losses) and Gross Calorific Value of the Fuel as per actual for the three (3) Months preceding the first Month for which Tariff is to be determined and no Fuel price escalation shall be provided during the Contract Year;

(iii) Maintenance of spares at the rate of twenty percent (20%) of Operation and Maintenance Expenses;

(iv) Receivables equivalent to two (2) Months of Capacity Charges and Energy Charges for sale of electricity calculated on the Normative Availability Factor, and

(v) Operation and Maintenance Expenses for one (1) Month.

The interest on working capital base shall be computed on following basis -

(a) rate of interest on working capital shall be on normative basis and shall be equal to the short-term prime lending rate of State Bank of India as on April 1 of the year of the then applicable Tariff Regulations or the April 1 of the year in which the Power Station or a Unit thereof, as the case may be, is declared under commercial operation, whichever is later.

(b) Interest on working capital shall be payable on normative basis notwithstanding that OPGC has not taken loan for working capital from any outside agency.

(e) Operation and Maintenance Expenses

Normative Operation and Maintenance Expenses shall be Rupees in lakh/MW as would be applicable for 1st year of Commercial Operation as per the then applicable Tariff Regulations and the same shall be multiplied by a factor of zero point nine (0.9).

A separate compensation allowance Unit-wise shall be payable to meet expenses on new assets of capital nature including in the nature of minor assets, in the following manner from the year following the year of completion of ten (10), fifteen (15) or twenty (20) years of useful life.

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	(Rs. lakh/MW/year)
0 – 10	Nil
11 – 15	0.15
16 – 20	0.35
21 – 25	0.65

(f) Secondary Fuel Oil expenses

(i) Expenses on secondary Fuel Oil in Rupees shall be computed corresponding to normative secondary Fuel Oil consumption (SFC) of 1.0 ml/kWh, in accordance with the following formula -

= SFC x LPSFi x NAPAF x 24 x NDY x IC x 10

Where,

SFC –	Normative Specific Fuel Oil consumption in ml/kWh
LPSFi –	Weighted Average Landed Price of Secondary Fuel in Rs./ml considered initially
NAPAF –	Normative Availability Factor in percentage
NDY –	Number of days in a year
IC -	Installed Capacity in MW.

(ii) Initially, the landed cost incurred on secondary Fuel Oil shall be taken based on actual of the weighted average price of the three (3) preceding Months and in the absence of landed costs for the three (3) preceding Months, latest procurement price, before the start of the year.

(iii) The secondary Fuel Oil expenses shall be subject to Fuel price adjustment at the end of the each year of Contract Year as per following formula -

SFC x NAPAF x 24 x NDY x IC x 10 x (LPSFy – LPSFi)

Where,

LPSFy =	The weighted average landed price of secondary Fuel Oil for the year in Rs. /ml

5. Computation of Capacity / Fixed Charge and Energy Charge

The fixed cost of the Power Station shall be computed on annual basis, based on norms specified under this Schedule, and recovered on monthly basis under the Capacity Charges.

The Capacity Charge (inclusive of incentive) payable for a calendar Month shall be calculated in accordance with the following formulae -

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(i) In case the Power Station is in commercial operation for less than ten (10) years on April 1 of the financial year

AFC x (NDM / NDY) x (0.5 + 0.5 x PAFM / NAPAF) (in Rupees);

Provided that in case the Plant Availability Factor achieved during a financial year (PAFY) is less than seventy percent (70%), the total Capacity Charge for the year shall be restricted to -

AFC x (0.5 + 35 / NAPAF) x (PAFY / 70) (in Rupees).

(ii) In case the Power Station is in commercial operation for ten (10) years or more on April 1 of the year -

AFC x (NDM / NDY) x (PAFM / NAPAF) (in Rupees).

Where,

AFC =	Annual fixed cost specified for the year, in Rupees.
NAPAF =	Normative Availability Factor in percentage
NDM =	Number of days in the Month
NDY =	Number of days in the year
PAFM =	Plant Availability Factor achieved during the Month, in percent:
PAFY =	Plant Availability Factor achieved during the year, in percent

(iii) The PAFM and PAFY shall be computed in accordance with the following formula -

$$\text{PAFM or PAFY} = 10000 \times \sum_{i=1}^{N} DCi / \{ N \times IC \times (100 - AUX) \} \%$$

Where,

AUX =	Normative Auxiliary Energy Consumption in percentage.
DCi =	Average Declared Capacity (in ex-bus MW), for the i[th] day of the period i.e. the Month or the year as the case may be, as certified by the concerned Load Dispatch Centre after the day is over. (regulation 21(4) of CERC may be examined with respect to DCi)
IC =	Installed Capacity (in MW) of the generating station
N =	Number of days during the period i.e. the Month or the year as the case may be.

(iv) In case of fuel shortage during normal operation, OPGC may propose to deliver a higher MW during peak load hours by saving fuel during off peak hours. SLDC/RLDC may then specify a pragmatic day ahead of schedule for OPGC to optimally utilize its MW and energy capability in consultation with GRIDCO. The average Declared Capacity in such an event shall be taken to be equal to the maximum peak hour ex-power plant schedule specified by SLDC/RLDC for that day.

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6. **Energy Charge**

(a) The energy charge ("**Energy Charge**") shall cover the primary Fuel cost, and shall be payable for the total energy scheduled to be supplied to GRIDCO during the calendar Month on ex-bus basis, at the energy charge rate of the Month (with Fuel price adjustment). Total Energy Charge payable to OPGC for a Month shall be -

(Energy charge rate in Rs./kWh) x {Scheduled Energy (ex-bus) for the Month in kWh.}

Energy charge rate (ECR) in Rupees per kWh on ex-power plant basis shall be determined in accordance with the following formulae:

ECR = {(GHR – SFC x CVSF) x LPPF / CVPF} x 100 / (100 – AUX)

Where,

AUX = Normative Auxiliary Energy Consumption in percentage.

CVPF = Gross Calorific Value of primary Fuel as fired, in kCal per kg.

CVSF = Calorific value of secondary Fuel, in kCal per ml.

ECR = Energy charge rate, in Rupees per kWh sent out.

GHR = Gross Station Heat Rate, in kCal per kWh.

LPPF = Weighted average landed price of primary Fuel, in Rupees per kg during the Month.

SFC = Specific Fuel Oil consumption, in ml per kWh.

(b) Fuel cost/ price

(i) The Power Station shall source Coal from various sources in order to ensure optimum operation of the plant at prices placed and agreed by GRIDCO, which are detailed as follows,

(ii) The Fuel price shall be weighted average of the following -

(a) Landed -fuel price of Coal received at MGR from the Captive Coal Mine;

(b) Landed -fuel price of Coal received from the subsidiary of Coal India Limited, or other government owned sources, pursuant to Coal Linkage and Fuel Supply Agreement entered there under.

(c) Landed -fuel price of Coal purchased from the open market through long/ medium/ short term or spot contracts such as E'auction, forward contracts including imported coal etc.

(iii) Fuel price of Coal received from the Captive Coal Mine -

The Fuel price of Coal received from the Captive Coal Mine shall be the sum of -

(a) Amount paid to the Coal Mine Operator under a lump sum OR Per ton OR cost plus contract as the case may be.

(b) Washery charges payable to the washing division.

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(c) Fixed charge recovery on the capital cost (including replacement costs) incurred on the Captive Coal Mine by OPGC consisting of following which is not otherwise included partly or fully in (a) and (b) above.

i) Return on equity at sixteen percent (16%) on XX% of such capital cost;

ii) Depreciation at the rate of XX% on capital cost with ninety-five percent (95%) of such capital cost being depreciable asset provided that assets specific to mining activities which has a lower life as compared to the Companies Act shall be depreciated based on its estimated life as per Prudent Utility Practices;

iii) Interest on debt on XX% of such capital cost as per financing plan;

iv) Operation and maintenance expenses at two point five percent (X%) of such capital cost escalated @ XX% every year

v) Interest on working capital at XX rate or a lump sum amount of [•];

vi) Other adjustments such as foreign exchange, interest rates etc.;

Note: Values not mentioned in (i) to (vi) above are to be filled suitably and in due course, based on the terms of the contract executed with the Captive Coal Mine Operator and availability of applicable regulations /guidelines / best practices, which can be adopted at a later date, for Tariff fixation.

(d) Ash back filling charges;

(e) Amortized portion of further expenses on mine closure;

(f) Statutory levies if any, such as royalty, taxes etc.; and

The per tonne rate of recovery of fixed charges in respect of coal supply from the Captive Coal Mine shall be computed at a 85% capacity utilisation.

In the event of a Ministry of Coal / regulatory guideline coming in to force for pricing of Coal from Captive Coal Mine allotted to power companies such regulated price formulae shall be substituted here and be applicable from the notified date.

(iv) Fuel price of Coal received from the subsidiary of Coal India Limited, or other government sources, pursuant to Coal Linkage or otherwise shall be as follows -

The landed cost shall include price of Coal corresponding to the grade and quality of Coal inclusive of royalty, Taxes, and duties as applicable, transportation cost by rail / road or any other means.

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(v) Fuel price of Coal purchased from the open market through long / medium / short term or spot contracts such as E'auction, forward contracts including imported coal shall be as follows -

The landed cost of Coal for the Month shall include price of Coal corresponding to the grade and quality of Coal inclusive of import duty, royalty, Taxes, and duties as applicable, transportation cost by rail / road or any other means.

(vi) For the purpose of computation of Energy Charge, the Coal price in the case of (iii), (iv) and (v) shall be arrived at after considering normative transit and handling losses as percentage of the quantity of Coal dispatched by the Coal supply company during the Month as given below -

Pithead source of supply : zero point two percent (0.2%)

Non-pithead source of supply : zero point eight percent (0.8%)

(vii) Fuel price adjustment shall be done twice a year in order to account for price variation of Coal from any of the above mentioned sources.

(c) In the event of GRIDCO not availing any part of the Available Capacity the Capacity Charge payable by GRIDCO shall also include (i) any take or pay amounts under any applicable Fuel Supply Agreement, and (ii) the fixed charge recovery at clause 6(b)(i) of the Schedule that would have been received if such Available Capacity would have been accepted by GRIDCO.

7. **Others**

(a) Tax on income

Tax on the income streams of OPGC shall not be recovered from GRIDCO, other than as provided by the Appropriate Commission from time to time.

(b) Other taxes / duties / levies / cess

Statutory taxes, levies, duties, royalty, cess or any other kind of impositions(s) imposed/ charged by any Government (central /state) and / or any other local bodies / authorities on generation of electricity including auxiliary consumption or any other type of consumption including water, environment protection, sale or on supply of power/ electricity and/ or in respect of any of its installations associated with the Power Station payable by OPGC to the authorities concerned shall be computed as per the provisions of the prevailing Tariff norms of the Tariff Regulations and shall be borne and additionally paid by GRIDCO on a proportionate basis with other beneficiary(ies) in a proportionate manner. Provided however that any charge in respect of the energy sent outside the State of Orissa out of capacity not allocated to GRIDCO, shall not be charged to GRIDCO in any manner.

(c) Foreign exchange rate variation

(i) OPGC may hedge foreign exchange exposure in respect of the interest on foreign currency loan and repayment of foreign loan acquired for the Power Station, in part or full in the discretion of OPGC.

(ii) OPGC shall recover the cost of hedging of foreign exchange rate variation corresponding to the normative foreign debt, in the relevant year on year-to-year basis as expense in the period in which it arises and extra rupee

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liability corresponding to such foreign exchange rate variation shall not be allowed against the hedged foreign debt.

(iii) To the extent OPGC is not able to hedge the foreign exchange exposure, the extra rupee liability towards interest payment and loan repayment corresponding to the normative foreign currency loan in the relevant year shall be permissible provided it is not attributable to OPGC or its suppliers or contractors.

(iv) OPGC shall recover the cost of hedging and foreign exchange rate variation on year-to-year basis as income or expense in the period in which it arises.

(v) Recovery of cost of hedging and foreign exchange rate variation shall be made directly by OPGC, from GRIDCO on a proportionate basis.

(d) Sharing of CDM benefits

The proceeds after adjusting all expenses including, payment to third party advisers/ consultants for generating/ developing such offsets/ credits plus return on such costs at SBI PLR of carbon credit from approved CDM project shall be shared in the following manner, namely-

(i) One hundred percent (100%) of the gross proceeds on account of CDM to be retained by OPGC in the first year after the Commercial Operation Date of the Power Station;

(ii) in the second year, the share of GRIDCO shall be proportionate share of total ten percent (10%) which shall be progressively increased by ten percent (10%) every year till it reaches fifty percent (50%) at the Power Station level, where after the proceeds shall be shared in equal proportion, by OPGC and GRIDCO.

8. Norms of operation for the purpose of computation of Tariff

(a) Recovery of Capacity Charge, Energy Charge and incentive by OPGC shall be based on the operational norms specified herein;

(b) The operation norms are subject to finalization based on the final Performance Test of individual Unit or all Units of the Power Station, during Commissioning and operation thereafter;

(c) The savings on account of secondary Fuel Oil consumption in relation to norms shall be shared with GRIDCO in the ratio of 50:50, in accordance with the following formula at the end of the year -

(SFC x NAPAF x 24 x NDY x IC x 10 -ACsfoy) x LPSFy x 0.5

Where,

ACsfoy = Actual consumption of secondary Fuel Oil during the year in ml

(d) Standard operating norms

(i) Gross Station Heat Rate

= 1.065 X Max Design Unit Heat Rate (kCal/kWh)

Where the design heat rate of a unit means the unit heat rate guaranteed by the supplier at conditions of one hundred percent (100%) Maximum

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Continuous Rating, zero percent (0%) make up, design coal and design cooling water temperature/back pressure. Provided that the design heat rate shall not exceed the following maximum design unit heat rates depending upon the pressure and temperature ratings of the units:

Pressure rating (kg / sqcm)	-	247
SHT / RHT (Deg C)	-	567/593 Regulation 26(ii)(B) of Tariff Regulations provides for 565/593.
For turbine driven BFP Max Turbine Cycle Heat Rate (kCal / kWh)	-	1850
For motor driven BFP Max Turbine Cycle Heat Rate (kCal / kWh)		1810
Min. Boiler efficiency	-	0.85
Max Design Unit Heat Rate (kCal/kWh) in case of turbine driven BFP	-	2176
Max Design Unit Heat Rate (kCal/kWh) in case of turbine driven BFP		2130
Secondary Fuel Oil consumption (ml/kWh)	-	1.0
Auxiliary consumption (%) with induced draft Cooling Tower and Steam driven boiler feed pump	-	6.5%
Auxiliary consumption (%) with induced draft Cooling Tower and Steam driven boiler feed pump		9.0%

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ANNEXURE A: TARIFF DEPRECIATION SCHEDULE

Sl. No.	Asset Particulars	Depreciation rate (Salvage value = 10%)
		SLM
A	Land under full ownership	0.00%
B	Land under lease	
(i)	For investment in land	3.34%
(ii)	For cost of clearing the Site	3.34%
C	Assets purchased new	
(a)	Plant and machinery in generating stations	
(i)	Steam electric NHRB and waste heat recovery Boilers	5.28%
(b)	Cooling towers and circulating water systems	5.28%
(c)	Building and Civil Engineering works of a	
(i)	Offices and showrooms	3.34%
(ii)	Containing thermo-electric generating plant	3.34%
(iii)	Temporary erections such as wooden Structures	100.00%
(iv)	Roads other than Kutcha roads	3.34%
(v)	Others	3.34%
(d)	Transformers, Kiosk, sub-station equipment and other fixed apparatus (including plant	
(i)	Transformers including foundations having rating of 100 KVA and over	5.28%
(ii)	Others	5.28%
(e)	Switchgear including cable connections	5.28%
(f)	Lightning arrestor	
(i)	Station type	5.28%
(ii)	Pole type	5.28%
(iii)	Synchronous condenser	5.28%
(g)	Batteries	5.28%
(h)	Cabling	
(i)	Lines on fabricated steel operating at terminal voltages	5.28%

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Sl. No.		Asset Particulars	Depreciation rate (Salvage value = 10%)
		higher than 66 KV	
	(ii)	Lines on steel supports operating at terminal voltages higher than 13.2 KV but not exceeding 66 KV	5.28%
	(iii)	Lines on steel or reinforced concrete support	5.28%
(i)		Meters	5.28%
(j)		Self propelled vehicles	9.50%
(k)		Air Conditioning Plants	
	(i)	Static	5.28%
	(ii)	Portable	9.50%
(l)		Office furniture / equipment	
	(i)	Office furniture and furnishing	6.33%
	(ii)	Office equipment	6.33%
	(iii)	Internal wiring including fittings and Apparatus	6.33%
(m)		Street light fittings	5.28%
(n)		Apparatus let on hire	
	(i)	Other than motors	9.50%
	(ii)	Motors	6.33%
(o)		Communication equipment	
	(i)	Radio and high frequency carrier equipment	6.33%
	(ii)	Telephone lines and telephones	6.33%
(p)		IT equipments	15.00%
(q)		Any other assets not covered above	5.28%

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ANNEXURE B: CAPITAL STRUCTURE

	Power Station Total	GRIDCO's Share in various scenarios		
		During the period of first six (6) Months commencing from the Commercial Operation Date of Unit-3	During the period Commencing from beginning of seventh (7th) Month till the Commercial Operation Date of Unit-4 if the same has not occurred in this six (6) Month from COD of Unit-3.	During the period from commencing Commercial Operation Date of Unit-4 till Expiry Date
	1320	330	450	660
Capital Cost				
Land and Development				
Construction Cost				
Spares				
Commissioning				
MGR				
Development Expenses				
Interest and Financing Cost				
Total				
Equity				
Debt				
Total				

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ANNEXURE C: FUEL COST/ PRICE

1. Coal Linkage
2. E-Auction/Imported Coal
3. Captive Coal Mine
4. Fuel Oil (HFO OR LDO)

ANNEXURE D: CAPACITY CHARGE REIMBURSEMENT BY GRIDCO TILL THE COMMERCIAL OPERATION OF CAPTIVE COAL MINE (FULL CAPACITY OPERATION) AND MGR

1. OPGC is developing the Project which constitutes Power Station and Captive Coal Mines. Power Station in turn includes Unit 3 & Unit 4 to operate as base load Power Plant, and the MGR constituting the railway transportation network from the Captive Coal Mine to the site for transportation of Coal. It is acknowledged by the Parties that the development activities of obtaining Consents applicable to Unit 3 & Unit 4 have been substantially completed. However, the same for MGR and Captive Coal Mines are at various stages of completion. It is further acknowledged by the Parties that if OPGC waits till Development Closure of Captive Coal Mine and Development Closure of MGR (both terms as defined hereunder) to be achieved to commence construction of Unit 3 & Unit 4 so that Commissioning of Unit 3 & Unit 4 coincides with a definite and sufficient Coal supply and transportation of such Coal supply through the MGR from Captive Coal Mine to operate Unit 3 & Unit 4 at or above the Normative Availability Factor, there would be delay in Commissioning of Unit 3 & Unit 4 and supply of Electrical output to GRIDCO.

2. The Parties have agreed that OPGC can proceed with construction of Unit 3 & Unit 4 and certain part of MGR and make efforts in bridging the gap of Coal supply, if any, through interim tapered Coal Linkage from Government of India and/or sourcing Coal from other sources. As part of this arrangement, it has been agreed between OPGC and GRIDCO that in the event there is a delay in the Development Closure of MGR and/or Development Closure of the Coal Mine resulting into shortfall in delivery of Coal at Power Plant battery limit required for generating power from Unit 3 & Unit 4 up to Normative Availability Factor, GRIDCO shall pay Capacity Charge Reimbursement payments constituting (i) the shortfall in the Capacity Charge and (ii) other consequential add on costs to be incurred by OPGC ("Capacity Charge Reimbursement Payments") during such period in respect of the Contracted Capacity as further detailed in Clause 5 below.

3. The Capacity Charge Payments by GRIDCO to OPGC shall be covered by the provisions contained in this Annexure D to Schedule 4 of this Agreement read together with the provisions stated in Schedule 4. Once the Capacity Charge Reimbursement Payment Period (as herein after defined) is over, these provisions and more particularly this Annexure D shall cease to have any effect.

4. The Parties agree that during the occurrence of any Force Majeure event affecting the Fuel supply to the Power Station, no payment under Article 11 shall be made to OPGC by GRIDCO until the expiry of the Capacity Charge Reimbursement Payment Period.

5. Definitions

The following terms used in this Schedule, unless repugnant to the context shall have the meaning assigned to it in the definition clause

"Capacity Charge Reimbursement Payment(s)"	shall mean the payment at Clause 5 under this Schedule.
"Capacity Charge Reimbursement Payment Period"	shall mean the period commencing with the COD of Unit-3 or Unit-4 which ever occurs earlier and ending with the Scheduled Full Capacity Commercial Operation Date of Captive Coal Mine or Scheduled Commercial Operation Date of MGR whichever is later.

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"Development Closure of Captive Coal Mine"	shall mean achieving all of the following milestones –in respect of the Captive Coal Mine i) All the private, government and forest land required for commencing the mining activities are acquired with full physical possession thereof; ii) The final forest clearance is received; iii) The revised mining plan to be followed by the Coal Mine Operator has been approved by the Ministry of Coal; iv) The mining lease has been received; v) The water clearance for the mine is received; vi) Construction power for the mine is received; vii) Magazine permit for doing the mining activity is received; and viii) Such other Consents as may be applicable for carrying out mining activities as per Prudent Utility Practices are received.
"Development Closure of MGR"	shall mean achieving all of the following milestones in respect of the MGR – (i) All the private, government and forest land required for constructing of the MGR are acquired with full physical possession thereof; (ii) The final forest clearance is received; (iii) National Highway clearance is received; (iv) Railway crossing clearance is received; (v) Such other Consents as may be applicable for construction, operation and maintenance of the MGR as per Prudent Utility Practices are received.
"Production Schedule of Captive Coal Mine"	shall mean the scheduled production from the Captive Coal Mine commencing on the Scheduled Initial Commercial Operation Date of Captive Coal Mine and ending with the Scheduled Full Capacity Commercial Operation Date of Captive Coal Mine and shall be as follows – 1st 12 Months - .... MMT Next 12 Months - .... MMT Next 12 Months - .... MMT Next [•] Months - .... MMT

"Scheduled Initial Commercial Operation Date of Captive Coal Mine"	shall mean [•] no. of Months from the date on which Development Closure of Captive Coal Mine has occurred.
"Scheduled Full Capacity Commercial Operation Date of Captive Coal Mine"	shall mean [•] no. of Months from the date on which Development Closure of Captive Coal Mine has occurred.
"Scheduled Commercial Operation Date of MGR"	shall mean [•] no. of Months from the date on which Development Closure of MGR has occurred.

6. During the Capacity Charge Reimbursement Payment Period if there is a shortfall in required Coal delivery for any reason whatsoever for the Unit or Units to generate power up to the Normative Availability Factor, computation of Capacity Charge/ fixed charge as per Para 5 of Schedule 4 shall be made as if the Availability Factor is equivalent to Normative Availability Factor.

   Provided that during the period commencing with Scheduled Initial Commercial Operation Date of Captive Coal Mine or Scheduled Commercial Operation Date of MGR whichever is later and ending with the last date of Capacity Charge Reimbursement Payment Period, if there is a shortfall in the Coal delivery from the Captive Coal Mine in comparison to the Production Schedule of Captive Coal Mine, then such shortfall shall not be considered for Capacity Charge Reimbursement Payment and in such circumstance the Capacity Charge shall be computed at Availability Factor arrived at Normative Availability Factor reduced by loss of generation due to such shortfall.

   Provided further that other consequential add on costs referred to in Clause 2 of this Schedule shall include but shall not be limited to (i) the additional cost towards higher oil consumption, (ii) the higher specific Coal consumption arising out of operation of Units 3 & Unit 4 at a low load factor or variation in load due to shortfall in Coal supply, (iii) costs arising out of additional repair and maintenance costs due to such low load operation, and (iv) costs associated with additional start ups beyond four (4) start ups in a Contract Year.

7. The Parties agree and acknowledge that OPGC shall not be entitled to make any claim under Article 11 for Force Majeure leading to shortfall in Coal delivery so long as OPGC is in receipt of Capacity Charge Reimbursement Payment in respect of the same shortfall.

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SCHEDULE 5: SUPPLEMENTAL ESCROW AGREEMENT

This Supplementary **Agreement** (this " **Supplemental Escrow Agreement**") dated as of [•] is made at [•]

By and among

GRIDCO LIMITED, a company incorporated under the provisions of the Companies Act, 1956 and having its registered office at Janpath, Khurda, Bhubaneswar – 751 022, Orissa, India (hereinafter called as "**GRIDCO**"), which expression shall unless repugnant to the context or meaning thereof, includes its successors and permitted assigns;

AND

ORISSA POWER GENERATION CORPORATION LIMITED, a company within the meaning of the Companies Act, 1956 and having its registered office at Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar – 751023, Orissa, India (hereinafter called as "**OPGC**"), which expression shall unless repugnant to the context or meaning thereof, shall include its nominees, successors and assigns),

AND

UNION BANK OF INDIA, a banking company constituted under the Banking Companies (Acquisition and Transfer of Undertakings) Act, 1970, and having its head office at 239, Bidhan Bhawan Marg, Nariman Point, Mumbai – 400021 and having a branch at Bhubaneswar Main Branch, 101, Janpath, Unit-3, Bhubaneswar – 751001, Orissa, India in its capacity as escrow agent (hereinafter referred to as "**Escrow Bank**"), which expression shall unless repugnant to the context or meaning thereof, includes its successors and permitted assigns.

GRIDCO, OPGC, and Escrow Bank, as the context may require, may hereinafter be individually referred to as a "**Party**" and collectively as the "**Parties**".

WHEREAS:

A. OPGC owns and operates Ib valley Thermal Power Station at Village Banaharpalli, District Jharsuguda in the State of Orissa comprising two (2) generating units of 210 MW each whose entire power generation is purchased by GRIDCO pursuant to Bulk Power Supply Agreement dated 13 August, 1996 (the "**PPA 1**").

B. The Government of Orissa ("**GOO**") as sole promoter holding the entire share capital of OPGC decided to divest a part of its holdings in favour of a private entity and to facilitate said divestiture executed a shareholders' agreement with said private entity, and in fulfilment of the conditions precedent in the said Shareholders Agreement, GOO entered into a tripartite agreement dated 18 October, 1998 ("**Tripartite Agreement**") with GRIDCO and OPGC (copy appended as Annexure A) which *inter alia* provides for creation of an escrow mechanism for timely payment of Bills raised by OPGC under the PPA 1.

C. GOO directed GRIDCO and OPGC to create an escrow mechanism and render it operational forthwith, and in terms of said directive, GRIDCO requested Escrow Bank to hold and administer amounts deposited in an escrow account established pursuant to the Escrow Agreement dated 30 November, 1998 ("**Existing Escrow Agreement**") for securing payment obligations of GRIDCO to OPGC under Bills presented by OPGC from time to time in accordance with the terms of the PPA 1, a copy of which Existing Escrow Agreement is annexed herewith as Annexure B.

D. In accordance with the terms of the Existing Escrow Agreement, GRIDCO has entered into an escrow agreement with CESCO on [•], and annexed herewith at Annexure D is a copy of such CESCO Escrow Agreement.

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E. Subsequently, OPGC, GRIDCO, and GOO agreed to amend the Tripartite Agreement pursuant to which OPGC agreed to implement Unit-3 and Unit-4 with 660 MW capacity each and also agreed to dedicate fifty percent (50%) of the power to be generated from the Power Station to GRIDCO, copy of this Amended Tripartite Agreement dated [•] ("**Amended Tripartite Agreement**") is appended as Annexure C.

F. In furtherance of the terms of the Amended Tripartite Agreement, OPGC and GRIDCO have signed a Power Purchase Agreement dated [•] ("**PPA 2**") setting out the terms and conditions for the sale of Contracted Capacity and supply of electricity by OPGC to GRIDCO for the fifty percent (50%) power to be generated from Power Station.

G. As per the terms and condition of the PPA 2, GRIDCO and OPGC are obligated to use the escrow mechanism under the Existing Escrow Agreement and render it operational forthwith, and pursuant whereto, GRIDCO requested Escrow Bank to hold and administer amounts deposited in the GRIDCO Escrow Account established pursuant to the Existing Escrow Agreement for also securing payment obligations of GRIDCO to OPGC under Bills presented by OPGC from time to time under the PPA 2.

H. To secure the due discharge by GRIDCO of its obligations under the PPA 2, GRIDCO and OPGC enter into this Supplemental Escrow Agreement for servicing payment obligations of GRIDCO under the PPA 2.

NOW, THEREFORE, in consideration of the premises and for other good and valuable consideration, the receipt of which are hereby acknowledged, the parties agree as follows -

ARTICLE I

DEFINITION

SECTION 1.1 Capitalized Terms

- Each capitalized term used herein and not otherwise defined herein, shall have the definition assigned to such term in the PPA 2 and the Existing Escrow Agreement , as such definition exists on the date hereof.

SECTION 1.3 Definitions

"CESCO"	means Central Electricity Supply Company of Orissa Ltd. established for undertaking the Electricity Distribution and retail Supply Business in the Central Zone comprising the electrical circles of Bhubaneswar, Cuttack and Dhenkanal, and mean to include its successors and assigns in office.
"CESCO Escrow Agreement"	shall have the meaning ascribed thereto in Existing Escrow Agreement .
"Event of Default"	shall have the meaning ascribed thereto in Section 6.1 hereof.
"GRIDCO Account"	shall have the meaning ascribed thereto in Existing Escrow Agreement .
"GRIDCO Escrow Account"	shall have the meaning ascribed thereto in Existing Escrow Agreement .
"OPGC Account 1"	means the account of OPGC, which has been established and maintained with the Escrow Bank in accordance with the terms of the Existing Escrow

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Agreement.

"OPGC Account 2" means the account of OPGC to be established and maintained with the Escrow Bank pursuant to Section 2.2(b) hereof.

All other capitalised terms used in this Supplemental Escrow Agreement shall bear the same meaning as ascribed to in PPA-2

ARTICLE - II

APPOINTMENT OF ESCROW AGENT

Establishment of Account

SECTION 2.1 **Acceptance of Appointment of Escrow Agent**

(a) The Escrow Bank hereby agrees to act and to accept all cash, payments and amounts to be delivered to or held by the Escrow Bank pursuant to the terms of this Supplemental Escrow Agreement. The Escrow Bank shall hold and safeguard the GRIDCO Escrow Account during the term of this Supplemental Escrow Agreement and shall treat the cash in the GRIDCO Escrow Account, to be held in the custody of the Escrow Bank, in trust in accordance with the provisions of this Supplemental Escrow Agreement.

(b) Subject to the provisions of Existing Escrow Agreement, the rights of GRIDCO in the monies held in the GRIDCO Escrow Account are set forth in their entirety in this Supplemental Escrow Agreement and GRIDCO shall not claim any rights against or to the monies in the Escrow account adverse to the terms of this Supplemental Escrow Agreement.

SECTION 2.2 **Establishment of Escrow Accounts**

(a) All amounts deposited in the GRIDCO Escrow Account maintained by the Escrow Bank shall be dealt with strictly in accordance with the Existing Escrow Agreement and this Supplemental Escrow Agreement. Subject to the charge created pursuant to PPA 1, GRIDCO shall not create any lien, charge, encumbrance or other security over the amount deposited/ to be deposited in the GRIDCO Escrow Account or receivables from CESCO in any manner affecting the operation of the escrow mechanism or the interest of OPGC in securing payment for the amounts due to OPGC under the PPA 2.

(b) Within thirty (30) days after the date of this Supplemental Escrow Agreement, OPGC shall have established in its own name an account (the "**OPGC Account 2**") with the Escrow Bank, that shall be maintained at all times with the Escrow Bank until the termination of this Supplemental Escrow Agreement.

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(c) OPGC shall maintain OPGC Account 1 with the Escrow Bank exclusively for PPA 1 and OPGC Account 2 shall be maintained with the Escrow Bank exclusively for PPA 2.

ARTICLE III

DEPOSITS INTO ESCROW ACCOUNT

SECTION 3.1 **Deposits of Receivables**

Subject to the terms of Existing Agreement and the primary obligations created thereto in favour of OPGC by GRIDCO,

(a) GRIDCO agrees and confirms that throughout the term of this Supplemental Escrow Agreement, it shall cause and direct CESCO to deposit into the GRIDCO Escrow Account amount for the supply of electricity by GRIDCO to CESCO for the distribution and retail supply in the area comprising of Bhubaneswar, Cuttack, and Dhenkanal. If GRIDCO shall receive any such amounts directly, it hereby agrees that it will be holding such amounts in trust for the benefit of the Escrow Bank (as agent for OPGC) and shall immediately deliver such amounts in the exact form (but with GRIDCO's endorsement, if necessary) to the Escrow Bank for deposit in the GRIDCO Escrow Account. GRIDCO hereby undertakes to bring in additional funds/ receivables, which shall form part of the GRIDCO Escrow Account, in case of any shortfall in the GRIDCO Escrow Account with respect to the Letter of Credit amount specified in Article 9.7.2.

(b) Any deposit made into the GRIDCO Escrow Account under this Supplemental Escrow Agreement shall be irrevocable and all interest, income or gain earned or realized on amounts on deposit in the GRIDCO Escrow Account shall be retained therein and be treated for all purposes of this Supplemental Escrow Agreement as part of the GRIDCO Escrow Account.

(c) CESCO Escrow Agreement obligates CESCO to deposit -

(i) all receivables and payments from the consumers and purchasers of electric capacity and/ or energy from CESCO are collected in designated collection account established and maintained by the Escrow Bank under the CESCO Escrow Agreement;

(ii) all the amounts collected are being remitted to "**CESCO Escrow Account**" established and maintained by the Escrow Bank under the CESCO Escrow Agreement: and

(iii) on the GRIDCO payment date under the supply agreement with CESCO, the Escrow Bank under the CESCO Escrow Agreement shall duly transfer and remit the amount due from CESCO for the purchase of electric capacity and/or energy from GRIDCO from CESCO Escrow Account to GRIDCO Escrow Account maintained by the Escrow Bank in terms of the Existing Escrow Agreement and this Supplemental Escrow Agreement.

(d) if GRIDCO shall receive directly from or on behalf of CESCO any amounts due for the electric capacity and/ or electricity supplied by GRIDCO to CESCO for distribution and retail supply, GRIDCO hereby agrees that it will be holding such amounts in trust for the benefit of the Escrow Bank and shall immediately deliver such amounts in entirety to the Escrow Bank for deposit in the GRIDCO Escrow Account.

(e) GRIDCO agrees and confirms that concurrently with the execution and delivery of this Supplemental Escrow Agreement, CESCO shall irrevocably instruct and shall cause and direct each of the divisional officers in CESCO to transfer monies and funds received for electricity supplied by CESCO directly to the CESCO Escrow Account.

SECTION 3.2 Subject to the terms of Existing Escrow Agreement and the primary obligations created thereto in favour of OPGC by GRIDCO,

(a) OPGC shall raise the Bills on GRIDCO with requisite details for the payment due from GRIDCO to OPGC for each billing period as provided in the PPA 2 and a copy of the Bill raised by OPGC shall be delivered to the Escrow Bank. As from the date of delivery of the Monthly Bill and/ or Supplementary Bill (which delivery shall be on or rather the date on which the billing may be done under the provisions of the PPA 2), the Escrow Bank shall enter the amount of the Bill in the OPGC Account 2, as outstanding from GRIDCO to OPGC as provided under Article 9 of the PPA 2 and the same will form part of the outstanding amount for the purposes of this Supplemental Escrow Agreement.

(b) Thereafter the Escrow Bank shall permit any withdrawal by GRIDCO from the GRIDCO Escrow Account only in accordance Section 3.3 below. If GRIDCO raises any objection to any billing as provided in Article 9 of the PPA 2 pending the resolution of the Disputes, the amount as specified in Article 9 in respect of a Bill shall be taken as the amount outstanding and necessary adjustments shall be made for the claims of OPGC or GRIDCO upon the resolution of the disputes as provided under the PPA 2.

(c) GRIDCO shall establish a Letter of Credit in favour of OPGC for the sum and on the terms and conditions specified in the PPA 2. OPGC shall be entitled to draw the amount under the Letter of Credit(s) in case any payment of the amount due to OPGC remains unpaid on the Due Date. If the Letter of Credit is encashed, GRIDCO shall take steps to replenish the Letter of Credit. The rights of OPGC under this Supplemental Escrow Agreement shall be in addition to the Letter of Credit established by GRIDCO in terms of the PPA 2.

(d) In the event of GRIDCO's failure to make payments either through the Letter of Credit(s) as provided for in Section 3.2(c) above or otherwise the amounts deposited in the GRIDCO Escrow Account shall be automatically transferred by the Escrow Bank, without any further act deed or things to be done by GRIDCO or OPGC, on a daily basis to OPGC Account 1 (as a priority till the primary obligations are discharged) and the OPGC Account 2 (as the case may be) maintained with the Escrow Bank towards payments of all outstanding amounts under the Bill raised by OPGC on GRIDCO under the PPA 1 and the PPA 2. OPGC shall be entitled to appropriate the amount in the OPGC Account 1 and the OPGC Account 2 in any manner as OPGC may consider appropriate and GRIDCO shall not have any claim in amounts transferred to the OPGC Account 1 or the OPGC Account 2.

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SECTION 3.3 **Payments to GRIDCO**

After fully satisfying amounts of all the outstanding Bills of OPGC in terms of section 3.2 (a), (b), (c) and (d), the Escrow Bank shall transfer the amounts in the GRIDCO Escrow Account on a daily basis to GRIDCO Account without any further act deed or things to be done by OPGC or GRIDCO. GRIDCO shall be entitled to appropriate the amount in the GRIDCO Account in any manner as GRIDCO may consider appropriate and OPGC shall not have any claim in the amount so transferred to GRIDCO Account from GRIDCO Escrow Account.

ARTICLE IV

REPRESENTATION AND WARRANTIES

SECTION 4.1 **Representation and Warranties**

GRIDCO hereby represent and warrants to OPGC that:

(a) GRIDCO is a company formed under the Companies Act, 1956, and is validly existing under the Laws and has all requisite legal power and authority to execute this Supplemental Escrow Agreement and to carry out the terms, conditions and provisions, hereof;

(b) This Supplemental Escrow Agreement constitute the valid legal and binding obligation of GRIDCO, enforceable in accordance with the terms hereof;

(c) There are no actions, suits or proceedings pending or, to GRIDCO knowledge, threatened, against or affecting GRIDCO before any court or administrative body or arbitral tribunal which might materially adversely affect the ability of GRIDCO to meet and carry out its obligations under this Supplemental Escrow Agreement;

(d) The execution and delivery of this Supplemental Escrow Agreement by GRIDCO has been duly authorized by all requisite action, and will not contravene any provision of, or constitute a default under any other agreement or instrument to which it is a party or by which it or its property may be bound; and

(e) No charge, security interest or other encumbrance exists over the GRIDCO Escrow Account or the receivables from CESCO other than the second charge created by this Supplemental Escrow Agreement.

ARTICLE V

COVENANTS

SECTION 5.1 OPGC covenants and agrees that as soon as available, OPGC shall deliver to GRIDCO and the Escrow Bank a copy of the Monthly Bill or Supplementary Bill furnished to GRIDCO pursuant to the PPA 2;

SECTION 5.2 GRIDCO covenants that the copy of the CESCO Escrow Agreement as annexed in Annexure D is the true copy of the agreement entered

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into amongst GRIDCO and CESCO, and the same has neither been amended/ modified nor any waiver has been granted there under without the prior consent of OPGC. Further, the execution and performance of this Supplemental Escrow Agreement will not prevent GRIDCO or OPGC in enforcing any of their respective rights under the PPA 2 or this Supplemental Escrow Agreement.

ARTICLE VI

EVENTS OF DEFAULT

SECTION 6.1 **Events of Default**

"**Event of Default**" shall mean the occurrence or existence of any one or more of the following -

(a) if GRIDCO is in material breach of any of its obligation under the Existing Escrow Agreement, this Supplemental Escrow Agreement, the PPA 1, the PPA 2 or the CESCO Escrow Agreement.

(b) Failure of GRIDCO or the Escrow Bank to deposit or to procure to deposit the amount from CESCO Escrow Account to the GRIDCO Escrow Account.

(c) Failure of GRIDCO to replenish any Letter of Credit in terms of the PPA 2.

And thereupon and at any time thereafter, the Escrow Bank shall transfer amounts held in the GRIDCO Escrow Account to the OPGC Account 1 and the OPGC Account 2, which shall be then applied to the payment of the secured obligations as and when the same become due on the terms and conditions contained in the Existing Escrow Agreementand this Supplemental Escrow Agreement.

ARTICLE VII

EXPENSES, INDEMNIFICATION

SECTION 7.1 **Expenses**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 7.2 **Indemnification**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

ARTICLE – VIII

MISCELLANEOUS

SECTION 8.1 **Amendment, etc.**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.2 **Notices**

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Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.3 **Governing Law**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.4 **No Third party Beneficiaries**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.5 **Satisfaction Requirement**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.6 **No Waiver**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.7 **Severability**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.8 **Counterparts**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.9 **Successors and Assigns**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.10 **Termination**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.11 **Term of this Supplemental Escrow Agreement Controlling**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.12 **Dispute Resolution**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

SECTION 8.13 **Further Documents**

Similar provision applicable in the Existing Escrow Agreement shall prevail for the Supplemental Escrow Agreement.

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SECTION 8.14 The Parties hereby irrevocably submit to the non exclusive jurisdiction of the appropriate courts in Bhubaneswar, Orissa in regards to all legal proceedings.

IN WITNESS WHEREOF, the Parties have caused this Supplemental Escrow Agreement to be duly executed as of the day and years first above written.

GRIDCO LIMITED

By:

Name:

Title:

ORISSA POWER GENERATION CORPORATION LIMITED

By:

Name:

Title:

UNION BANK OF INDIA

By:

Name:

Title:

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BHUBANESWAR

SCHEDULE 6: UNATTESTED DEED OF HYPOTHECATION

THIS UNATTESTED DEED OF HYPOTHECATION ("Deed 2") is executed at [___________] on this the [____] day of [______________] 2011:

BY

GRIDCO LIMITED, a company incorporated and registered under the provisions of the Companies Act, 1956, and having its registered office at Janpath, Khurda, Bhubaneswar – 751022, Orissa, India (hereinafter referred to as the **"GRIDCO"** which expression shall unless it be repugnant to the subject or context thereof, include its successors, legal representatives and permitted assigns) acting through its authorized officers;

IN FAVOUR OF

ORISSA POWER GENERATION CORPORATION LIMITED, a company incorporated and registered under the Companies Act, 1956, and having its registered office at Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar – 751023, Orissa, India (hereinafter be referred to as the **"OPGC"** which expression shall, unless repugnant to the context or meaning thereof, be deemed to include its successors, legal representatives and permitted assigns) acting through its authorized officers.

GRIDCO and OPGC may, as the context may require, individually be referred to as a "**Party**" and collectively as the "**Parties**".

WHEREAS

A. OPGC owns and operates Ib valley Thermal Power Station at Village Banaharpalli, District Jharsuguda in the State of Orissa, comprising two (2) generating units of 210 MW each whose entire power generation is purchased by GRIDCO pursuant to Power Supply Agreement dated 13 August 1996 (**"Power Purchase Agreement 1"** or **"PPA 1"**).

B. The Government of Orissa (**"GOO"**) as sole promoter holding the entire share capital of OPGC, decided to divest a part of its holdings in favour of a private entity and to facilitate said divestiture, executed a shareholders' agreement with said private entity, and in fulfilment of the conditions precedent under the said shareholders agreement, GOO entered into a tripartite agreement dated 18 October 1998 with GRIDCO and OPGC.

C. Accordingly, GRIDCO and OPGC along with Union Bank of India (acting as Escrow Bank thereto) entered into an Escrow Agreement on 30 November 1998 (**"Existing Escrow Agreement"**), wherein GRIDCO agreed to deposit and/ or procure to deposit all its receivables in the GRIDCO Escrow Account (as defined in the Escrow Agreement), and operate the same in accordance with the terms of the Existing Escrow Agreement , and also created a primary obligation on all the receivables of GRIDCO forming part of GRIDCO Escrow Account thereunder, and in furtherance of the terms of PPA 1 and Existing Escrow Agreement , GRIDCO created a security in the Existing Escrow Agreement deemed to be considered as deed of hypothecation (**"Deed 1"**) in favour of OPGC simultaneously with the Existing Escrow Agreement .

D. OPGC is now in the process of setting-up of the two (2) additional power generating units namely Unit-3 and Unit-4 with an installed capacity of 660 MW each (**"Power Station"**) at the same site where the first two units are being operated, and in order to tie-up for the long-term bulk supply of power to be generated from the Power Station, has entered into a long term Power Purchase Agreement with GRIDCO on [•] (**"PPA 2"**).

E. In accordance with the terms of the PPA 2 and in order to fulfil their respective obligations thereunder, GRIDCO and OPGC along with Union Bank of India (acting as Escrow Bank) have entered into a new Escrow Agreement 2 on [•] ("**Supplemental Escrow Agreement**"), wherein GRIDCO has agreed to deposit and/ or procure to deposit all its receivables in the GRIDCO Escrow Account (as defined in the Existing Escrow Agreement), and operate the same in accordance with the terms of the Supplemental Escrow Agreement relating to the payment obligations under PPA 2.

F. Pursuant to Article 9.8.2 of the PPA 2, GRIDCO is under an obligation to contemporaneously with the execution of the Existing Escrow Agreement , enter into a separate Deed of Hypothecation, whereby GRIDCO shall hypothecate to OPGC, effective from 45 (forty-five) days ("**Effective Date**") prior to the Scheduled COD of the Unit-3 and Unit-4 (as applicable), the amounts to the extent as required for the Letter of Credit and the Receivables in accordance with the terms of such Deed of Hypothecation to ensure the due payment of all the monies payable by GRIDCO to OPGC under the PPA 2.

G. Accordingly, in view of the aforesaid, OPGC has called upon GRIDCO to execute this Deed 2, which GRIDCO has agreed to do in the manner hereinafter expressed.

NOW THEREFORE IT IS AGREED AS UNDER -

1. DEFINITIONS AND INTERPRETATION

1.1 Definitions

Unless otherwise defined, capitalised terms in this Deed 2, shall have the same meanings, as ascribed to them in the PPA 2 and Existing Escrow Agreement , with PPA 2 having priority over the Existing Escrow Agreement , in case of any contradiction. In this Deed 2, the capitalised terms not otherwise defined shall have the following meanings:

"Agreement Date"	shall mean the date of the execution of this Deed 2;
"Effective Date"	shall mean to have the same meaning as ascribed to it in Recital F;
"Existing Escrow Agreement"	shall mean to have the same meaning as ascribed to it in Recital C;
"Escrow Bank"	shall mean Union Bank of India, having its head office at 239, Bidhan Bhawan Marg, Nariman Point, Mumbai - 400021, Maharashtra, India, and acting through its branch at Bhubaneswar Main Branch, 101, Janpath, Unit-3, Bhubaneswar – 751001, Orissa, India;
"GRIDCO Escrow Account"	shall mean to have the same meaning as ascribed to it in the Existing Escrow Agreement ;
"Hypothecated Assets"	shall mean to have the same meaning as ascribed to it in Clause 3.1;
"Supplemental Escrow Agreement"	shall mean to have the same meaning as ascribed to it in Recital E;
"PPA 2"	shall mean to have the same meaning as ascribed to it in Recital D;
"Power Purchase Agreement 1 or PPA 1"	shall mean to have the same meaning as ascribed to it in Recital A;

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"Power Station"	shall mean to have the same meaning as ascribed to it in Recital D;
"Project Documents"	shall mean to have the same meaning as ascribed to it in the PPA 2;
"Project"	shall mean to have the same meaning as ascribed to it in the PPA 2;
"Receivables"	shall mean to have the same meaning as ascribed to it in the PPA 2; and
"Receiver"	shall mean to have the same meaning as ascribed to it in Clause 4.2.

1.2 **Interpretation**

Save where the contrary is indicated, any reference in this Deed 2 to -

(a) a reference to a Clause, unless indicated to the contrary, is a reference to a clause, to this Deed 2;

(b) an **"encumbrance"** shall be construed as a reference to a mortgage, charge, pledge, lien or other encumbrance securing any obligation of any person or any other type of preferential arrangement (including, without limitation, title transfer and retention arrangements) having a similar effect;

(c) **"indebtedness"** shall be construed so as to include any obligation (whether incurred as principal or surety) for the payment or repayment of money, whether present or future, actual or contingent;

(d) a **"person"** shall be construed as a reference to any person, firm, company, corporation, society, trust, government, state or agency of a state or any association or partnership (whether or not having separate legal personality) of two (2) or more of the above and a person shall be construed as including a reference to its successors, permitted transferees and permitted assigns in accordance with their respective interests;

(e) the **"winding-up"**, **"dissolution"**, **"insolvency"**, or **"reorganization"** of a company or corporation shall be construed so as to include any equivalent or analogous proceedings under the Law of the jurisdiction in which such company or corporation is incorporated or any jurisdiction in which such company or corporation carries on business including the seeking of liquidation, winding-up, reorganization, dissolution, arrangement, protection or relief of debtors;

(f) defined terms in the singular shall include the plural and vice versa, and the masculine, feminine or neutral gender shall include all genders;

(g) references to the Deed 2 or any other agreement, document or other instrument includes (subject to all relevant approvals) a reference to the Deed 2, such other agreement, document or other instrument as amended, modified, revised, supplemented, substituted, or novated from time to time but disregarding any amendment, revision, supplement or modification made in breach of the PPA 2;

(h) references to any statutory provisions shall be construed as references to those provisions as replaced, amended, modified or re-enacted from time to time;

(i) a time of day shall, save as otherwise provided in any agreement or document be construed as a reference to Indian Standard Time;

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(j) the Recitals to this Deed 2 shall be deemed to form an integral part of the Deed 2 and shall be read as if they are specifically incorporated herein, and all different parts of this Deed 2 are to be taken as mutually explanatory and supplementary to each other and if there is any inconsistency between or among the parts of this Deed 2, they shall be interpreted in a harmonious manner so as to give effect to each part;

(k) the table of contents and headings or sub-headings are inserted for convenience only and shall not affect the interpretation or construction of the Deed 2;

(l) the words "**hereof**", "**herein**" and "**hereunder**" and words of similar import, when used in the Agreement shall refer to the Agreement as a whole and not to any particular provision of the Agreement;

(m) the words "**include**", "**includes**" and "**including**" when used in the Deed 2 are deemed to be followed by the phrase "**without limitation**" or "**but not limited to**";

(n) whenever a provision of the Deed 2 requires an approval or consent by a Party and notification of such approval or consent is not delivered within the applicable time limit, then, unless otherwise specified, the Party whose consent or approval is required shall be conclusively deemed to have withheld its consent or approval; and

(o) terms defined in this Deed 2 by reference to any other agreement, document or instrument shall have the same meanings as assigned to them respectively in such agreement, document or instrument, whether or not such agreement, document or instrument is then in effect.

1.3 Inconsistency

The provisions contained herein shall be read in conjunction with the provisions of the PPA 2 and Supplemental Escrow Agreement as may be amended, supplemented or modified from time to time and to the extent of any inconsistency or repugnancy, the PPA 2 shall prevail to all intents and purposes.

2 COVENANT TO PAY

2.1 Covenant to Pay

In pursuance of the PPA 2 and in consideration of OPGC having agreed to supply the power in accordance with the terms of the PPA 2, and subject to the terms and conditions set out thereto and in consideration of the premises, GRIDCO hereby covenants with OPGC that it shall make the payments and/ or procure to make the payments to OPGC of all other monies in the manner set out in the PPA 2 and shall duly observe and perform all the terms and conditions of the PPA 2.

3 HYPOTHECATION AND RANKING

3.1 Hypothecation

In pursuance of the PPA 2 and for the consideration aforesaid, the GRIDCO Escrow Account (which shall consist of the amounts to the extent as required for the Letter of Credit as per the PPA 2 and any of the Receivables or monies to be payable by GRIDCO to OPGC under the PPA 2) (hereinafter collectively referred to as the "**Hypothecated Assets**"), are hereby hypothecated as and by way of first ranking *pari-passu* charge for the due payment of all the and monies payable to OPGC under the PPA 2. However, it is clarified that GRIDCO shall have a primary obligation under Deed 1 to meet the demands of OPGC in accordance with the terms of PPA 1, and the obligation created hereunder shall be GRIDCO's secondary obligation.

3.2 Ranking

The charge created in favour of OPGC over the Hypothecated Assets as security for the due payment of all the monies payable to OPGC under the PPA 2, shall be by way of secondary obligation ranking pursuant to the primary obligation of GRIDCO created under Deed 1 for all purpose and all intents.

4 COVENANTS OF GRIDCO

4.1 Events of Default and Remedies

On or upon the non-payment of the payments in accordance with the PPA 2 and Supplemental Escrow Agreement, OPGC or any of its nominees shall, without any notice and without assigning any reason and at the risk and expense of GRIDCO and if necessary as attorney for and in the name of GRIDCO, recover, and receive for realisation or otherwise dispose of or deal with all or any part of the Hypothecated Assets and to enforce, realise, settle, compromise and deal with any rights or claims relating thereto without being bound to exercise any of these powers or be liable for any losses in the exercise or non-exercise thereof and without prejudice to OPGC's rights and remedies of suit or otherwise. Notwithstanding any pending suit or other proceeding, GRIDCO undertakes to authorise OPGC on demand to operate Hypothecated Assets in the manner as OPGC may deem fit.

Provided however that OPGC shall not be in any way be liable or responsible for any loss, or damage that GRIDCO may suffer or sustain on any account whatsoever by reason of exercise or non-exercise of rights and remedies available to OPGC as aforesaid and that all such loss, or damage shall be wholly debited to the account of GRIDCO howsoever the same may have been caused.

4.2 Appointment of Receiver

On or upon the occurrence of an non-payment of the payments in accordance with the PPA 2 and Supplemental Escrow Agreement, OPGC or any of its nominee will have the right to appoint a receiver or receivers with respect to the Hypothecated Assets or any part thereof ("**Receiver**") and the following provisions shall apply to such Receiver -

(a) Unless otherwise directed by OPGC, such Receiver shall have and exercise all powers and authorities vested in OPGC hereinafter set forth or under Law or as OPGC may think expedient, including the following rights, power and authorities-

(i) to take possession of and collect all or any part of the Hypothecated Assets and for that purpose to take any proceedings and enforce any order or judgement in the name of GRIDCO or otherwise as the Receiver shall consider fit;

(ii) to manage or carry on or concur in carrying on the business of GRIDCO (including, without limitation, the performance of the Project Documents, as the Receiver shall consider fit, in each case, without being responsible or liable for any loss or damage);

(iii) to make any arrangement or compromise between GRIDCO and any other person or pay any compensation or incur any obligation which OPGC or the Receiver shall consider fit;

(iv) for the purpose of exercising any of the powers, authorities and discretions conferred on it by this Deed 2 and/ or defraying any costs or expenses which may be incurred by it in the exercise thereof or for any other purpose, to borrow money from any source on the security of the Hypothecated Assets;

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(v) to obtain all clearances, permissions, approvals and any consents or licenses necessary or appropriate to carry out any of the matters referred to in this Deed 2 or otherwise as OPGC or Receiver shall consider fit;

(vi) to redeem any prior encumbrance and settle and pass the accounts of the encumbrances so that any accounts so settled and passed shall be conclusive and binding on GRIDCO and the money so paid shall be deemed to be an expense properly incurred by the Receiver;

(vii) to appoint and discharge employees, officers, agents, professionals and others for the operation of the upon such terms as to remuneration or otherwise as the Receiver may consider fit and to discharge any persons appointed by GRIDCO;

(viii) to settle, compromise and arrange any claims, accounts, disputes, questions and demands with or by any person or body who is or claims to be a creditor of GRIDCO under the Project Documents, the clearances or relating in any way to the Hypothecated Assets or any part thereof;

(ix) to bring, prosecute, enforce, defend and discontinue all such actions and proceedings in relation to the Hypothecated Assets or any part thereof as the Receiver shall consider fit;

(x) to dispose of all or any part of the Hypothecated Assets as the Receiver shall consider fit;

(xi) to do all such things and take all such action as may be required in order to ensure the continued safe, efficient and economic operation of the Project;

(xii) to promote the formation of companies with a view to purchasing all or any of the undertaking, property, assets and rights of GRIDCO in respect of the Project or otherwise;

(xiii) to do all such other acts and things (including, without limitation, signing and executing all documents and deeds) as may be considered by OPGC or Receiver to be incidental or conducive to any of the matters or powers aforesaid or otherwise incidental or conducive to the improvement or realisation of the Hypothecated Assets;

(xiv) to exercise all such other powers and authority as OPGC shall consider fit to confer and so that OPGC may in relation to such part of the Hypothecated Assets as is the subject of a charge herein confer any powers and authorities which it could give if it were an absolute beneficial owner thereof;

(b) Unless otherwise directed by OPGC, such Receiver shall have and exercise all powers and authorities vested in OPGC;

(c) Such Receiver shall, in the exercise of his powers, authorities and discretions, conform to the regulations and directions from time to time made and given by OPGC;

(d) OPGC may, from time to time, fix the remuneration of such Receiver and shall direct payment thereof out of the Hypothecated Assets, but GRIDCO alone shall be liable for the payment of any such remuneration;

BHUBANESWAR

(e) OPGC may, from time to time and at any time, require such Receiver to give security for the due performance of his duties as such Receiver and may fix the nature and amount of the security to be given to OPGC;

(f) OPGC may pay over to such Receiver any monies constituting part of the securities to the intent that the same may be applied for the purpose hereof by such Receiver and OPGC may, from time to time, determine what funds the Receiver shall be at liberty to keep in hand with a view to the performance of his duties as such Receiver; and

(g) Every such Receiver shall be the agent of GRIDCO for all purposes and GRIDCO alone shall be responsible for his acts and defaults, loss or misconduct and liable on any contract or engagement made or entered into by him and for his remuneration, and OPGC shall not incur any liability or responsibility therefore by reason of its making or consenting to his appointment as such Receiver.

4.3 Separate Hypothecated Assets

All the Hypothecated Assets and all realisations and all documents under this security shall always be kept distinguishable and held as the exclusive property of OPGC specifically appropriated to this security and be dealt with only under the directions of OPGC and subject to the terms hereof, and GRIDCO shall not create or continue any charge, mortgage, lien or other encumbrance upon or over the same or any part thereof except in favour of OPGC, nor suffer any such charge, mortgage, lien or other encumbrance or any attachment or distress to affect the same or any part thereof nor do or allow anything that may prejudice this security and OPGC shall be at liberty to incur all costs and expenses as may be necessary to preserve this security and to maintain the same in accordance with the terms hereof and claim reimbursement thereof; *provided that* except to the extent specifically permitted by OPGC, in writing, GRIDCO shall not dispose of all or any of the Hypothecated Assets.

4.4 Information covenant

GRIDCO shall, whenever required by OPGC, give full particulars to OPGC of the Hypothecated Assets, and shall furnish and verify all statements, reports, returns, certificates and information from time to time and as required by OPGC and make, furnish and execute all necessary documents to give effect to this security.

4.5 Continuing security

Subject to the terms hereof, the security created hereunder shall be a continuing security for the due payment of all the monies payable by GRIDCO to OPGC under the PPA 2 and these presents shall not affect, impair or discharge the liability of GRIDCO on account of winding up (voluntary or otherwise) or by any merger or amalgamation, reconstruction or otherwise of GRIDCO with any other company or take-over of the management or nationalisation of the undertaking of GRIDCO. Also, the successor entity of GRIDCO in case of its disbandment and/or the assignment of any or all the obligations pursuant to PPA 2 in favour of any third party shall have a continuing obligation towards OPGC in accordance with the terms hereof.

4.6 Free from encumbrance

GRIDCO hereby declares that the Hypothecated Assets are and will at all times be the absolute property of GRIDCO at the sole disposal of GRIDCO, and/ or to be created with the specific permission of OPGC, be free from any charge, trust, pledge, lien, claim or encumbrance. Subject to the charge created under Deed 1, the security created herein is in addition to, and independent of, any other security or right or remedy now or at any time hereafter held by or available to OPGC.

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GRIDCO shall also not create any form of lien, charge, encumbrance, obligation or other security over the amount deposited/ to be deposited in the GRIDCO Escrow Account or receivables from CESCO in any manner affecting the operation of the escrow mechanism or otherwise the interest of OPGC in securing payment for the amounts due to OPGC under the PPA 2..

4.7 Attorney of Borrower

GRIDCO hereby appoints OPGC and each Receiver as its attorney and authorises OPGC and each Receiver, upon occurrence of non-payment of the payments in accordance with the PPA 2 and Supplemental Escrow Agreement to act for and in the name of GRIDCO to do whatever GRIDCO may be required to do under these presents and generally to use the name of GRIDCO in the exercise of all or any of the powers by these presents conferred on OPGC and each such Receiver and GRIDCO shall bear the expenses that may be incurred in this regard.

5 LIMITATION OF LIABILITY

5.1 Limitation of Liability

OPGC shall not be under any liability whatsoever towards GRIDCO or any other person for any loss or damage to the Hypothecated Assets from or in whatever cause or manner arising whether such Hypothecated Assets are/ are not in the possession of OPGC at the time of such loss or damage or the happening of the cause thereof. GRIDCO shall at all times indemnify and keep indemnified OPGC and each Receiver from and against all suits, proceedings, costs, charges, claims and demands whatsoever that may at any time arise or be brought or made by any person against OPGC and each Receiver in respect of any acts, matters and things lawfully done or caused to be done by OPGC and each Receiver in connection with the Hypothecated Assets or in pursuance of the rights and powers of OPGC and each Receiver under this Deed 2 and/ or under the PPA 2.

6 DISTRIBUTION OF MONIES

6.1 Distribution of Monies

Subject to the provisions of the Existing Escrow Agreement, the monies resulting from the enforcement or realisation of the security created hereunder or any part thereof shall, be appropriated and applied towards liquidating the outstanding monies under the PPA 2.

7 RELEASE OF CHARGE

7.1 Release of Charge

On or after the date on which all the obligations of GRIDCO under the PPA 2 have been fully performed or otherwise discharged, the security interest created pursuant to this Deed 2 shall be released.

8 MISCELLANEOUS

8.1 Amendment and Waiver

Subject to the PPA 2, GRIDCO and OPGC may amend or supplement the terms of this Deed 2 by mutual agreement in writing. No failure or delay by OPGC in exercising any right, power or remedy herein shall impair or extinguish such right, power or remedy or operate as a waiver thereof, nor shall any single or partial exercise of the same preclude any further exercise thereof or the exercise of any other right, power or remedy. The rights, powers and remedies herein provided are cumulative and do not exclude any other rights, powers and remedies provided by Law. A waiver or consent granted by OPGC will be effective only if given in writing and for the instance and for the purpose for which it is given.

8.2 Notice

Any notice or other communication pursuant to this Deed 2 shall be as provided in accordance with Article 18.10 of the PPA 2.

8.3 Independent Security

Nothing herein shall prejudice the rights or remedies of OPGC in respect of any present or future security, guarantee obligation or decree for any indebtedness or liability of GRIDCO to OPGC.

8.4 Severability

Any provision in this Deed 2 that is or may become prohibited or unenforceable in any jurisdiction shall, as to such jurisdiction, be ineffective only to the extent of such prohibition or unenforceability without invalidating the remaining provisions of this Deed 2 or affecting the validity or enforceability of such provisions in any other jurisdiction.

8.5 Discharges and Releases

Notwithstanding any discharge, release or settlement from time to time between OPGC and GRIDCO, if any discharge or payment in respect of the due payment of all the monies payable by GRIDCO to OPGC under the PPA 2, or any other person is avoided or set aside or ordered to be surrendered, paid away, refunded or reduced by virtue of any provision, Law or enactment relating to bankruptcy, insolvency, liquidation, winding up, composition or arrangement for the time being in force or for any other reason, OPGC shall be entitled hereafter to enforce this Deed 2 as if no such discharge, release or settlement had occurred.

8.6 No Legal Title for OPGC

OPGC shall not have any form of legal title to any part of the Hypothecated Assets, *provided however that* OPGC shall have a beneficial interest in the Hypothecated Assets.

8.7 Limitation of Rights of Others

Nothing in this Deed 2, whether express or implied, shall be construed to give to any person other than OPGC any legal or equitable right, remedy or claim under or in respect of this Deed 2, except as expressly provided in this Deed 2, any covenants, conditions or provisions contained herein, in the Hypothecated Assets, all of which are, and shall be construed to be, for the sole and exclusive benefit of OPGC.

8.8 Stamp Duty and other charges

GRIDCO shall pay all stamp duty, other Taxes, penalties or other charges payable on or in connection with the execution, issue, delivery, registration of this Deed 2 and any document, act and registration performed pursuant hereto, if and when GRIDCO may be required to pay the same according to any of the PPA 2 or according to the Law for the time being or at any time in force. If GRIDCO fails to pay the stamp duty, other Taxes, penalties or other charges payable hereinabove, then OPGC may (but is not obligated to) pay such amounts, on behalf of GRIDCO. OPGC shall be entitled to be indemnified out of the Hypothecated Assets charged/ to be charged in favour of OPGC for any amount paid by OPGC as aforesaid.

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8.9 Assignment

This Deed 2 shall be binding upon, and inure to the benefit of the Parties and their respective successors and permitted assigns. Subject to the terms of the Existing Escrow Agreement and the right of OPGC to assign rights hereunder in favour of its Lenders, this Deed 2 shall not be assigned by GRIDCO (and GRIDCO shall not create or permit to subsist any encumbrance over all or any of its rights and benefits under this Deed 2) other than by mutual consent between the Parties to be evidenced in writing.

Provided that, such consent shall not be withheld – (a) if GRIDCO seeks to transfer to any transferee all of its rights and obligations under this Deed 2; and (b) such transferee is either the owner(s) or operator(s) of one or more of the distribution system of Orissa and/ or such transferee is a successor entity of GRIDCO; and (c) this Deed 2 *mutatis mutandis* shall continue to remain valid and binding on such successor.

9 GOVERNING LAW

9.1 Governing Law

This Deed 2 is governed by and shall be construed in accordance with the laws of India.

10 DISPUTE RESOLUTION

10.1 Dispute Resolution

Any controversy or dispute arising out of or relating to this Deed 2 that cannot be resolved by the Parties shall be resolved in accordance with the applicable dispute resolution procedure set forth in the PPA 2.

GRIDCO has caused its common seal to be affixed hereto on the day, month and year first above written.

THE COMMON SEAL OF GRIDCO, has, pursuant to the resolution of its Board of Directors passed in that behalf on [•], 20[•] hereunto been affixed in the presence of Mr. [•] who has signed these presents in token thereof.

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ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

SCHEDULE 7: SUBSTITUTION RIGHTS OF LENDERS

1 **Substitution of OPGC**

(a) Subject to the terms of this Agreement, upon the occurrence of an OPGC Event of Default under this Agreement, the Lenders shall have the right to seek substitution of OPGC by a Selectee, for the purposes of securing the repayments of the all the amounts payable under the Financing Agreements by OPGC and performing the obligations of OPGC under this Agreement, in accordance with the provisions of this Schedule.

(b) The Lenders may seek to exercise right of substitution by an amendment or novation of this Agreement and the Project Documents executed between GRIDCO and OPGC, if any, in favour of the Selectee. GRIDCO and OPGC shall cooperate with the Lenders to carry out such substitution.

2 **Notice For OPGC Event Of Default**

GRIDCO upon serving the GRIDCO Preliminary Default Notice on OPGC in accordance with the terms of this Agreement shall simultaneously also issue a copy of the same to the Lenders.

3 **Substitution Notice**

Within a period of [30] days following the expiry of the GRIDCO Consultation Period, unless the Parties shall have otherwise agreed to the contrary, or an OPGC Event of Default giving rise to the GRIDCO Consultation Period shall have been remedied, the Lenders shall be entitled to notify GRIDCO and OPGC of the intention of the Lenders to substitute OPGC by the Selectee for the residual period of this Agreement ("**Substitution Notice**") and GRIDCO shall raise no objection to the Lenders exercising such rights.

4 **Process of Substitution of OPGC**

The Lenders may, on delivery of a Substitution Notice notify GRIDCO and OPGC on behalf of all the Lenders about the Lenders' decision to invite and negotiate, at the cost of the Lenders, offers from third parties to act as Selectee, either through private negotiations or public auction and/ or a tender process. Selectee shall be entitled to receive all the rights of OPGC and shall undertake all the obligations of OPGC under this Agreement and other Project Documents executed between OPGC and GRIDCO, in accordance with these terms of substitution.

The Lenders and OPGC shall ensure that OPGC shall transfer, absolutely and irrevocably, the ownership of the Power Station to such Selectee simultaneously with the amendment or novation of this Agreement and other Project Documents executed between OPGC and GRIDCO in favour of the Selectee as mentioned in Clause 1(b) above.

5 **Modality for Substitution**

The Lenders shall in addition to any other criteria that they may deem fit and necessary, apply the following criteria in the selection of the Selectee:

(a) if OPGC is proposed to be substituted during the Construction Period, the Selectee shall possess the technical and financial capability used to perform and discharge all the residual duties, obligations and liabilities of OPGC under this Agreement. If OPGC

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is proposed to be substituted during the Operating Period, this criteria shall not be applicable; and

(b) the Selectee shall have the capability and shall unconditionally consent to assume the liability for the payment and discharge of amounts owing, if any, of OPGC to GRIDCO under and in accordance with this Agreement.

6 Modalities

The following modalities shall be applicable to any substitution of OPGC by the Selectee pursuant to this Agreement:

6.1 The substitution of OPGC by the Selectee shall be deemed to be complete upon the Selectee executing all necessary documents and upon transfer of ownership and complete possession of the Power Station by OPGC, as the case may be, to the Selectee. GRIDCO shall novate all the Project Documents; which they had entered in to with OPGC in order to make the substitution of OPGC by the Selectee effective. The quantum and manner of payment of the consideration payable by the Selectee to OPGC towards purchase of the Power Station and assumption of all the rights and obligations of OPGC under this Agreement and the Project Documents as mentioned in this Agreement shall be entirely between OPGC, Selectee and the Lenders, and GRIDCO shall in no way be responsible to bear the same.

6.2 Upon the substitution becoming effective pursuant to sub-clause 6.1 above, all the rights of OPGC under this Agreement shall cease to exist.

Provided that, nothing contained in this sub-clause shall prejudice any pending/ subsisting claims of OPGC against GRIDCO or any claim of GRIDCO against OPGC prior to such termination.

6.3 The Selectee shall, subject to the terms and conditions of the substitution have a period of ninety (90) days to rectify any breach and/ or default of OPGC, subsisting on the date of substitution and required to be rectified and shall incur the liability or consequence on account of any previous breach and/ or default of OPGC.

6.4 The decision of the Lenders in the selection of the Selectee shall be final and binding on OPGC and shall be deemed to have been made with the concurrence of OPGC. OPGC expressly waives all rights to object or to challenge such selection and appointment of the Selectee on any ground whatsoever.

6.5 The Lenders shall be solely and exclusively responsible for obtaining any and all consents/ approvals or cooperation, which may be required to be obtained from OPGC under this Agreement and GRIDCO shall not be liable for the same.

7 OPGC's Waiver

7.1 Subject to the terms of the Financing Agreements, OPGC irrevocably agrees and consents (to the extent to which applicable Law may require such consent) to any actions of the Lenders exercising their rights under and in accordance with these terms.

7.2 OPGC irrevocably agrees and consents (to the extent to which applicable law may require such consents) that from the date specified in Clause 6.2 above, it shall cease to have any rights under this Agreement or the Financing Agreements other than those expressly stated therein.

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8 Substitution Consideration

8.1 The Lenders and GRIDCO shall be entitled to appropriate any consideration received for the substitution of OPGC as hereinabove provided from the Selectee towards the payment of Lenders' and GRIDCO's respective dues, to the exclusion of OPGC.

8.2 OPGC shall be deemed to have nominated, constitutes and appoints the Lenders as its constituted attorney for doing all acts, deeds and things as may be required to be done for the substitution of OPGC by the Selectee pursuant to these terms.

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ANNEXURE-2

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Government of Odisha
Department of Energy
*****

NOTIFICATION

No. 10485 / En, Bhubaneswar, Date. 20/12/18
OPGC- 25/2018

Sub.: Arrangements for contracting of power through a Power Purchase Agreement (PPA) from 1320 MW Unit-3 & 4 Expansion project of OPGC.

1. As per the approval of the State Cabinet, a Notification bearing No. 10061 dated 12.10.2009 was issued for resolving the issues pertaining to tariff of Unit-1&2 and for enabling early commissioning of Unit-3&4 of OPGC. The Para.4 of the Notification stipulated that:

   "OPGC shall take expeditious steps to commission Unit-3&4 with installed capacity of 2x660 MW with adoption of super critical technology and shall make half of the power generated from these Units available to GRIDCO. Since both the units will not be commissioned at a time, OPGC is allowed to share 50% of the power generated from the 3rd unit to GRIDCO and sell the balance 50% power for a period of 6 months within which the 4th unit shall be commissioned. In case the 4th unit is not commissioned within 6 months of commissioning of the 3rd unit, minimum power to be shared with State / GRIDCO from the expansion unit of OPGC would be 450 MW instead of 420 MW."

2. Consequent to this Notification, PPA has been executed between OPGC and GRIDCO for 50% of the capacity of the expansion project i.e. 660 MW. The balance 50% of the capacity was to be sold by OPGC in the open market. However, due to several developments in the power sector extraneous to OPGC, it has not been possible for OPGC to tie up the balance 50% power in suitable arrangements outside GRIDCO. In the meanwhile, in order to secure fuel for the plant OCPL (a joint venture Company between OPGC & OHPC) has been formed and Manoharpur & dip side Manoharpur coal blocks have since been allocated to OCPL. The coal mined from these blocks is meant to be utilised for the end-use plants of OPGC.

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

3. It is therefore necessary to tie up the entire power from Unit-3&4 projects of OPGC with GRIDCO in a mutually beneficial arrangement to enhance the long term energy security of the State.

4. After careful consideration, Government have been pleased to approve the arrangement worked out in the "Shareholders' meeting of OPGC" to contract the PPA for the entire capacity of Unit-3 & 4 between OPGC and GRIDCO in the following manner:

(i) OPGC and GRIDCO shall execute a supplementary Agreement to the existing PPA on same terms as the executed PPA for 50% (660 MW), for another 25% (330 MW) of OPGC expansion capacity, to be effective from COD of Units 3&4, till 31st March, 2023. The Supplementary Agreement shall also include enhancement of the PPA from 75% to 100% from 1st April 2023 for a period of 25 years thereafter.

(ii) Supplementary Agreement shall provide for amendment of the existing PPA for 50% of OPGC-II expansion capacity (660 MW) to be co-terminus with the arrangement as proposed in (i) above and to incorporate changes with respect to coal sourcing from OCPL.

(iii) Further, OPGC and GRIDCO will enter into a separate Power Purchase Agreement for balance 50% of Unit-4 (330 MW) for first four years on best effort basis with mutually agreed margin for GRIDCO. The agreed threshold limit of tariff would be Energy Charge Rate (ECR) (Variable Cost). The net excess amount, if any, realised over and above, the total tariff (fixed charges and for energy charge rate), other direct expenses and the mutually agreed margin of GRIDCO shall be shared equally between OPGC and GRIDCO for their portion of the capacity.

(iv) OPGC should ensure that it is not classified as NPA with any FIs/ Banks and drawal of loan would continue as required for completion of the project. It should also endeavour for achieving cost savings to manage the cash flows, without insisting for further equity from shareholders to support cash loss situation, if any.

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(v) OPGC, GRIDCO and OPTCL shall ensure evacuation of the entire capacity of expansion project of OPGC through STU (OPTCL) network in due course.

(vi) Shareholders would infuse the committed equity in OPGC and OCPL for completion of the project in time so as to allow timely drawal of loan.

(vii) OPGC, GRIDCO, OPTCL and Department of Energy, Government of Odisha will take necessary approval from OERC for above arrangements.

By order of the Governor

18.12.18

Commissioner-cum-Secretary to Govt.

Memo No. 10486 / En, Date. 20/12/2018

Copy along with softcopy (word format) forwarded to the Deputy Director, Printing Stationery and publication, Odisha, Madhupatna, Cuttack (deputydirectorpp@rediffmail.com) / C&T (Commerce) Department, Gazette Cell with a request to publish the Notification in the next issue of Odisha Gazette and to supply 50 copies of the same to this Department.

Sangram Keshari Swain
18.XII.18
Special Secretary to Government

Memo No. 10487 / En, Date. 20/12/2018

Copy forwarded to PS to Additional Chief Secretary to Hon'ble Chief Minister, Odisha/ PS to Hon'ble Minister, Energy/ Sr. PS to Chief Secretary/ PS to DC-cum-Additional Chief Secretary/ PS to Additional Chief Secretary, Steel & Mines Deptt./ PS to Principal Secretary, PE Deptt./ PS to Principal Secretary, Finance Deptt./ PS to Principal Secretary, Law Deptt./ Sr. Pr. PS to Commissioner-cum-Secretary, Energy Deptt./ CMD, GRIDCO & OPTCL, Bhubaneswar/ Secretary, OERC, Bhubaneswar/ MD, OPGC, Bhubaneswar/ Director (Finance) OPGC, Bhubaneswar/ Director (Commerce) GRIDCO, Bhubaneswar/ Vice President, AES Corporation, HIG-4, Jayadev Vihar, Bhubaneswar for favour of kind information and necessary action.

Sangram Keshari Swain
18.XII.18
Special Secretary to Government

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

ANNEXURE-3

भारतीय गैर न्यायिक

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SUPPLEMENTARY AGREEMENT TO THE POWER PURCHASE AGREEMENT ENTERED INTO BETWEEN GRIDCO AND OPGC DATED 4TH JANUARY 2011, FOR SALE OF POWER FROM UNITS 3 & 4 OF OPGC EXPANSION PROJECT HAVING INSTALLED CAPCITY OF 2X660 MW (1320 MW)

This **SUPPLEMENTARY POWER PURCHASE AGREEMENT** hereinafter called the "**SupplementaryAgreement**" is entered into at Bhubaneswar on the 24 th Day of January, 2019:

BY AND BETWEEN

ODISHA POWER GENERATION CORPORATION LIMITED, a company incorporated under the Companies Act, 1956 and having its registered office at Zone-A, 7th Floor, Fortune Towers, Chandrasekharpur, Bhubaneswar – 751 023, District Khurda, Odisha, India (hereinafter called as "**OPGC**"), which expression shall unless repugnant to the context or meaning thereof include its successors and permitted assigns, as a party of the **FIRST PART**;

AND

GRIDCO LIMITED, a company incorporated under the provisions of the Companies Act, 1956 and having its registered office at Janpath, Bhubaneswar – 751 022, District Khurda, Odisha, India (hereinafter called as "**GRIDCO**"), formerly known as Grid Corporation of Odisha Limited, which expression shall unless repugnant to the context or meaning thereof include its successors and permitted assigns, as a party of the **SECOND PART**.

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OFFICE OF THE DIRECTOR (COMML.) GRIDCO LIMITED BBSR

Odisha Power Generation Corporation Ltd. Bhubaneswar

ODISHA POWER GENERATION CORPORATION LTD.

WHEREAS:

A. OPGC and GRIDCO have entered into a Power Purchase Agreement (PPA-2) dated 4th January 2011, for sale of power equal to 50% of the Installed Capacity from the Power Station. The PPA 2 was subsequently filed by GRIDCO before the Odisha Electricity Regulatory Commission (OERC) on dated 30.12.2011 under Section 86 of the Electricity Act 2003, read with Section 21 of the Odisha Electricity Reforms Act 1995. OERC, after a hearing held on 17.02.2012, passed an order dated 04.04.2012, approving the PPA 2.

B. OPGC commenced construction of the Power Station from March 2014 for the main plant consisting of 2 x 660 MW supercritical units, at the same location as its existing plant situated at Ib Thermal Power Station Complex, Banharpalli, under Jharsuguda District of Odisha.

C. OPGC, which was allotted Manoharpur and Dip Side Manoharpur coal blocks in July 2007, under Government Dispensation route, had commenced development of the coal blocks including land acquisition and other permits and clearances required for commencing operations. The Supreme Court in a judgement in September 2014,cancelled allocation of coal blocks allotted for captive use for both power and non-power purposes. The coal blocks allotted to OPGC were also de-allocated pursuant to the Supreme Court judgement. Pursuant to the de-allocation process, the Government of India issued the Coal Mine Special Provisions Ordinance, 2014 (subsequently enacted as the Coal Mine Special Provisions Act, 2015) and Rules thereunder, in accordance with which, the Manoharpur and Dip Side Manoharpur Coal Blocks were allotted to Odisha Coal and Power Ltd. (OCPL), a joint venture company of OPGC holding 51% equity shares and Odisha Hydro Power Corporation Ltd. (OHPC) holding 49% equity shares, for the end use of OPGC Expansion Project, i.e. Units 3, 4, 5 and 6. The allotment agreement for allotment of Manoharpur and Dip Side Manoharpur Coal Blocks to OCPL was executed on 31st August 2015.

D. Whereas Government Of Odisha issued a Notification dated 20th December, 2018, outlining arrangement for sale of power on regulated basis, relevant clauses of which are reproduced as provided below,

4.After careful consideration, Government have been please to approve the arrangement worked out in the " Shareholder's meeting of OPGC" to contract the PPA for the entire capacity of Unit3 & 4 between OPGC and GRIDCO in the following manner:

(i) OPGC and GRIDCO shall execute a Supplementary Agreement to the existing PPA on same terms as the executed PPA for 50% (660 MW), for another 25% (330 MW) of OPGC expansion capacity, to be effective from COD of Units 3&4, till 31st March, 2023. The Supplementary Agreement shall also include enhancement of the PPA from 75% to 100% from 1st April 2023 for a period of 25 years thereafter.

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(ii) *Supplementary Agreement shall provide for amendment of the existing PPA for 50% of OPGC-II expansion capacity (660 MW) to be co-terminus with the arrangement as proposed in (i) above and to incorporate changes with respect to coal sourcing from OCPL*

(iii) *Further, OPGC and GRIDCO will enter into a separate Power purchase Agreement for balance 50% of Unit-4(330 MW) for first four years on best effort basis with mutually agreed margin for GRIDCO. The agreed threshold limit of tariff would be Energy Charge Rate (ECR) (Variable Cost).The net excess amount , if any, realised over and above, the total tariff (fixed charges and for energy charges rate), other direct expenses and the mutually agreed margin of GRIDCO shall be shared equally between OPGC and GRIDCO for their portion of the capacity.*

(iv) *OPGC should ensure that it is not classified as NPA with any FIs/Banks and drawal of loan would continue as required for completion of the project. It should also endeavour for achieving cost savings to manage the cash flows, without insisting for further equity from shareholders to support cash loss situation, if any.*

(v) *OPGC, GRIDCO and OPTCL shall ensure evacuation of the entire capacity of expansion project of OPGC through STU (OPTCL) network in due course.*

(vi) *Shareholders would infuse the committed equity in OPGC and OCPL for completion of the project in time so as to allow timely drawal of loan.*

(vii) *OPGC, GRIDCO, OPTCL and Department of Energy, Government of Odisha will take necessary approval from OERC for above arrangements.*

The True copy of the said Notification is annexed herewith as **Annexure-A** to this Supplementary Agreement.

The Parties are now entering into this Agreement to amend the terms of the Power Purchase Agreement dated 4th January 2011 (PPA 2) to the extent of adhering to the revised understanding reached between the Parties and the GoO.

NOW THEREFORE, IN CONSIDERATION OF THE PREMISES AND MUTUAL AGREEMENTS, COVENANTS AND CONDITIONS SET FORTH HEREIN, IT IS HEREBY AGREED BY AND BETWEEN THE PARTIES AS FOLLOWS:

1) **AGREEMENT REACHED BETWEEN THE PARTIES**

a. The Contracted Capacity from Units 3 & 4 shall be equal to 75% of the Installed Capacity from the Commercial Operation Date (COD) of the Power Station till 31stMarch 2023. Thereafter, from 1st April 2023 for a further period of 25 years therefrom, the Contracted Capacity shall be enhanced to 100% of the Installed Capacity. The Tariff for such Contracted Capacity shall be determined in accordance with the CERC Tariff Regulations as envisaged in PPA 2

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b. To give effect to the above arrangements described in (a) above, and to record the supply of coal from OCPL, specific provisions of the existing PPA-2 as set forth in **Annexure – B**, are hereby amended to include the enhanced Contracted Capacity and forms an integral part of this SupplementaryAgreement.

c. GRIDCO intends to schedule all power from OPGC Expansion Project (Unit #3 and #4) through the OPTCL (STU) network and pay all the applicable charges thereof. Payment liability of any potential Point of Connection (POC) Charges and Losses associated with the usage of CTU network with respect to the additional power beyond 50% of station capacity if scheduled from Unit-4, will be mutually settled between GRIDCO & OPGC at a later stage.

2. **OTHER PROVISIONS**

2.1 This SupplementaryAgreement shall become effective from the date of its execution.

2.2 The amendments made by this SupplementaryAgreement shall form an integral part of PPA 2 and on and from the date hereof any reference to PPA 2, shall include a reference to PPA 2, with amendments made in this Supplementary Agreement. This SupplementaryAgreement together with PPA 2 shall be read and construed as one document.

2.3 Except for the amendments made to PPA 2 as provided in this SupplementaryAgreement, all the other terms and conditions of PPA 2, shall remain in full force and effect.

2.4 This SupplementaryAgreement may be executed in two (2) counterparts by the Parties, each of which when so executed and delivered shall be an original and the other counterpart shall together constitute one and the same instrument.

2.5 This SupplementaryAgreement shall be governed by, and construed in accordance with, the laws of India and the dispute resolution procedure set out at Clause 17.3 of PPA 2 shall apply *mutatis mutandis* to this SupplementaryAgreement.

2.6 Capitalized terms used but not defined in this SupplementaryAgreement have the same meaning ascribed to them in PPA – 2.

2.7 The PPA 2 (Dated 04.01.2011) will be suitably amended in line with the Government of Odisha Notification 10485 dated 20.12.2018, direction of OERC vide Order dated 04.04.2012 in Case No.113 of 2011 and this Supplementary Agreement. The Supplementary Agreement and the Amendments to PPA 2 shall be filed before OERC for necessary approval.

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IN WITNESS WHEREOF the Parties have executed these presents through their authorized representatives at Bhubaneswar.

For and on behalf of [GRIDCO]

MKDas

Signature with seal
Shri Manas Kumar Das
Director (Commercial)
GRIDCO Limited, BBSR

Witness:

1. Ssnayak
(S.S.NAYAK), Sr.GM,PP
2. (P.K.DAS), G.M (Elect.)

For and on behalf of [OPGC]

Indranil Dutta

Signature with seal
Managing Director
Odisha Power Generation Corporation Ltd.
Bhubaneswar

Witness:

1. Ritwik Mishra
(RITWIK MISHRA) GM, CRA, OPGC
2. Manoranjan Mishra
(MANORANJAN MISHRA Company Secretary OPGC)

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ANNEXURE- A

Government of Odisha
Department of Energy
*****

NOTIFICATION

No. 10485 / En, Bhubaneswar, Date. 20/12/18
OPGC- 25/2018

Sub.: Arrangements for contracting of power through a Power Purchase Agreement (PPA) from 1320 MW Unit-3 & 4 Expansion project of OPGC.

1. As per the approval of the State Cabinet, a Notification bearing No. 10061 dated 12.10.2009 was issued for resolving the issues pertaining to tariff of Unit-1&2 and for enabling early commissioning of Unit-3&4 of OPGC. The Para.4 of the Notification stipulated that:

    "OPGC shall take expeditious steps to commission Unit-3&4 with Installed capacity of 2x660 MW with adoption of super critical technology and shall make half of the power generated from these Units available to GRIDCO. Since both the units will not be commissioned at a time, OPGC is allowed to share 50% of the power generated from the 3rd unit to GRIDCO and sell the balance 50% power for a period of 6 months within which the 4th unit shall be commissioned. In case the 4th unit is not commissioned within 6 months of commissioning of the 3rd unit, minimum power to be shared with State / GRIDCO from the expansion unit of OPGC would be 450 MW instead of 420 MW."

2. Consequent to this Notification, PPA has been executed between OPGC and GRIDCO for 50% of the capacity of the expansion project i.e. 660 MW. The balance 50% of the capacity was to be sold by OPGC in the open market. However, due to several developments in the power sector extraneous to OPGC, it has not been possible for OPGC to tie up the balance 50% power in suitable arrangements outside GRIDCO. In the meanwhile, in order to secure fuel for the plant OCPL (a joint venture Company between OPGC & OHPC) has been formed and Manoharpur & dip side Manoharpur coal blocks have since been allocated to OCPL. The coal mined from these blocks is meant to be utilised for the end-use plants of OPGC.

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3. It is therefore necessary to tie up the entire power from Unit-3&4 projects of OPGC with GRIDCO in a mutually beneficial arrangement to enhance the long term energy security of the State.

4. After careful consideration, Government have been pleased to approve the arrangement worked out in the "Shareholders' meeting of OPGC" to contract the PPA for the entire capacity of Unit-3 & 4 between OPGC and GRIDCO in the following manner:

   (i) OPGC and GRIDCO shall execute a supplementary Agreement to the existing PPA on same terms as the executed PPA for 50% (660 MW), for another 25% (330 MW) of OPGC expansion capacity, to be effective from COD of Units 3&4, till 31st March, 2023. The Supplementary Agreement shall also include enhancement of the PPA from 75% to 100% from 1st April 2023 for a period of 25 years thereafter.

   (ii) Supplementary Agreement shall provide for amendment of the existing PPA for 50% of OPGC-II expansion capacity (660 MW) to be co-terminus with the arrangement as proposed in (i) above and to incorporate changes with respect to coal sourcing from OCPL.

   (iii) Further, OPGC and GRIDCO will enter into a separate Power Purchase Agreement for balance 50% of Unit-4 (330 MW) for first four years on best effort basis with mutually agreed margin for GRIDCO. The agreed-threshold limit of tariff would be Energy Charge Rate (ECR) (Variable Cost). The net excess amount, if any, realised over and above, the total tariff (fixed charges and for energy charge rate), other direct expenses and the mutually agreed margin of GRIDCO shall be shared equally between OPGC and GRIDCO for their portion of the capacity.

   (iv) OPGC should ensure that it is not classified as NPA with any FIs/ Banks and drawal of loan would continue as required for completion of the project. It should also endeavour for achieving cost savings to manage the cash flows, without insisting for further equity from shareholders to support cash loss situation, if any.

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(v) OPGC, GRIDCO and OPTCL shall ensure evacuation of the entire capacity of expansion project of OPGC through STU (OPTCL) network in due course.

(vi) Shareholders would infuse the committed equity in OPGC and OCPL for completion of the project in time so as to allow timely drawal of loan.

(vii) OPGC, GRIDCO, OPTCL and Department of Energy, Government of Odisha will take necessary approval from OERC for above arrangements.

By order of the Governor

18.12.18

Commissioner-cum-Secretary to Govt.

Memo No. 10486 / En, Date. 20/12/18

Copy along with softcopy (word format) forwarded to the Deputy Director, Printing Stationery and publication, Odisha, Madhupatna, Cuttack (deputydirectorpp@rediffmail.com) / C&T (Commerce) Department, Gazette Cell with a request to publish the Notification in the next issue of Odisha Gazette and to supply 50 copies of the same to this Department.

Sanjeeb Kesari Swain
18. XII. 18
Special Secretary to Government

Memo No. 10487 / En, Date. 20/12/2018

Copy forwarded to PS to Additional Chief Secretary to Hon'ble Chief Minister, Odisha/ PS to Hon'ble Minister, Energy/ Sr. PS to Chief Secretary/ PS to DC-cum-Additional Chief Secretary/ PS to Additional Chief Secretary, Steel & Mines Deptt./ PS to Principal Secretary, PE Deptt./ PS to Principal Secretary, Finance Deptt./ PS to Principal Secretary, Law Deptt./ Sr. Pr. PS to Commissioner-cum-Secretary, Energy Deptt./ CMD, GRIDCO & OPTCL, Bhubaneswar/ Secretary, OERC, Bhubaneswar/ MD, OPGC, Bhubaneswar/ Director (Finance) OPGC, Bhubaneswar/ Director (Commerce) GRIDCO, Bhubaneswar/ Vice President, AES Corporation, HIG-4, Jayadev Vihar, Bhubaneswar for favour of kind information and necessary action.

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OFFICE OF THE DIRECTOR (COMML.) GRIDCO LIMITED BBSR

Sanjeeb Kesari Swain
18. XII. 18
Special Secretary to Government

Indranil Dutta

Odisha Power Generation Corporation Ltd. Bhubaneswar

ANNEXURE - B

PROPOSED AMENDMENTS TO PPA 2

A. **Proposed amendments for enhancement of capacity from 50% to 75% from date of COD to 31/03/2023 & 100% from 01/04/2023 for 25 years thereafter are set out below. Pursuant to discussions, the Parties will set out the amendments to PPA-2 in more detail.**

Sr	Reference	Existing Provision	Amended Provision
		(I) Change in Definitions	
1.	*Article-1, 1.1: Definitions*	***"Expiry Date"** means the Twenty Fifth (25^{th})……. on 01 January, 2040, i.e. in the Contract Year 2039-40;*	**"Expiry Date"** means 31 March 2048
		(II) Sale & Purchase of Power	
2.	*Article-7*	**Clause 7.2.1:** *"GRIDCO's entitlement to the power generation from the Power Station shall at all times be its Contracted Capacity of fifty percent (50%) of the Installed Capacity. Provided …………"*	**Clause 7.2.1:** *"GRIDCO's entitlement to the power generation from the Power Station, i.e. the Contracted Capacity shall:* *(i) from the COD of the Power Station till 31 March 2023, be equal to seventy-five percent (75%) of the Installed Capacity; and* *(ii) From 1st April 2023, be equal to 100% of the Installed Capacity till Expiry Date.* *It is clarified that after the commissioning of Unit 3 or Unit 4 of the Power Station (whichever unit achieves COD earlier), and till the COD of the second Unit, GRIDCO's entitlement shall be 75% of the Installed Capacity of First Unit to achieve COD.* *The remaining part of 7.2.1 shall be completely deleted.*
3.	*Schedule-3*	*Schedule-3: Power Share Table*	*Modified Power Sharing Table is set out as Exhibit – A to the Supplementary Agreement. (Amended Table is provided below)*

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Sr	Reference	Existing Provision	Amended Provision
4.	*Schedule-5*	*Recital F of the Supplemental Escrow Agreement:* *In furtherance of the terms of the Amended Tripartite Agreement, ………… fifty percent (50%) power to be generated from Power Station.*	*Recital F of the Supplemental Escrow Agreement:* *In furtherance of the terms of the Amended Tripartite Agreement, ………… fifty percent (50%) power to be generated from Power Station.Subsequently, pursuant to supplementary agreement dated [] to PPA 2, it was agreed that GRIDCO will procure 75% of the Installed Capacity from the COD of the Power Plant till 31 March 2023 and 100% of the Installed Capacity from 1st April 2023 onwards till Expiry Date.*

Schedule 3: Indicative Power Sharing Table

	Scenarios	Installed capacity (MW)	Entitlement of GRIDCO	Availability of the Power Station	Total Generation of the Power Station equivalent to Availability	GRIDCO's share in terms of Availability	OPGC's share in terms of Availability
		(MW)	(%)	(%)	(MW)	(MW)	(MW)
A.	On Commissioning of Unit–3 or Unit-4 (whichever occurs earlier) and six months thereafter till commissioning of the subsequent Unit.	660	75%	100	660	495	165
				85	561	421	140
B	Upon commissioning of Unit-3 or unit-4 (whichever occurs later) and delayed beyond six (6) months from commissioning of the earlier unit(To Fulfill the condition of Notification dated 12.10.2009)	660	75%	100	660	495	165
				85	561	421	140

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	Scenarios	Installed capacity (MW)	Entitlement of GRIDCO	Availability of the Power Station	Total Generation of the Power Station equivalent to Availability	GRIDCO's share in terms of Availability	OPGC's share in terms of Availability
		(MW)	(%)	(%)	(MW)	(MW)	(MW)
C	Upon Commissioning of Unit–3 and Unit-4, i.e. COD of the station (whichever occurs later) until 31 March 2023.	1320	75%	100	1320	990	330
				85	1122	842	281
D	From COD of the Station onwards till 31st March 2023 (Both Unit-3 and Unit-4 Commissioned but one unit operational and the other under outage).	660	75%	100	660	495	165
				85	561	421	140
E	From 1 April 2023 onwards (for Both Unit-3 and Unit-4)	1320	100%	100	1320	1320	0
				85%	1122	1122	0
F	From 1 April 2023 onwards (Both Unit-3 and Unit-4 Commissioned but one unit operational and the other under outage).	660	100%	100	660	660	0
				85	561	561	0

Note:- The Availability of 85% has been considered as per the normative NAPAF as per the CERC Regulations in effect, to show Sharing of power (Indicative).

B. <u>Proposed amendments to incorporate change in source of coal from captive mines to that of Odisha Coal and Power Ltd. (OCPL)</u>

As allotment of Manoharpur and Dip Side Manoharpur coal mines to OPGC were cancelled by the Hon'ble Supreme Court of India vide its judgment dated 25.08.2014 in W.P. (Criminal.) No. 120 of 2012 and subsequently the same mines were allotted to Odisha Coal and Power Ltd. ("OCPL") vide allotment agreement dated 31st August 2015, for specific end use of OPGC Expansion Units 3,4,5 & 6, hence all references and covenants in connection with the "Captive Coal Mines" as defined in the PPA 2, shall not apply anymore and stand deleted.

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C. All references to UI or unscheduled interchange shall be construed as payments under the CERC (Deviation Settlement and Related Matters) Regulations, 2014, as amended from time to time shall be applicable to OPGC.

D. Reference to "Fuel Supply Agreement" shall include a reference to Fuel Supply Agreement to be entered into between OPGC and OCPL.

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ANNEXURE-4

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OPGC
Power for Progress

IB THERMAL POWER STATION
2 x 660 MW UNITS 3 & 4
JHARSUGUDA, ODISHA

DOCUMENT NO.: K8B09-DPR-G-001

DETAILED PROJECT REPORT

CONSULTANT

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
Development Consultant House, Block - DG/4,
Saltlake City, Sector - II, Kolkata - 700 091, INDIA

ODISHA POWER GENERATION CORPORATION LTD.
BHUBANESWAR

DETAILED PROJECT REPORT FOR IB TPS - 2 X 660 MW UNITS 3 & 4 Jharsuguda, Odisha

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SECTION-1

INTRODUCTION AND EXECUTIVE SUMMARY

1.1 INTRODUCTION

Odisha Power Generation Corporation Limited (OPGC) is now setting up 1320 MW (2 x 660 MW) Thermal Power adjacent to its existing 2 x 210 MW Power Plant at IB Thermal Power Station in Banharapalli, Jharsuguda district in the North-west of Odisha.

Odisha Power Generation Corporation Limited (OPGC) was incorporated by the Government of Odisha in 1984 as a fully owned corporation of the Government of Odisha. As a part of the restructuring of the power sector in the state, the government of Odisha divested 49 per cent of its equity in the Corporation in January, 1999 through an international competitive bidding process and the stake was picked up by AES Corporation, USA. AES Corporation is a global power generation and distribution company with stakes in 132 power plants in 29 countries. As such, AES Corporation provides its technical and managerial expertise in the day-to-day working of the company.

Two (2) units of 210 MW capacity each came up in the first phase of construction at IB Thermal Power Station. OPGC commissioned its first 210 MW unit at IB TPS on 21st December, 1994. Ever since its inception, the project has been making profits, with the plant load factor steadily increasing from around 36% in 1994 to 83%90% in 2006-07 and now around 75% in 2017-18.

The Company is now developing the expansion Project 2x660 MW on EPC concept of following work packages –

i. Main Power Plant,

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ii. Balance of Plant,

iii. Merry Go Round system

iv. Ash Pond,

v. Ash Water Recycling System

The Power plant work is split into two major packages - Main Plant package comprising boiler, turbine and other auxiliaries within BTG Island and Balance of Plant package covering Coal Handling Plant (CHP), Water Treatment Plant (WTP), Ash Handling Plant (AHP), etc.

The objective of this Detailed Project Report is to establish the project details such as site features, basic plant configuration, salient technical features, project execution plan, and the financial requirements of the entire project.

The land for the Power block and associated auxiliaries has already been acquired by OPGC. The identified land for the power station has the advantage from the point of view of:

a) Utilization of the infrastructure developed for the existing 2 x 210 MW units adjacent to the site.

b) Availability of adequate habitation-free, non-agricultural land which is partially developed and above flood level.

c) Availability of sufficient water of appropriate quality on perennial basis from the Hirakud reservoir.

d) Supply of adequate fuel (coal) with effective transportation system to ensure the least delivered cost of fuel at the plant site.

e) Proximity of highways for transport of secondary fuel and heavy equipment.

f) Facility of interconnection with transmission system for evacuation of power.

g) Environmental considerations.

h) Demand for power in the region.

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1.2 EXECUTIVE SUMMARY

It has been observed from the statistical figures on power demand and energy requirements in the 17th Electric Power Survey (EPS), published by Central Electricity Authority (CEA) under the Ministry of Power, Government of India, that the energy demand/supply position for Odisha 12th Five Year Plan require substantial capacity addition particularly in thermal sector. In order to bridge the gap between the demand and supply, immediate capacity addition in the thermal sector is necessary. Keeping this in mind, 2 x 660 MW units 3 & 4 of the IB Thermal Power Station is implemnetd during the 12th Plan Period, which shall add 1320 MW additional capacity to the existing station.

In **Section-2** of this report, the justification of the project along with the energy and peak power demand vis-à-vis unit size selection are discussed.

In **Section-3** of this report the basic requirements for a thermal power station vis-à-vis availability at the designated site has been elaborated. The expansion units would require around 400 hectares of land and around 4100 cum/hr of raw water for condenser cooling circuit and other plant purposes and 7.6 million ton of coal per year for operation of the 2 x 660 MW station at a planned plant load factor of 90% are required. The site has the following advantages:

- Availability of uninhabited land.
- Proximity to dedicated mines leading to low fuel transportation cost.
- Availability of good infrastructural facility of existing units.
- Availability of road linkage with national & state highways at Jharsuguda town.

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In **Section-4** of this report, the features of the selected site are discussed. The power project is the expansion of the existing IB Thermal Power Station at Banaharpalli in Jharsuguda District, in the state of Odisha in India. The site is geographically located at Latitude 21° 48' North and Longitude 83° 52' East and the elevation of the site is around 199.5 m above MSL. The main Howrah-Mumbai railway line passes 20 km north of the plant (at Belpahar). The plot is above the highest flood level of the area. Water requirements of the expansion units shall be met through the existing raw water intake channel from the Hirakud reservoir.

In **Section-5** of this report, the technical features of the 660 MW set size outlining the design parameters of main plant and equipment are discussed. A reheat steam cycle with regenerative feed heating arrangement operating in sliding pressure mode with supercritical steam parameters has been utilized. Application of supercritical technology will improve the power cycle efficiency to around 42% while reducing the emissions from the power plant.

In **Section-6** of this report, the auxiliary systems of the power generating units are discussed. All auxiliaries and accessories would deploy the state-of-the-art technology to ensure safe and continuous operation of the unit with minimum unscheduled outage.

The existing 5.6 km raw water intake channel connecting the IB Thermal Power Station with the Hirakud reservoir shall also cater to the water requirements for these 2 x 660 MW units 3 & 4. Recirculating water cooling system with Induced Draft cooling towers using clarified quality water is envisaged for the station.

Coal with about 3200 Kcal/kg of overall heat value is planned for the power station use. A 2800 TPH twin-stream conveying system is constructed for the station.

Bottom Ash shall be safely disposed of to the existing Ash Pond in lean slurry form without causing damage to the environment. Fly ash from

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the power plant shall be evacuated in dry form and disposed through HCSD system to the Ash Pond of Units 3 & 4 for first five years and later on transported to mine for mixing with OB and backfilling.

In **Section-7** of this report, the electrical equipment and systems are discussed. The electric generators would be 3-phase, 50 Hz, hydrogen-cooled, 3000 rpm machine with brushless excitation system and would generate power at 21 KV as per manufacturer's standard at 0.85 power factor (lagging). The electrical system would be equipped with adequately sized equipment and with generous redundancy to ensure uninterrupted operation.

In **Section-8** of this report, instrumentation and control philosophy of the station is dealt in adequate details. The station envisages the state-of-the-art Distributed Digital Control, Monitoring & Information System (DDCMIS) which will integrate various closed loop sub-systems, open loop sub-systems, monitoring and information sub-system covering the entire plant. The system will also integrate the various proprietary control packages supplied by the main equipment vendors for harmonious plant operation.

Details of basic plant features and the relevant layout within the identified plot are furnished in **Section-9** of this report.

The plant layout for the station has been developed keeping in view optimum use of land available within the identified plot, land

contour, wind rose pattern of the area, direction of supplies of input, direction of road access, coal conveyor entry, utilisation of the spare capacity of the existing units to the maximum extent possible, operational ease and initial investment requirement.

To minimise emission of Suspended Particulate Matter (SPM) along with boiler flue gases Electrostatic Precipitators of adequate size will be provided at the exit of each boiler to bring down SPM emission level under 50 mg/ Nm^3. A twin-flue 275 m high stack is envisaged for the 2 x 660 MW units 3 & 4. Liquid effluents from the plant will be properly treated before re-use. A detailed scheme for the unit has been provided in **Section-10** along with general discussion on the entire environmental aspects.

The project would be implemented on Engineering, Procurement & Construction (EPC) mode in two major packages, namely, Main Pant Package and Balance of Plant Package. The performance guarantees, timeframe and the penalty clauses shall be well defined in the contract with the package vendors. As such, the package Contractors will arrange all the construction equipment. Project authority would provide clear site, statutory clearances etc. to the Contractor. In **Section-11** of this report, the construction facilities have been discussed.

In **Section-12** of this report, O&M staff requirement for operating and maintaining the plant is narrated. It is assumed that some of the functions during annual maintenance would be contracted out. A total manpower requirement of 400 persons has been envisaged for the units 3 & 4. This may undergo revision as per project authority's own model of manpower deployment. The training requirements of O&M personnel are also discussed under this section.

In **Section-13** of this report, employee facilities and residential township requirement are outlined. An expansion of the existing township would be necessary to accommodate the plant personnel of the expansion units.

The project execution, monitoring and control, project schedule, have been discussed under **Section-14** of this report. The project is to be implemented through EPC concept by reputed, experienced and financially sound Contractors to ensure timely completion. Project authority has already engaged the services of an Owners' engineer in formulating the concepts, systems, basic and detailed engineering,

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procurement, construction, management services, Erection and testing management services, inspection, quality control, expediting and Project management. Some of the enabling works viz. land grading, construction of in-plant roads at the site, boundary wall, etc. would also be undertaken by the contractor. The project (two units) is planned to be implemented and will be handed over for commercial operation within a timeframe of 52 months from the date of placement of order to the Main Plant contractor.

Based on available quotes and in-house data, the project cost estimate has been worked out. A total capital outlay of Rs. 101650 million including interest during construction and margin money for working capital, would be involved. The details are furnished below:-

Areas of Contract	Approved Project Cost
BTG	3,892.00
BOP	2,877.00
MGR Land	114.00
MGR(Civil works)	670.00
Power Plant Colony	35.00
Residential Colony	200.00
Ash pond construction	289.00
400 KV Line	30.00
Development Expenses	44.00
CSR cost	25.00
Startup raw material & Fuel	300.00
Construction Management	75.00
Construction Insurance	70.00
EPC Contingencies	193.00
Non EPC contingency	88.00
Working Capital margin	40.00
Financing charges and IDC	1,223.00
Total	**10,165.00**

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1.3 PROJECT AT A GLANCE

1.3.1	Owner	ODISHA POWER GENERATION CORPORATION LIMITED
1.3.2	Project site Office Address	IB Thermal Power Station PO – Banaharpalli Dist. – Jharsuguda, Odisha - 768234 India
1.3.3	Registered Office Address (for communication/ correspondence/ contact)	Odisha Power Generation Corporation Ltd. 7th Floor, Zone-A Fortune Towers, Chandrasekharpur, Bhubaneswar - 751023 Odisha, India Tel: 0674-2303765 / 66 Fax: 0674-2303755
1.3.4	Project	2 x 660 MW Units 3 & 4 of IB Thermal Power Station
1.3.5	Location	Banaharpalli village, Jharsuguda, Odisha
1.3.6	Elevation above mean sea level	199.5 M
1.3.7	Nearest Railway Station	Belpahar (20 km)
1.3.8	Nearest Seaport	Paradeep / Haldia
1.3.9	Nearest Airport	Bhubaneswar
1.3.10	Ambient Temperature	
	a) Monthly max. dry bulb temp.	(Summer / Winter / Monsoon) 38.4 °C/28.0 °C/33.4 °C
	b) Monthly min. dry bulb temp.	(Summer / Winter / Monsoon) 25.4°C/16.7 °C/26.8 °C
	c) Design temp. for electrical	Max. 50 °C. (Class F insulation with temp. rise limited to Class B)

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1.3.11	Relative Humidity		
	a)	Maximum	(Summer / Winter / Monsoon) 46% / 67% / 87%
	b)	Minimum	(Summer / Winter / Monsoon) 21% / 33% / 87%
1.3.12	Wet Bulb		
	a)	Daily maximum	(Summer / Winter / Monsoon) 23.9 °C/17.8 °C/25.5 °C
	b)	Daily minimum	(Summer / Winter / Monsoon) 17.6 °C/13.4 °C/25.4 °C
1.3.13	Design Ambient wet bulb temperature for Cooling Tower		27 °C
1.3.14	Wind data		
	a)	Basic wind speed	44 m/s
1.3.15	Seismic data		
	a)	Zone	III (as per IS 1893)
	b)	Basic horizontal seismic coefficient	As per IS 1893
1.3.16	Most Predominant wind direction		From S and SW direction in summer and NE and N direction in winter
1.3.17	Rainfall		
	a)	Max intensity of rainfall per year	2656.6 mm (max) in 1961; 901.0 mm (min) in 1979; 1460 mm (avg.)
	b)	Period of monsoon showers	June - September

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PRELIMINARY PROJECT PARTICULARS

Main Fuel	: Indian coal from Manoharpur and Dip-side Manoharpur coal mine blocks in IB Valley.
Fuel Transportation	: By railway wagons
Water	: From Hirakud reservoir; around 4100 cum/hr of river water required for 2 x 660 MW Units.
Land	: 400 Ha of vacant land adjacent to existing 2 x 210 MW units.
Land Use Pattern & Ownership	: Vegetation-free land, owned by OPGC
Land Development	: The station will be laid in non-terraced manner, with the main power block area graded to an elevation of 199.50 M above MSL.

Technical Features:-

Power Generating Unit	: Two units of 660 MW turbine generator sets fed by steam from pulverised coal fired boiler having supercritical steam parameters.
Cooling System	: Semi-open recirculating condenser cooling system with wet-type induced draft cooling tower.

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OPGC

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Coal Handling System	:	Coal handling facility, which would comprise unloading from railway wagons and stacking by stacker and reclaimer in the coal yard. Coal will be finally transported to the boiler area through conveyors and fed to the bunker level conveyors. System capacity considered is 3000 TPH.
Ash Disposal System	:	Bottom ash shall be extracted in lean slurry form and transported to the Ash pond. Fly ash from the power plant shall be evacuated in dry form and disposed through HCSD system to the Ash Pond of Units 3 & 4 for first five years and later on transported to mine for mixing with OB and backfilling.
Power Evacuation	:	Power from the 2 x 660 MW Units 3 & 4 will be stepped up to 400 kV through Generator transformer and will be evacuated through two (2) nos. 400 kV double circuit transmission lines from plant switchyard to Jharsuguda. One D/C line will be connected to state grid substation at Lapanga and the other D/C will be connected to PGCIL substation at Sundergarh for inter-state power transfer.
Environmental Aspects	:	One 275 m high twin flue stack as per MoEF guidelines with adequately designed electrostatic precipitators to contain SPM and suitably designed waste water treatment to satisfy MoEF notification.
Manpower Requirement	:	400 personnel during plant operation.
Township	:	320 dwelling units would be developed for essential staff in the

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		identified plot for township, thus providing 80% satisfaction level.
Mode of Implementation	:	EPC mode, with two packages – Main Plant Package and Balance of Plant Package for the power plant.
Project Time Frame	:	As presently assessed based on progress of the project, commercial Operation date (COD) of both the unit shall be 31st January 2019

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SECTION-2

NEED FOR THE PROJECT

2.1 INTRODUCTION

Faced with severe power deficit in the Country, the capacity addition in 10th and 11th Plan periods has been planned to fulfill the aims and objectives of the National Electricity Policy of Government of India namely,

i) Every house shall have Access to Electricity within next 5 years.

ii) Demand shall have to be fully met by 2012. Energy and peaking shortages to be overcome and spinning reserve at least 5% at the national level to be ensured.

iii) Per capita electricity consumption over 1000 units by 2012 to be ensured.

iv) Minimum consumption of 1 unit per household per day as a merit good by year 2012.

2.2 ALL INDIA & REGIONWISE POWER SCENARION

Peak Demand & Energy Demand

To meet the vision as enumerated in the above policy, expected Peak demand and Energy Demand as forecast in 17th EPS by CEA are 152,700MW and 968 Billion Units (BU) respectively by 2011-12. Same are expected to be 218,209MW and 1,392BU by 2016-17.

All India Power Scenario as on 2007-08, Peak Demand was 107,791MW having deficit of 15.8% and Energy Demand was 608 BU having deficit of 9.5%. Region-wise, the deficit figures during that period are as follows:

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Region	Peak Demand (MW)	Deficit (%)	Energy Demand (BU)	Deficit (%)
NR	32,462	9	199	10
WR	38,277	23.2	224	15.4
SR	26,913	10.11	171	3.1
ER	11,385	6	69	4.8
NER	1,684	20	8	11.5

(Source: CEA-Power scenario at a glance).

Above power scenario depicts that urgent attention and time bound programme for capacity addition are warranted to meet the "National Electricity Policy 2005"

As per the prevailing situation, of the total installed capacity of 151,073.41 MW under utility sector, hydel generation accounts for 36,916.76 MW, thermal power of 96,794.24 MW, nuclear sector 4,120 MW and non-conventional and renewable energy sources 13,242.41 MW which includes Small Hydro Project (SHP), Biomass Gas (BG), Biomass Power (BP), Urban & Industrial waste Power (U&I), and Wind Energy. Of the thermal generation:

- Coal accounts for 79,208.88 MW
- Gas accounts for 16,385.61 MW and
- Oil accounts for 1,199.75 MW.

The restricted Cumulative Annual Growth Rate (CAGR) in energy consumption, as recorded in the country for past few years ranges between 8.4% and 13.9%. Govt. of India has, thus, laid special emphasis on accelerated rate of capacity addition and also on containing the cost of energy within reasonable limits. For a developing economy, as in India, cost of energy needs to be maintained at an optimum value which will act as catalyst to industrial as well as agricultural growth.

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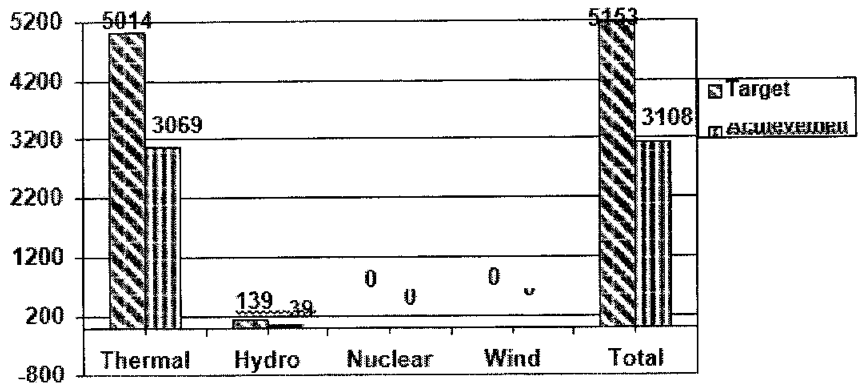
Gross capacity addition in India for past five years is as follows: -

2004-05	:	3949 MW
2005-06	:	3519 MW
2006-07	:	5093 MW
2007-08	:	6485 MW
2008-09	:	3108 MW

(Upto 31ST July 2009) Source : CEA

In all-India context there is considerable mismatch between planned target and actual capacity additions as evidenced by the following bar graph for the period of April '09 to July '09. This puts further pressure on the need for capacity additions in the foreseeable future to bridge the demand-supply gap.



Target & Achievement (MW)
April 2009 - July 2009

Availability of power will improve the overall life style vis-à-vis economic growth at an accelerated rate. This has prompted the entrepreneurs to establish power plants at different locations of the country. Coal being the main source of fuel in India, locating coal based thermal power station near pit had is economical option. In Indian context moving huge quantity of coal solid fuel through rail routes is becoming increasingly difficult with cost of transportation soaring high. Railway network is already overstrained and coal tariff over last five years has increased substantially. With expansion of power grid network by State Transmission Utility (STU), OPTCIL and by Central Transmission utility (STU), PGCIL and the fund allocated in this sector, transmission of electricity is cheaper in comparison to transportation of fuel, particularly for pit head thermal Power Station.

2.3 POWER SCNEARIO OF ODISHA

The State of Odisha has adequate quantity of coal blocks and easy transportation to the plant site by using railway or otherwise. It is needless to mention that Odisha has all the potential to become the powerhouse of the country with 51571 million tonnes of coal reserve, which is about 24% of total reserve of the country and adequate water resource. There are several proposals (nearly 18250 MW) for installing major power stations by Private Sector industrial giants as well as NTPC in the state.

Since, State of Odisha in eastern region is expected to be major power-hub of the country and its locational advantage with nearby regions, namely southern region and western region, PGCIL has already established HVDC links, both back-to-back bi-polar link and long distance DC transmission link, between eastern region and southern region. It is also connected with the western region with flexible AC Transmission network. Thus the central transmission network within the State has the capability of bulk power transfer to adjacent power starving regions, wherever situation demands.

Odisha also has comparatively larger sea face. One of the major Sea ports of India, namely Paradeep Port, is located in this state. Gopalpur sea port is also located here, but its operation is seasonal. Govt. of Odisha has made long-tern plan for establishing number of Sea ports, both in private sector and in public sector in future. Thus for imported coal based power plant, Odisha is also to be the one of the best suited in India.

Odisha is in the process of fast industrial growth in the country. The state has large gap between the power demand and availability, thus

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calling for immediate requirement addition of power plants. Though Odisha has lots of deposits of lignite, some of the lignite deposits are already linked to existing power plants and other industry in Odisha. Coal from captive mine at Manoharpur & Dipside Manoharpur in IB valley would be transported and unloaded to the plant site by using existing Semi Merry-Go-Round (SMGR) system, which is increasing attraction for extension of existing plant.

In **Annexure-2.1** enclosed, the generic information about the Installed Capacity in the state of Odisha as on 31.07.2009 are given.

In **Annexure-2.2**, the year-wise Demand/Load Growth trend in the state of Odisha is shown. The graph indicates the extent of energy addition required.

As per the National Electricity plan of CEA, the requirement vis-à-vis availability figures in the State of Odisha as on 31.12.2008 was as follows:

- Peak Demand : 3,064 MW
- Peak Availability : 3,025 MW
- Shortfall : 39 MW (Minus 1.3%)
- Energy Requirement : 6,870 MU
- Energy Availability : 6,793 MU
- Energy Shortfall : 77 MU (Minus 1.1%)

As per 17th Electric Power Survey of CEA, Electric Energy requirement in the State of Odisha will be 24,699 MU for 2010 – 2011 and 27,149 MU for 2011 – 12. The expected Peak Demand in the corresponding periods are projected as 4051 MW and 4459 MW respectively.

Hence, it may be surmised that capacity addition is necessary to overcome above projected shortfall. Capacity augmentation over 1900 MW (considering targeted PLF and T&D losses as 90% and 20% respectively) will be needed by 2012 to close the demand and supply gap to some extent.

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It is interesting to note that gross generation in non-utility sector in the state is 9197 MU with an installed capacity of 1663 MW and is only second highest in the country after Gujarat. The state has also laid substantial weightage on power generation by different category of industries located in the state for their own purpose as well as export to grid the excess generation available with clear terms. In view of hesitations observed in setting up utilities under IPP sector by several project proponents since opening of the economy in 1991, GOI has laid special emphasis on power generation, transmission, distribution, trading and use of electricity in The Electricity Act 2003 by rationalizing laws and procedural requirements to make these more attractive to the entrepreneurs.

2.4 PROJECT JUSTIFICATION

Installation of a large thermal power plant is felt necessary to bridge the gap between demand and supply of electricity. It will also help to correct hydro and thermal mix in the Odisha grid. Being an extension project, rather than a green-field one, IB TPS 2 x 660 MW units 3 & 4 can be commissioned at the earliest and then the benefit from the Project may be accrued from 12th Plan period onwards. The cost of Infrastructure will be a marginal extra over that incurred for the Stage – I units. This will result in saving of cost and time.

The station planned on pithead basis is expected to operate at high load factor on year-round basis on the basis of the following intrinsic features in terms of load and operating regime –

- High load Demand in the National as well as State levels thus permitting operation of the station at high plant load factor.
- Evacuation possibility through the State grid as well as through the national grid to the state as well as other power deficit regions of the country.

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- Low energy cost expected from the station for low transportation cost of fuel.

Over past few years, there is a rising trend in the power cost which is attributable to market forces, cross subsidy loaded on this sector and rise in the cost of raw materials. Thus tariff based power procurement policy has been given priority in the recent deliberation of the GOI. Introduction of the Electricity Act 2003 has provided the necessary impetus for power generation both in utility and non-utility sectors. This power station will be developed as an IPP and it will deliver net power to the grid after meeting in-house energy requirement for its own auxiliaries.

2.5 UNIT SIZE SELECTION

From the foregoing discussion, it has already been established that the 2 x 660 MW units 3 & 4 of the IB TPS by capacity addition of 1320 MW is justified to meet the growing power demand of the State as well as the country. It has been envisaged that two units of 660 MW size would be installed for the 2 x 660 MW units 3 & 4 of IB Thermal Power Station. In line with present-day practice, the unit is based on once-through super-critical boiler technology instead of conventional drum type sub-critical boiler technology, for its improved efficiency and reduced emission. There are number of projects having similar unit size, both in public sector and in private sector, in the process of implantation. When this project will reach to its commissioning stage, operating experience of once-through supercritical boiler is expected to be available in the country.

Thus for selecting the unit size and station configuration for the 1320 MW thermal power plant, the criteria given importance are :

- Cost of Energy generated from the station.
- Financial and commercial incentives admissible as per GOI norms for "Mega Power Projects".

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- Load demand of the State and of the Country.
- Thermodynamic Cycle efficiency and reduced emission.
- Expected Operating experience of similar size.
- Station availability.
- Plant Load Factor attainable.
- Specific investment requirement.
- Project Time frame and Man-Power requirement.

For this project, two units each of 660 MW set emerges as a favourable configuration as this set size is endowed with the following merits:-

⇒ Present-day policy for establishing large thermal power projects.

⇒ Present-day technology.

⇒ High thermodynamic efficiency and reduced emission.

⇒ Favourable operating experience.

⇒ Load variation capability, if required.

⇒ Availability of Skilled personnel for O&M of large size thermal power plants in the country.

Annexure-2.1

Installed Capacity in Odisha State as on 31-07-09

(FIGURES IN MW)

Sector	Thermal			Total Thermal	Nuclear	Hydro (Renewable)	R.E.S* (MNRE)	Total
	Coal	Gas	Diesel					
STATE	420.0	0.0	0.0	420.0	0.0	2067.93	32.3	2520.2
PRIVATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CENTRAL	1455.43	0.0	0.0	1455.43	0.0	107.0	0.0	1562.43
TOTAL	1875.43	0.0	0.0	1875.43	0.0	2174.93	32.3	4082.66

RES*= Renewable Energy Sources includes Small Hydro Project (SHP), Biomass Gasifier (BG), Biomass Power (BP), Urban and Industrial Waste Power (U&I) and Wind Energy.

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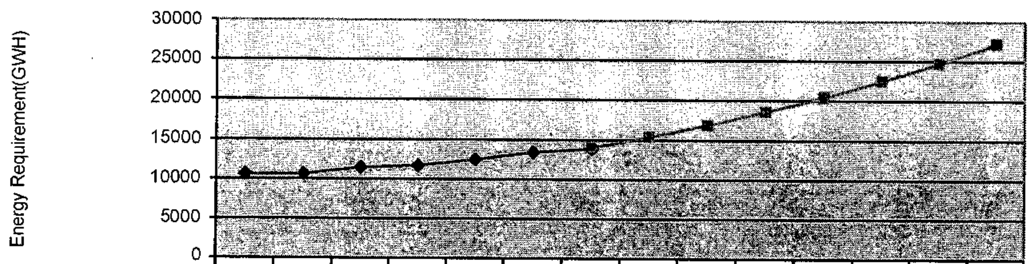
Annexure – 2.2

Demand/Load Growth trend in Odisha

Odisha : Energy Requirement(GWH)



	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Actual Avl.	1061	1062	1149	1168	1248	1337	1385							
Estimated							1398	1537	1690	1858	2043	2246	2469	2714
Shortage														

YEAR

BHUBANESWAR

SECTION-3

BASIC REQUIREMENTS

3.1 INTRODUCTION

The basic inputs for setting up and operating large sized thermal power station are availability of:

i) Adequate land for setting up the station along with ash dump, township and other facilities

ii) Adequate water supply of suitable quality round the year basis and space for in-plant storage facility

iii) Adequate quantity of fuel supply on regular basis as per the desired transportation logistics

iv) Facilities of power supply/ evacuation from the station.

v) Infrastructural facilities like road and rail access, skilled and unskilled labour, housing and civic amenities

This section discusses the requirements vis-à-vis the availability within the stipulated time frame of above features at the site for expansion of the existing coal based power station.

3.2 LAND AREA REQUIREMENT

The land requirement for a coal-fired thermal power station can broadly be classified under four basic heads namely,

a. Main Plant area

b. Landmass for ash disposal

c. Township

d. Other requirements such as corridor for intake water pipe routes, ash disposal route, railway/road access, transmission corridor, etc.

Like any expansion project, this expansion project is also endowed with certain benefits. The land required for the upcoming 2 x 660 MW units is already available, thus virtually eliminating the vexing problem of land procurement which involves time consuming procedural clearance, rehabilitation and related issues. Nevertheless the land required for expansion of existing township (20 Ha) and disposal of fly ash (165 Ha) under exigency has to be acquired.

Depending on the site features, land configuration and related technical requirements, the broad break-down of land requirements for different segments/systems of a typical 1320 MW (2 x 660 MW) coal fired power plant with provision of additional land at the power plant site for doubling the number of units in future, may be as follows: -

Land Requirement	Area (in Hectares)
Main Plant Area	200
Housing Area	20
Ash Disposal Area	165
Other Requirements	15
Total Land Requirement	**400 Ha.**

The above land requirement envisaged for the expansion of the existing power plant, considers installation of 2 x 660 MW capacity conventional coal based thermal power station with provision for another two-unit extension in the future. The estimated space requirement considers main plant area, cooling towers, space for flue gas desulphurization plant, coal storage and handling facility, fuel oil system, 400 kV switchyard, water storage and treatment facilities, ash handling/management, space for housing area etc. as planned.

The site location indicates sufficient availability of land for the power

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plant, ash disposal/management complex for emergency situation and housing area.

3.3 WATER - REQUIREMENT & AVAILABILITY

In a coal-fired thermal power station, water is used to meet the following basic consumptive requirements:

a) Cooling water for steam condenser to act as the heat sink for the thermodynamic cycle. However, for power stations employing semi-open recirculating cooling systems with cooling towers, only a small percentage of total circulating water flow is required as make-up. The cooling system in a large sized thermal power plant is the largest consumer of water and its make-up requirement itself accounts for more than 70% of the total consumptive water requirement of the station when all the facilities have been commissioned.

b) Cooling of electrical and mechanical auxiliary equipment, such as, generators, large motors, compressors and other heat exchangers through closed circuit cooling system using demineralised water as primary coolant and main auxiliary cooling water as the secondary coolant.

c) Power cycle make-up.

d) For miscellaneous services viz.

   i) Fire fighting.

   ii) General services viz. Air Conditioning and ventilation, floor washing etc.

   iii) Sealing and cooling water for equipment of ash handling system.

   iv) Dust suppression in coal yard and coal handling plant.

v) Potable use in the plant and housing complex.

vi) Transport media for ash in case of High Concentration Slurry Disposal (HCSD) of ash (under exigency condition).

vii) Horticulture and afforestation.

The estimated consumptive water requirement based on raw water analysis shown in **Annexure-3.1** for the 2 x 660 MW expansion units is of the order of 4100 cu.m/hr when all plants are commissioned. The breakdown of the estimate is given in **Annexure-3.2**. This estimate considers limited use of recycled wastewater particularly cooling tower blowdown to be recovered. This quantity would be utilised in low priority areas viz. CHP, AHP, afforestation, etc.

3.4 FUEL – REQUIREMENT, AVAILABILITY & TRANSPORTATION

Coal:

Coal from Manoharpur and Dip side of Manoharpur coal fields of MCL is considered as the primary fuel for the expansion project. OPGC has been allotted with these two coal blocks by Ministry of Coal, Government of India, in IB Valley area with a reserve of about 530 million tonnes for captive use of its expansion power project. Manoharpur coal block has been explored fully and has net geological reserves of about 180 million tonnes and Dip side of Manoharpur (Regionally explored) has geological reserves of 350 million tonnes approximately. Coal for the present plant generation capacity of 2 x 210 MW is being met by supplying coal from Mahanadi Coalfield Limited (MCL) from Lakhanpur open cast collieries of Belpahar coal block in IB Valley. For the 2 x 660 MW units 3 & 4 crushed (-20 mm) coal will be supplied from the mine end. As indicated by the project authority coal equivalent to Grade ‘F’ classification will be available as main fuel for the station. The tentative analysis of coal and ash is given in **Annexure-3.3**. With the quality of coal given in **Annexure-3.3** about 6.9 MMT for design coal would be required for the station annually at 90% PLF. The following features in system design are adopted:

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- An in-plant storage of 10 days is planned.
- The height of coal stack is contained within 10 m.
- Crushed coal of (-) 20 mm is stacked to avoid self-ignition.

On the basis of composition of coal mentioned above, it is estimated that maximum daily coal requirement with design gross calorific value of 3200 kcal/kg and average station heat rate of 2140 kcal/kWh for 2 x 660 MW units would be around 21,200 MT per day at TMCR. Estimation of coal requirement for 2 x 660 MW station with 90% plant load factor (PLF) and considering worst coal is as follows:

Parameter	Fuel Requirement for 2 X 660 MW
Hourly coal requirement at TMCR (T/hr) considering **worst** coal	958
Daily coal requirement (TPD) @ TMCR considering **worst** coal	20690
Annual Coal requirement (MMT) @ 90% PLF considering **worst** coal	7.6

Auxiliary liquid fuels:

Light Diesel Oil (LDO) is to be used for cold start-up and Heavy Fuel Oil (HFO) as support fuel for flame stabilization. For the purpose of this report, a specific auxiliary fuel consumption of 1 ml/kWh is considered as per the CERC norms. The actual consumption will however depend on average daily plant load factor, grid stability, quality of coal etc. It can be expected that the power station will be operated at high plant load factor on a sustained basis, thus fuel oil requirement may be optimised.

Hence for the expansion project only Heavy Fuel Oil (HFO) system would be installed. The existing Fuel oil system is using only Light Diesel Oil (LDO) and the capacity of the same is adequate to meet the requirement of LDO for 2 × 660 MW units 3 & 4. Two (2) nos. HFO tanks of capacity 4000 m^3 each are to be installed considering 7 days' storage requirement with 30% BMCR load of one boiler. Tentative analyses of above auxiliary fuel oils are furnished in **Annexure-3.4** and **Annexure-3.5** respectively.

Fuel Transportation:

For existing plant, the coal is made available by Mahanadi Coalfield Limited (MCL) from Lakhanpur open cast collieries of Belpahar coal block in IB Valley having its loading head at Ubuda, about 11 kms. from the plant end. OPGC has its own private railway siding connecting the Plant to the existing Indian Railway network at Lajkura Railway station traversing a distance of about 19 km through MCL's loading yard at Chinguriguda.

The coal for the units 3 & 4 will be transported from the Manoharpur block mines to the plant site by using Merry-Go-Round (MGR) captive Railway system. A broad gauge Railway siding with MGR system is to be constructed to connect IB Thermal power station with the loading station near Manoharpur Coal Block of IB valley coal field near Manoharpur Village and provision of unloading bulb at the power plant. Loading Bulb with MGR system is in the loading yard near Manoharpur Coal Blocks. The railway siding for Manoharpur Coal Blocks takes off from the OPGC existing Railway siding near Jorabaga Village and connects the loading yard of ITPS with provision of 3 Nos. of crossing stations (one existing at Ubuda plus two new crossing stations).

Both auxiliary liquid fuels, LDO and HFO will be received from nearby depot to the plant site by rail/road tankers and shall be unloaded by using existing HFO/LDO unloading system. Existing fuel oil unloading systems (both rail and road) are sufficient to cater the requirement of expansion units. As mentioned earlier, existing LDO system has sufficient capacity to meet the requirement for the expansion units.

However, for storing the HFO, two (2) nos. HFO tanks of 4000 m^3 capacity are envisaged for the expansion project.

3.5 POWER EVACUATION

Power from the 2 x 660 MW units 3 & 4 will be stepped up to 400 kV through Generator transformer and will be evacuated through two (2) nos. 400 kV double circuit transmission lines from plant switchyard. One D/C line will be connected to state grid substation at Lapanga and the other D/C will be connected to PGCIL substation at Sundergarh which are 19 KM and 50 KM. respectively from the plant switch yard.

3.6 OTHER INFRASTRUCTURAL FACILITIES

Being an expansion project, almost all infrastructural facilities are readily available in the plant site. The facilities, which are considered essential during early stage of construction, are: -

a) Access roads.
b) Construction water and treated potable water.
c) Construction power.
d) Housing facility for the construction staff with water supply, electricity, community facilities viz. market, school, health care, entertainment facilities etc.
e) Ancillary or small-scale industries to feed the expansion project.
f) Local availability of skilled and unskilled manpower.
g) Telecommunication facility etc.

Among the above infrastructure facilities, the nearest railway station, Belpahar is located about 20 km north of the plant site. The national highway NH-200 (Chandikhole to Raipur) and state highway SH-10 (Sambalpur to Sundergarh) pass through Jharsuguda town which is 40 km north east of the plant site. However, communication facilities viz. telephone, facsimile, internet, etc. are to be expanded for timely implementation of the project.

Workforce from the local villages can also be made available for deployment at the initial stage of the expansion. To accommodate a large workforce during construction of the project, it is envisaged that some housing facilities viz. temporary labour hutments, guest houses, bachelor's hostel, residential quarters need to be developed along with necessary augmentation of existing civic amenities.

Being an expansion project, construction power and water shall be tapped from the existing facilities. Workshop and other related facilities of the existing plant shall be utilised as far as possible. Facilities available at nearby Jharsuguda town may also be explored.

Annexure-3.1

ANALYSIS OF RAW WATER

SL. NO.	PARAMETER	VALUE					
		Summer		Monsoon		Winter	
		Min.	Max.	Min.	Max.	Min.	Max.
1	Temperature, ^0C	25.0	36.0	26.0	30.0	20.0	25.0
2	pH	7.5	9	6.7	8	7	8.2
3	Conductivity, S/cum	110	200	90	200	80	120
4	TDS mg/lit	75	120	60	200	50	75
5	Turbidity, NTU	5	10	5	70	5	30
6	P Alkalinity, mg/lit	0	6	0	0	0	0
7	M Alkalinity, mg/lit	60	80	35	75	50	75
8	Chloride, mg/lit	5	30	5	25	5	20
9	Total hardness, mg/lit	50	80	35	80	30	30
10	Mg Hardness, mg/lit	15	30	10	25	10	25

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Annexure – 3.2

ESTIMATION OF CONSUMPTIVE WATER REQUIREMENT
For 2x660 MW IB TPS at Jharsuguda (Units 3&4)

Sl. No	CONSUMPTION POINTS	DM WATER (M3/HR.)	Filtered Water (M^3/HR.)	Clarified Water (M3/HR.)	Raw Water (M^3/HR.)	Remarks
1.	a. Heat Cycle Make-up	63				
	b. Make-up Requirement for Closed Circuit Cooling System	4				
	c. Chemical Feed	4				
	d. CPU Regeneration Requirement	20				
	e. Water Requirement for H_2 Generation Plant	2				
	Sub-Total :	**93**	**93**			
	f. Waste from DM Plant		14			
	Sub-Total :		**107**			
2.	a. Potable Water Requirement		35			
	b. Waste from Filtration Plant		8			
	Sub-Total :		**150**	**150**		
3.	a. Service Water including HVAC			177		
	b. Seal Water and other misc. requirement for AHP Plant			200		
	c. Coal Handling Plant Equipment Cooling			50		
	d. Cooling Tower Make-up Requirement (including Loss from Side Stream Filtration Plant)*			3364		Cycle of Concentration = 6 * CTBD 462 m^3/hr.
	e. Clarified water recycle back to Clarified Water Reservoir from Central Monitoring Basin			(-) 29		(e) Clarified water from CMB
	Sub-Total :			**3912**	**3912**	
4.	a. Ash Slurry Sump				---	
	b. Sludge Loss from Clariflocculator.				113	
	c. Evaporation and seepage loss in reservoir				5	
	Sub-Total :				**4030**	
5.	a. Design Margin & Contingency				70	
	b. Horticulture				--	Will be used from CMB
	c. CHP Dust Suppression System				--	Will be used from CMB
	GRAND TOTAL :				**4100**	**(Say 40.2 Cusec)**

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Annexure-3.3

ANALYSIS OF COAL

Sl. No.	Characteristics	Unit	Design Coal	Worst Coal	Best Coal
1.	**Proximate Analysis (As received basis) :-**				
	Total Moisture	%	13.1	13.7	12.4
	Ash	%	41.0	43.7	38.1
	Volatile Matter	%	20.2	22.2	17.7
	Fixed Carbon	%	25.8	23.7	28.2
2.	**Ultimate Analysis (As received basis) :-**				
	Carbon	%	37.87	33.74	42.52
	Hydrogen	%	1.74	2.09	1.09
	Nitrogen	%	0.92	0.45	1.84
	Oxygen	%	5.19	5.92	3.96
	Sulphur	%	0.18	0.40	0.09
	Carbonates	%	-	-	-
	Phosphorous	%	-	-	-
	Total Moisture	%	13.1	13.7	12.4
	Ash	%	41.0	43.7	38.1
	Gross Calorific Value	Kcal/Kg	3200	31003000	34503400
	Hard Grove Index		62.6	70.0	52.0
	YGP Index	mg/kg	-	-	-

ANALYSIS OF ASH

Sl. No.	Characteristics	Unit	Design Coal	Worst Coal	Best Coal
1.	Silica (SiO_2)	%	58.39	65.6	45.80
2.	Alumina(Al_2O_2)	%	27.8	39.60	18.50
3.	Iron Oxide(Fe_2O_2)	%	8.8	29.5	3.2
4.	Titania(Ti_2O_2)	%	1.28	1.7	0.6
5.	Phosphoric Anhydride(P_2O_5)	%	0.45	1.04	0.07
6.	Lime(CaO))	%	1.62	2.52	0.98
7.	Magnesia(MgO)	%	1.30	2.51	0.3
8.	Sulphuric Anhydride(SO_2)	%	0.19	0.45	0.08
9.	Alkalies (by diff.) ($Na_2O + K_2O$)	%	0.45	1.10	0.16
10.	Initial Deformation Temperature (IDT)	°C	1389.5	1330	1400
11.	Hemispherical Temperature (HT)	°C	>1400	>1400	>1400
12.	Flow Temperature (FT)	°C	>1400	>1400	>1400

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Annexure-3.4

ANALYSIS OF HEAVY FUEL OIL [HFO]

SL. NO.	PARAMETERS	VALUE
1.	Specification	IS-1593 (Latest Revision) Heavy Grade (HVFO)
2.	Acidity (Inorganic)	Nil
3	Ash Content	0.1% (maximum) by weight
4.	Gross Calorific Value	10,500 Kcal/kg. Approx.
5.	Flash Point (Pensky-Martens, closed)	66 °C (minimum)
6.	Kinematic Viscosity at 50 °C	170 Centi-stokes (maximum)
7.	Sediment by weight	0.25% (maximum)
8.	Water content by volume	1.0% (maximum)
9.	Total Sulphur	4.5 (maximum)
10.	Density (gm/ml at 15 °C)	0.95
11.	Pour Point (°C max.)	50 °C
12.	Vanadium content (ppm)	70 (Typical)
13.	Sodium + Potassium (ppm)	40 (Typical)
14.	Specific heat	0.48 Kcal/kg.

Note : Values indicated against Sl. 10, 11, 12 & 13 are typical and not covered under IS-1593.

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Annexure – 3.5

ANALYSIS OF LIGHT DIESEL OIL [LDO]

SL. NO.	PARAMETERS	VALUE
1.	Specification	IS-1460 (Latest Revision)
2.	Acidity (Inorganic)	Nil
3	Ash Content	0.02% (max.) by weight
4	Flash Point (Pensky-Martens, closed)	66 °C
5.	Pour Point (Winter)	12 °C
	Pour Point (Summer)	18 °C
6.	Kinematic Viscosity at 38 °C	2.5 to 15.7 Centistokes
7.	Sediment by weight	0.10% (maximum)
8.	Water content by volume	0.25% (maximum)
9.	Sulphur by weight	1.8% (maximum)
10.	Carbon Residue (Ramsbottom) by weight	1.5% (maximum)
11.	Gross Calorific Value	10,300 Kcal/kg.
12.	Specific gravity	0.85 at 15 °C

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SECTION-4

SITE FEATURES

4.1 INTRODUCTION

To ensure efficient, cost effective and trouble-free operation of a thermal power plant throughout the operating life, selection of a proper site with required features, infrastructure and inputs, is always the key factor to optimise on design and relevant site specific cost parameters. Integration of the technological equipment and systems with the specific features of the project location is viewed as an important aspect for the site under consideration.

The X660 MW is now developed adjacent to the existing 2 x 210 MW IB Thermal power station at Banaharpalli. The site is located in Jharsuguda District of Odisha on the bank of Hirakud reservoir and about 20 km south of Belpahar Railway Station and 40 km south west of Jharsuguda town. The main Howrah-Mumbai railway line passage 20 km North of the plant (at Belpahar). NH-200 (Chandikhole to Raipur) and NH-10 (Sambalpur to Sundargarh) pass through Jharsugurda Town. The site has got following intrinsic merits :-

- Availability of adequate land which was acquisitioned during construction of existing plant (Units 1 & 2).
- Optimum distance from fuel source since it is in the midst of one of the largest coal bearing regions in the country and most of the coal mines of MCL are within reasonable distance from the site.
- 220 kV double circuit transmission line exists for evacuation of power generates from existing units (Units 1&2), another two double circuit 220 kV line from IBTPS to Budipadar has also

been completed by OPTCL. Power from the 2 x 660 MW units 3 & 4 will be stepped up to 400 kV through Generator transformer and will be evacuated through two (2) nos. 400 kV double circuit transmission lines from plant switchyard. One D/C line will be connected to state grid substation at Lapanga and the other D/C will be connected to PGCIL substation at Sundergarh.

- Well connected by road and rail routes.
- Being an expansion project, developed infrastructure is already available.
- Hirakud Reservoir is 5.6 km from the plant site. The project authorities have got water allocation from Hirakud Reservoir which would ensure year-round availability of water for the station.

The basic requirements for the 2 x 660 MW units 3 & 4 is studied in the backdrop of the available infrastructural facilities and the requirement of developing further facilities to ensure compatibility and adequacy of technological options and implementation of the project within an optimum timeframe. The project would be developed as an expansion of 2 x 210 MW existing plant.

Thus considering the advantages of short lead distance from the captive mine with favourable transportation logistics and availability of a perennial water source within reasonable distance namely, Hirakud Reservoir, a plant in the region is favoured.

4.2 DESCRIPTION OF EXISTING PLANT

The project site is located at Banaharpalli in the Jharsuguda district of Odisha on the bank of Hirakud Reservoir and about 20 km south of Belpahar railway station and 40 km south west of Jharsuguda. The main Howrah- Mumbai railway line passes 20 km north of the plant (at

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Belpahar). NH-200 (Chandikhole to Raipur) and SH-10 (Sambalpur to Sundergarh) pass through Jharsuguda town.

Phase-I of the project which is in operation consists of two units of 210 MW each. The steam generating units and turbine generating units were supplied by M/s Bharat Heavy Electricals Limited (BHEL). These units at IB TPS have been operating satisfactorily with availability factor of over 90%.

The project has been built over an area of around 770 hectares leased from the Government of Odisha on a 99 years lease with annual rent and cess. Of the total area, 323 hectares have been earmarked for setting up the power plant, the first two units of which are already in operation as mentioned earlier. 183 hectares have been utilised for the two ash ponds of the existing units. Township, roads and markets, ash pipe corridor and the MGR system for coal transportation take up the balance area of 264 hectares.

Presently, coal is supplied by Mahanadi Coalfields Limited (MCL) from the Lakhanpur open cast mines of IB Valley under a long term coal linkage of 2.4 MTPA available for the project. Coal is transported to the plant by a semi-MGR system of a route length of 19.3 km. Coal Supply Agreement is under discussion with MCL and for the present, a working system has been evolved for carrying out the day-to-day transactions between OPGC and MCL.

Light Diesel Oil (LDO) and Heavy Furnace Oil (HFO) are envisaged as secondary fuels in the boiler for start-up and for flame stabilisation respectively. Both these fuels can be received at the plant by rail or road tankers. Currently, the plant is using only LDO which is received by road tankers and subsequently stored in tanks for use in the boilers.

Water is drawn from the Hirakud reservoir through a 5.45 km intake channel .The reservoir has a catchment area of 83.395 sq.km. with a current gross storage capacity of 7189 lakhs m^3. Presently the raw

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water requirement is 1250 m^3/hr after implementation of ash water recovery system for the existing units and the same will come down to 1150 m^3/hr after implementation of "zero discharge" scheme for the existing units. The project had taken approval from the Water Resources Department of Odisha to draw 5400 m^3/hr of water from the reservoir. Thus, 4250 cum/hr water will be available for the 2 x 660 MW units 3 & 4.

4.3 SELECTED SITE & FEATURES

The power project is for the expansion of the existing IB Thermal Power Station at Banaharpalli in Jharsuguda District, in the state of Odisha in India. The site is geographically located at Latitude 21° 28' North and Longitude 83° 58' East, respectively and the height of the site varies from 198 m to 202 m above MSL. The site is on the bank of Hirakud reservoir and about 20 km south of Belpahar Railway Station and 40 km south west of Jharsuguda town. The main Howrah-Mumbai railway line passes 20 km North of the plant (at Belpahar). NH-200 (Chandikhole to Raipur) and NH-10 (Sambalpur to Sundargarh) pass through Jharsugurda Town. The nearest major seaport is at Paradeep, domestic airport at Bhubaneswar and international airport is at Kolkata.

Land:

The plot of land is more or less flat ground and having no crop cultivation. The site elevation varies from198 m to 202 m above mean sea level (MSL). The existing project has been built over an area of 771 hectares leased from the Government of Odisha on a 99 years lease with annual rent and cess. For the expansion project (Units 3&4) an additional land of 19.4 ha has been estimated to be acquired for the expansion of the existing colony. For disposal of bottom ash and to cater the exigencies in case of disposal of fly ash an area of 165 ha has to be acquired. Outline alignment of the plot is shown in the enclosed Plant Layout drawing. The land area is adequate to meet the Plant requirements.

The location of the Plant is in close proximity of the existing Hirakud Reservoir at a distance of 5.6 km and water is easily available in the plant site through intake channel without any intake pumping system which minimizes the water transportation costs. The plant is also located at optimum distance from fuel source since it is in the midst of one of the largest coal bearing regions in the country and most of the coal mines of MCL are within reasonable distance from the site. Other technical aspects like wind direction, soil characteristics have been taken into consideration while developing the Plant Layout.

Fuel and Transportation Logistic:

OPGC have received an allotment of Captive mine at Manoharpur & Dipside Manoharpur in IB valley to supplement the coal which can be raised from this mine. OPGC have applied for long term coal linkage from MCL.

Assuming an annual plant load factor (PLF) of 90% average station heat rate of 2180 (worst coal) Kcal/kWh, the annual coal requirement works out as 7.6 Million Tons per annum for the 1320 MW station. The daily requirement of coal is estimated as 21057 Tons at TMCR considering design coal. Crushed coal from Manoharpur & Dipside Manoharpur shall be brought to the site by railway wagons using merry go round (MGR) system. Ten (10) days' storage of crushed coal will be maintained inside the plant to take care of any exigency situation.

Auxiliary liquid fuel, viz. LDO and HFO would be required for start-up and flame stabilization at lower load respectively. HFO/LDO shall be transported from nearby depot to the plant site by rail/road tankers and shall be unloaded by using existing HFO/LDO unloading system.

Water:
The Hirakud Reservoir is 5.6 km from the plan site and the plant area comes under the watershed of the major IB River. The plant will be using river water for cooling. Water is to be drawn from the reservoir

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and brought to the plant through intake channel. The length of the intake channel would be around 5.6 km. OPGC has already obtained an approval from the Water Resource Department of Odisha to draw water at the rate of 5400 m^3/hr required for all units which will be adequate to meet the requirement of existing 2 x 210 MW units plus the 2 x 660 MW units 3 & 4.

Infrastructure:

Among the infrastructural facilities, the district road is passing near the power station site. An approach road from the district road upto plant has already been constructed for movement of heavy equipment/over dimensioned consignment for the plant. The tentative route of the approach road is shown in the site location map enclosed. Nearby domestic airport is at Bhubaneswar at a distance of about 220 km. The port facility at Paradeep may be utilised for sea transportation of heavy equipment. The communication facilities viz. telephone, fasimile, internet, etc. are available which are to be extended / augmented for timely implementation of the project.

Infrastructural facilities in terms of availability of market, bus stand, hospital, schools, college, small scale industries to support construction of the new plant are available as it is an expansion project of 2 x 210 MW existing IB valley power plant. Workforce from local villages may be deployed at initial stage. To accommodate a large workforce during construction of the project, it is envisaged that some housing facilities viz. temporary labour hutments, guest house, bachelor's hostel, residential quarters may be developed along with necessary civic amenities.

The intrinsic features of the site requiring special mention are given hereunder -

- Large tracts of plain, government lands are easily available for 99 years lease on payment of annual rent and cess.

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- The land is more or less flat so no major cutting and filling is required.
- Backward area without any habitation and hence there is no requirement of rehabilitation of people since there is no displacement of people/villages.
- Power plant location is in proximity to the captive mines at Manoharpur and Dipside Manoharpur in IB valley. The uncrushed coal from Manoharpur and Dipside Manoharpur would be transported to the site by railway wagons using the existing semi merry go round (SMGR) system. Hence, material handling cost will be low.
- Expansion project will have the benefit of sharing the existing facilities of HFO/LDO transportation and unloading systems.
- The site is on the bank of Hirakud reservoir and about 20 km south of Belpahar Railway Station and 40 km south west of Jharsuguda. The main Howrah-Mumbai railway line passage 20 km North of the plant (at Belpahar). National Highways, NH-200 (Chandikhole to Raipur) and NH-10 (Sambalpur to Sundargarh) pass through Jharsugurda Town. With this good rail line and road connectivity, the project implementation and O&M activities are expected to be smooth.
- The nearest major seaport is at Paradeep, domestic airport is at Bhubaneswar and international airport is at Kolkata. So the plant has good connectivity by air.
- Proximity to the bank of Hirakud Reservoir which would ensure year-round availability of water for the station.
- Availability of skilled, semi-skilled and unskilled manpower.
- Availability of machinery and equipment for project construction from the existing plant. Availability of experienced project implementation team of OPGC.
- Good existing infrastructure facilities.
- Disposal of fly ash is major environment issue for mega power plant. The entire fly ash generated in the power plant shall be utilized in making ash mound to make the mega power project a

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environment friendly.

- Demand for power to the Eastern Region already exists.
- The region is rich in mineral wealth which is attracting large scale mineral based industries and hence the local power consumption is expected to go up further.
- Suitable climatic conditions.
- Connectivity to population centres with social amenities.

4.4 Meteorological Data

The nearest meteorological station of Indian Meteorological Department is at Jharsuguda. The published climatological table of Jharsuguda is given in **Annexure-4.1.** The major meteorological data for the selected plant area is given hereunder:-

Monthly max. dry bulb temperature	:	38.4 °C/28.0 °C/33.4 °C (Summer/winter/monsoon)
Monthly min. dry bulb temperature	:	25.4°C/16.7 °C/26.8 °C (Summer/winter/monsoon)
Daily max. wet bulb temperature	:	23.9 °C/17.8 °C/25.5 °C (Summer/winter/monsoon)
Daily min. wet bulb temperature	:	17.6 °C/13.4 °C/25.4 °C (Summer/winter/monsoon)
Maximum Relative Humidity	:	46% / 67% / 87% (Summer/winter/monsoon)
Minimum Relative Humidity	:	21% / 33% / 87% (Summer/winter/monsoon)
Average Annual Rainfall	:	1460 mm
Average relative Humidity	:	65%
Basic Wind Speed	:	44 m/sec.
Seismic Zone	:	III as per IS:1893, Part-1

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Annexure – 4.1 Climatological Table Of Jharsuguda

STATION : Jharsuguda 42886 LAT: 21 55 N LONG: 84 05 E HT. ABOVE M.S.L. 230 METERS DATA 1951 TO 1980

		Mean Temperature						Extremes		Cloud				Rainfall						
MN	SLP	DB	WB	MAX	MIN	HIGH	LOW	MAX DT	MIN DT	RH	VP	TOT	LOW	TOT	RAINY	WET	DRY	HEAVY	DAY	WS
1	990.6 986.9	16.7 23.9	13.4 16.4	27.7	12.0	30.8	7.5	33.2 04 1973	6.0 10 1976	67 43	12.8 12.7	1.7 2.1	0.5 0.8	12.5	1.1	61.4 1957	0.0	36.4	11 1968	5.6
2	988.6 984.4	20.1 28.0	15.1 17.8	30.8	14.7	35.0	9.9	37.9 22 1967	7.2 02 1967	57 33	13.2 12.2	1.7 2.0	0.6 1.0	18.0	1.3	116.7 1961	0.0	46.7	06 1961	6.3
3	986.2 981.6	25.4 32.9	17.6 19.4	35.5	19.0	40.0	13.9	42.7 31 1955	11.1 01 1961	44 25	14.0 11.8	1.8 2.4	0.5 0.9	21.0	1.8	97.8 1951	0.0	58.7	26 1951	6.9
4	982.9 977.6	30.8 37.2	21.3 21.4	40.1	24.2	43.6	19.2	46.0 29 1973	15.8 01 1957	41 21	17.7 12.8	2.1 3.2	0.5 1.7	13.8	1.4	58.9 1971	0.0	31.8	18 1952	7.5
5	978.5 973.5	32.9 38.9	23.9 23.1	41.8	27.1	45.3	22.3	48.0 22 1978	19.3 04 1963	46 24	22.3 15.5	2.5 3.8	0.6 2.1	29.9	2.2	107.8 1969	0.0	63.8	14 1963	8.0
6	975.1 971.3	30.2 33.4	25.0 25.1	37.2	26.4	43.4	22.0	46.3 01 1978	16.3 17 1973	66 54	27.4 25.1	5.9 6.6	2.5 3.5	228.7	9.5	524.9 1956	42.2 1975	197.9	11 1961	9.3
7	975.1 972.2	26.9 28.5	25.0 25.6	31.3	24.6	34.8	22.3	38.2 06 1979	17.4 30 1976	86 79	30.2 30.5	7.2 7.3	4.3 4.5	402.7	17.5	770.7 1961	230.9 1955	189.8	08 1961	9.0
8	976.1 973.2	26.8 28.1	25.1 25.5	31.0	24.5	34.0	22.4	36.2 03 1972	16.6 16 1976	87 81	30.6 30.6	7.2 7.3	4.3 4.5	428.5	17.3	657.9 1960	212.1 1965	257.8	20 1975	8.3
9	979.7 976.3	27.2 28.4	25.0 25.3	31.8	24.3	34.4	22.3	37.0 11 1968	16.7 05 1976	83 77	29.9 29.6	6.0 6.7	3.2 3.9	233.1	11.7	714.5 1961	42.5 1974	190.9	03 1973	6.8
10	985.4 981.9	25.7 28.1	22.6 23.2	31.9	21.6	34.3	17.0	36.1 19 * 1974	12.1 28 1976	75 65	24.9 24.5	3.6 4.2	1.5 2.2	65.0	4.0	181.5 1961	0.2 1979	110.2	09 1952	5.5
11	989.4 985.8	21.3 25.3	17.4 18.9	30.0	16.0	32.4	12.0	35.6 08 1976	8.4 30 1970	66 52	17.0 16.8	2.1 2.6	0.5 0.9	4.3	0.4	28.7 1953	0.0	26.8	24 1972	5.7
12	991.1 987.3	17.2 23.0	13.8 16.2	27.6	12.0	30.2	8.3	32.0 02 * 1977	6.1 29 1955	67 47	13.2 13.1	1.8 2.1	0.3 0.5	3.4	0.5	22.0 1978	0.0	18.8	01 1978	5.3
	983.2 979.3	25.1 29.6	20.4 21.5	33.1	20.5	45.6	7.2	48.0	6.0	65 50	21.1 19.6	3.6 4.2	1.6 2.2	1460.9	68.7	2656.6 1961	901.0 1979	257.8		7.0
	30 30	30 30	30 30	28	28	28	28	30	30	30 30	30 30	30 30	23 23	30	30	30	30	30		28

Occurred More Than Once

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STATION : Jharsuguda 42886 LAT: 21 55 N LONG: 84 05 E HT. ABOVE M.S.L. 230 METERS DATA 1951 TO 1980

	Weather						Wind speed				% Wind Direction									Total Cloud					Low cloud						Visibility				
	PPT	HAIL	THUN	FOG	D.STM	SQUA	62	61	19	0	N	NE	E	SE	S	SW	W	NW	0	0	T-2	3-5	6-7	8	0	T-2	3-5	6-7	8	F8	<1	1-4	4-10	10-20	MN >20
1	1.0	0.0	0.1	0.2	0.0	0.0	0	0	12	19	9	20	5	2	1	1	1	2	59	21	3	4	2	1	27	2	2	0	0	0	1.0	4.8	8.7	12.8	3.7
							0	0	8	23	9	4	2	3	3	3	2	5	69	19	6	4	2	0	26	3	2	0	0	0	0.0	3.7	12.2	7.6	7.5
2	1.5	0.0	0.3	0.8	0.0	0.0	0	0	11	17	12	20	4	4	2	1	1	1	55	20	3	3	1	1	24	2	2	0	0	0	1.1	3.3	5.9	13.7	4.0
							0	0	8	20	7	5	1	2	3	4	4	7	67	18	4	4	2	0	23	3	2	0	0	0	0.0	1.9	9.2	8.8	8.1
3	2.4	0.0	1.0	0.4	0.1	0.0	0	0	14	17	9	16	7	3	5	5	3	2	50	21	3	4	2	1	25	3	3	0	0	0	1.1	3.7	7.1	15.4	3.7
							0	0	11	20	6	5	1	2	6	8	4	11	57	17	5	6	2	1	23	5	3	0	0	0	0.1	2.4	9.8	11.1	7.6
4	1.4	0.0	0.8	0.3	0.1	0.0	0	0	16	14	3	7	5	6	14	15	4	3	43	18	5	5	2	0	25	3	2	0	0	0	1.5	3.4	4.5	15.3	5.3
							0	0	11	19	4	1	1	4	9	13	5	7	56	13	7	7	3	0	21	6	3	0	0	0	0.3	3.3	8.1	10.8	7.5
5	2.5	0.0	1.0	0.0	0.1	0.0	0	0	20	11	2	5	4	8	16	23	5	3	34	16	6	5	3	1	25	4	2	0	0	0	0.0	1.5	5.2	17.0	7.3
							0	0	17	14	4	3	4	7	12	15	6	9	40	10	8	8	4	1	19	7	4	1	0	0	0.1	1.7	9.3	12.9	7.0
6	10.4	0.0	3.3	0.0	0.1	0.0	0	0	21	9	2	4	3	6	13	32	10	3	27	5	3	9	7	6	10	6	10	2	2	0	0.0	2.6	6.6	14.7	6.1
							0	0	19	11	5	6	3	5	10	25	9	5	32	3	4	9	8	6	8	7	11	2	2	0	0.1	3.7	10.3	10.3	5.6
7	21.1	0.0	2.9	0.0	0.0	0.0	0	1	23	7	1	5	2	3	15	40	10	2	22	1	3	7	10	10	3	6	12	5	5	0	1.0	5.0	7.7	12.9	4.4
							0	0	20	11	3	6	3	4	14	28	7	4	31	2	2	6	11	10	4	6	13	4	4	0	0.7	4.4	10.2	9.4	6.3
8	20.4	0.0	3.8	0.0	0.0	0.0	0	0	22	9	3	5	3	4	14	37	7	2	25	1	2	8	10	10	2	5	14	4	6	0	1.0	5.3	7.8	12.3	4.6
							0	0	18	13	3	4	2	4	11	25	7	4	40	1	2	8	11	9	4	6	13	4	4	0	1.0	5.8	10.4	8.5	5.3
9	14.0	0.0	3.0	0.0	0.0	0.0	0	0	19	11	3	8	5	6	14	22	5	2	35	3	4	10	9	4	6	8	11	3	2	0	0.2	2.8	7.6	14.5	4.9
							0	0	13	17	3	4	4	8	8	12	5	4	52	1	4	9	10	6	5	9	11	3	2	0	0.2	4.1	11.2	9.0	5.5
10	5.7	0.0	0.8	0.4	0.0	0.0	0	0	15	16	7	17	9	6	7	5	2	2	45	11	5	8	5	2	16	6	6	2	1	0	0.1	2.4	6.6	15.3	6.6
							0	0	10	21	4	6	5	7	4	3	2	3	66	8	8	8	5	2	14	10	5	1	1	0	0.0	4.2	10.6	9.3	6.9
11	0.8	0.0	0.0	1.1	0.0	0.0	0	0	13	17	14	21	6	2	2	1	1	2	51	17	5	5	2	1	24	3	3	0	0	0	0.8	3.2	7.6	13.6	4.8
							0	0	8	22	9	7	2	3	2	1	2	3	71	14	7	5	3	1	23	5	2	0	0	0	0.0	5.8	10.2	7.0	7.0
12	0.4	0.0	0.0	1.1	0.0	0.0	0	0	12	19	11	21	5	2	1	1	0	2	57	21	4	4	2	0	27	2	2	0	0	0	1.4	3.6	8.7	14.6	2.7
							0	0	7	24	7	5	1	1	1	2	1	5	77	17	6	5	3	0	26	3	2	0	0	0	0.2	7.6	10.8	6.1	6.3
	81.6	0.0	17.0	4.3	0.4	0.0	0	1	198	166	6	12	5	4	9	15	4	2	43	155	46	72	55	37	214	50	69	16	16	0	9.2	41.6	84.0	172.1	58.1
							0	0	150	215	5	5	2	4	7	12	5	6	54	123	63	79	64	36	196	70	71	15	13	0	2.7	48.6	122.3	110.8	80.6
				28					24						29							29					29						29		
									24						29							29					29						29		

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SECTION – 5

POWER GENERATING EQUIPMENT

5.1 INTRODUCTION

The basic plant design would consider unitised concept. Judicious provisions would be considered for reasonable spare capacities in various systems and system components and inter-changeability of equipment/ system.

Basic design parameters for equipment and systems are as follows: -

• Design maximum ambient temperature	:	50 °C
• Design wet bulb temperature	:	27 °C
• Seismic Zone as per IS :1893	:	III
• Basic wind speed	:	44 m/s (as per IS 875)
• Condenser cooling water inlet temp.	:	33 °C (max.)
• Auxiliary Equipment inlet cooling water temp	:	36 °C (max.)
• Instrument air/plant air	:	Oil-free. In addition, instrument air will be moisture-free.
• Power supply to drives (3 Ph, 50 Hz)	:	Below 200 KW rating at 415V. Above 200 KW up to 1.5 MW at 3.3 KV. Above 1.5 MW at 11 KV.
• Control voltage for electrical equipment	:	At 220 V DC (unearthed)
• Power supply for control & Instrumentation	:	At 24 V DC.

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5.2 SELECTION OF TECHNOLOGY

From the viewpoint of available state-of-the-art technologies, two alternate proposals attract attention for planning the thermal power station under consideration. For electric power generation deploying Rankine Cycle, applications of both sub-critical and supercritical steam parameters are in vogue. Sub-critical steam cycle which represents the current dominant technology for converting heat from fuel into electricity, operate well below the steam/water critical pressure of 221.2 bar. However, higher plant thermal efficiency as well as improved environmental performance can be attained by increasing the operating pressure and temperature of steam. The technology deploying supercritical steam parameters in once-through mode was initiated in early 1950's, but was not pursued in USA due to poor plant availability. However, the technology was pursued in Europe and Japan to avail the intrinsic benefit available in terms of lower specific fuel consumption. With improvement in metallurgy of heat exchanger surfaces by newer alloying elements, the technology has attained desired level of success with high availability of plant in the 1990's. With extensive research in the field, the technology has now achieved acceptance both in developed and developing countries.

In supercritical boiler (boiler operating above the critical point, the critical pressure and temperature being 22.1 MPa & 374.2 °C respectively for water), as heat is applied to water, temperature rises but water does not boil. With addition of further heat, water molecules gradually get agitated, inter molecular space increases uniformly and fluid becomes less dense. Transition from dense phase water with compact molecular arrangement to wide spaced random arrangement of vapour is uniform. No internal bubbles are formed. Enthalpy changes uniformly and all other physical properties change uniformly from liquid to vapour stage with gradual rise in temperature.

Unlike sub-critical boiler, each tube in a supercritical boiler receives same quantity of heat input since all tubes pass through all heat zones minimizing variation in enthalpy.

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Steam generator consists of a number of parallel circuits connected by inlet and outlet headers. Pressurised water enters the circuit at one end and leaves as superheated steam at other end. Hence, Supercritical boilers are essentially **"once-through type".**

Once-through boilers have been designed in both two-pass and tower type design. Since flow is once-through, furnace wall tube temperature tends to increase at low load. Assisted circulation mode is superimposed to overcome this problem.

The volume of the evaporator system of once-through boiler is much smaller compared to a natural circulation boiler. This leads to smaller amount of water in the evaporator. Due to smaller inventory of stored water and steam, theoretical rate of response of supercritical unit is much faster than drum unit. In comparison to the sub-critical unit, the supercritical unit has low thermal inertia resulting in a shorter start-up time, faster rates of load change and shorter time of forced cooling operation during emergency shutdown. Pressure changes can be achieved more easily and a true sliding pressure operation mode with reasonable load change capabilities becomes possible. In supercritical unit, main steam temperature is controlled by water-fuel ratio control with back up spray attemperation. As a result, rated steam outlet temperature could be achieved at all loads with wide range of fuel quality. With supercritical parameters, there is an improvement of cycle efficiency attributable to elevated pressure and temperatures. However, for smaller units the improvement in heat rate is marginal (upto 3%). Using supercritical parameters is more advantageous for larger units where heat rate improvement is 5% or more.

Increase in overall plant thermal efficiency results in reduction of fuel consumption per unit of electricity generated, which in turn also reduces CO_2 emissions in coal fired power plant. Supercritical units also emit less SO_X and NO_X. Improvement in thermal efficiency also

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causes substantial reduction in emission of suspended particulate matter to the environment. Last but not the least better efficiency is associated with lower fuel costs.

As per the prevailing trend, single reheat has been selected and the final steam temperature at reheater outlet may be selected adequately high (about 596 °C) to avoid wet vapour in the later stage of the turbine and to attain a high cycle efficiency.

In general, water is considered as a good solvent and steam as poor one. This generalisation becomes increasingly less valid as operating pressure increases. As densities of two phases in equilibrium approach each other so do their solvent characteristic. Common impurities, like silica, sodium chloride, sodium sulphate, calcium sulphate, etc., remain soluble in water and their solubility in sub-critical steam is less. But above critical pressure solubility of these substances become higher in steam phase and since there is no phase separation, impurities get carried to steam phase. Hence, supercritical unit needs extremely pure feed water, resulting in the best possible feed water treatment. The make-up water and condensate must also be purified since marginal blow down is available to remove impurities. Thus, condensate polishing unit is a must in the condensate circuit for supercritical units.

For identical size, although once-through boilers avoid thick walled components like drum and replace it with small diameter separator vessel, the installation costs of supercritical plants are about 2.5 to 3.5% higher than sub-critical plants. Due to high pressure and high temperature, superheater and reheater need to adopt costly alloy steel metallurgy. Similarly, HP/ IP turbine section require higher Chromium, Molybdenum, Vanadium and Nickel content to retain high tensile strength at elevated temperature. All these added together raises the installation costs. The wall-thickness of HP turbine section also needs special consideration. While the wall-thickness should be high enough to withstand elevated pressure and temperature, the thickness has to

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be as low as possible to avoid massive material in order to increase the thermal flexibility and fast load changes. The wall thickness of the tubes and headers of once-through boiler needs to be designed for the selected pressure level.

Globally, more than five hundred supercritical plants are in operation. As per available information, their availability and maintenance costs are comparable to sub-critical plants, if not better. The benefits of supercritical technology, in a nutshell, may be surmised as:

- Improved thermal efficiency attainable
- Reduced fuel cost
- Reduction of carbon-di-oxide emission by as much as 15% per unit of electricity generated compared to typical sub-critical unit.
- Very good part load efficiency. Typically the drop in efficiency at part load is 50% of that of sub-critical units.
- Very low emissions of NO_X, SO_X and SPM achievable using modern flue gas clean-up equipment.
- Initial investment requirement comparable with sub-critical technology and less than other clean coal technology. This, however, depends on the unit size considered.
- The load change rate capability of the system is not restricted by the turbine.
- Steam temperature at the inlet and outlet of the reheater is nearly constant over a wide range.
- The boiler feed water pump power is significantly reduced at lower loads.
- Short start up times.

It is needless to mention that significant research and development work in the field are being carried out to optimize on:

- Equipment layout and heat rate
- Requirement of auxiliaries
- Environmental impact
- Initial cost

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- Plant availability

An evaluation of steam cycle performance shows that a cycle efficiency of about 42% is attainable in supercritical applications compared to 36% attainable with sub-critical steam parameters.

At a more specific level, improvements are possible and are being attained through:

- Increase in main and reheat steam temperatures and main steam pressure including transition to supercritical conditions.
- Changes of cycle configuration, namely, increasing number of reheat stages, feed heaters with associated increase in final feed water temperature.
- Changes in the boundary conditions of the cycle, namely, flow and temperature of flue gas at the outlet, condenser pressure etc.
- Reduction in auxiliary power consumption.
- Improvement in the performance of the individual plant components, which in turn, has an effect on the other areas listed above (coal combustion, turbine efficiency, pump efficiency, condenser performance etc.).

For the two unit station of 660 MW each with supercritical technology has been planned and hence currently under development. The choice of supercritical steam parameters in once-through boiler is prima facie guided by the improvement in cycle efficiency as listed above. The choice is, however, beset with use of higher alloy steels in the heat transfer surfaces. The salient technical features of the power generating equipment have been furnished in ***Annexure 5.1.***

The improvement in heat rate on weighted average basis as indicated for 660 MW supercritical sets over conventional sub-critical 660 MW machine is about 2.5%. From the above, it may be inferred that for a typical 660 MW set, the advantages in terms of improvement in heat

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rate is marginally offset by high investment requirement. The high capital investment requirement for supercritical boiler and turbine generator sets is attributable to high priced quality alloy steel involved. But with the improvement in cycle efficiency and the environmental benefit attainable, the choice tilts in favour of the super critical unit. However, it is expected that with considerable R&D efforts underway at present the cost of superior quality high-creep strength martensitic steel (P91, P92 and P122) would taper off by the turn of this decade. With the above in view, for the extension 2x660 MW station of OPGC at Odisha, adoption of super-critical steam parameters is favored.

5.3 THERMODYNAMIC CYCLE

To achieve higher efficiency without sacrificing availability, it was decided to consider steam parameters in the super critical range, which is also in line with the established practice of most of the manufacturers of 660 MW units.

The fuel considered for the station is coal, which will be made available from Manoharpur & Dipside Manoharpur coal blocks. Coal shall be transported to the plant site by railway wagons using the existing merry go round (MGR) system. The thermodynamic cycle will consist of Boiler, Steam Turbine, condenser, condensate extraction system, boiler feed system and condensate and feed water heaters along with all other necessary equipment for single reheat and regenerative feed heating.

Drawing No. K8B09-005-DWG-DPR-002 shows the typical flow diagram for steam and water envisaged for the 2 x 660 MW project. A reheat steam cycle with regenerative feed heating system is employed. A heat balance with three (3) HP Heaters, four (4) LP Heaters and one (1) direct contact heater – deaerator is presented in **Drawing No. K8B09-005-DWG-DPR-001**. Project specific HBD shall be developed by BTG Contractor during detail engineering stage. The heat balance diagram provided is typical for a 660 MW unit. The heat balance is based on 'ZERO' make up, 33°C condenser cooling water inlet temperature and condenser pressure of 76 mm Hg Abs.

As shown in the scheme and heat balance diagrams, the main steam from the boiler, after expansion through the HP turbine, would be sent back to the boiler for re-heating. The reheated steam, after expansion through the single casing double flow IP and LP turbines would be exhausted into the main condenser(s). The exhaust steam from the LP turbine would be condensed by circulation of Cooling water. Vacuum would be maintained by two (2) (1 working + 1 standby) 100% capacity vacuum pumps. The LP feed heating system would consist of three (3) to four (4) stages of low pressure heaters, one (1) gland steam condenser, one (1) external drain cooler for the low pressure heater and one (1) deaerator. HP feed heating system will consist of two (2) to three (3) stages of High Pressure Heaters. The condensate from the hot well would be extracted by 3 × 50% capacity condensate extraction pumps (2 working + 1 standby) and pumped to the deaerator through gland steam condenser, drain cooler and the LP heaters. The feed water after being deaerated in the deaerator would be pumped to the boiler through the high-pressure heaters. Oxygen content and pH of the feed water would be closely monitored to prevent corrosion damage to power cycle equipment. Continuous injection of dilute solution of hydrazine is envisaged at outlet of Deaerator (suction of Boiler Feed Pumps) for oxygen scavenging purpose. In order to control the pH of the feed water, continuous injection of dilute solution of Ammonia is envisaged at outlet of Condensate Polisher. Provision shall also be kept for injecting hydrazine at outlet of Condensate Polisher and ammonia at outlet of Deaerator. For each unit, three (3) boiler feed pumps (2 working + 1 standby) is envisaged. Two of the above Boiler Feed pumps, with 50% capacity rating each, would be steam turbine driven and the third pump, with 35% capacity rating, would be motor-driven. Normally the steam turbine driven pumps would be in operation. The motor driven pump shall be operated during start-

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up and during the failure of any of the two turbine driven pumps. The boiler feed pumps would be provided with lube oil system, automatic leak off and minimum flow re-circulation valves. Motor-driven BFW pump would be provided with modulating variable speed hydraulic coupling. Condensate drain from the HP heaters would be cascaded to the deaerator feed storage tank and the condensate drains from the LP heaters would be cascaded to the condenser through the drain cooler.

To meet the continuous and startup auxiliary steam requirements, two numbers auxiliary pressure reducing and desuperheating stations (PRDS), one taking tap off from main steam line (high capacity PRDS) and other taking tap off from cold reheat line (low capacity PRDS) shall be provided for each unit. The high capacity PDRS shall come into operation particularly during unit start-up and other exigencies while the low capacity PRDS shall cater to the normal operation requirements of the unit. Two nos. auxiliary steam headers shall be provided down-stream of the PRDS, a high temperature header and a low temperature header, from where the auxiliary steam requirements of various systems shall be tapped off.

The unit will also be provided with 60% HP and corresponding LP Turbine bypass system for quick start and large load rejections. The turbine generator unit would be so designed that it will be capable of cyclic duty and frequent start-ups and shutdowns during its lifetime. The salient features and parameters of major equipment of the 660 MW set are furnished hereinafter. The details of the unit may vary to some extent as per vendors' standard product. The basis of technical parameters of the main plant and auxiliary equipment for the 2 x 660 MW thermal power plant are discussed hereunder which describes the general requirements but is not intended to be exhaustive.

5.4 TURBINE GENERATOR UNIT

The steam turbine would be multi-stage, multi-cylinder, tandem compound, single reheat, condensing type machine operating at 3000

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rpm with minimum seven (7) uncontrolled extractions for regenerative feed heating. The turbine will be designed for main steam inlet parameters of around 247 Kg/cm^2 (a) pressure and 565°C (±5°C) temperature before the emergency stop valves of the HP turbine, reheat steam temperature of 593°C (±5°C) at IP turbine inlet with design exhausting condenser pressure and design condenser cooling water temperature of 33°C. The turbo-generator set would be designed for a maximum throttle steam flow at turbine valve wide open (VWO) condition of 105% of turbine maximum continuous rating (TMCR) flow. A quick acting HP and LP turbine bypass station would be provided as a part of the turbine package. The bypass station will act not only to stabilize boiler condition with sudden load dump/turbine trip out but also as a protection to the turbine during pressure rise resulting from sudden load throw off. In addition, it will enable quick start-up of the unit following a hot trip out by proper matching of boiler steam and turbine metal temperature. The bypass station would be sized for a flow corresponding to about 60% of Boiler MCR.

The steam turbine will be equipped with hydraulic turning gear for uniform heating/cooling of the rotor during start-up/shut-down. Highly sensitive electro-hydraulic governing system would be provided with suitable hardware to ensure fast speed of operation and safety. The electro-hydraulic governing system would be backed by hydro-mechanical governing and safety system ensuring stable operation under any grid fluctuation and load throw off condition. The turbo-generator unit would be provided with self-contained lubricating oil system for supplying oil to the turbine and generator bearings and also to the generator seal oil system. The lubricating oil would be cooled by closed circuit cooling water system utilising passivated demineralised water as cooling medium.

The steam turbine set complete with all auxiliaries, accessories and controls for driving electric generator sets of nominal rating 660 MW operating on unit system with independent steam generator feeding the turbine is considered for the station.

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Brief technical features of major systems and equipment are given in **Annexure-5.1.**

The unit would be capable of generating at MCR and also with valves wide open (VWO) conditions continuously with maximum cooling water temperature of 33°C and specified make-up to heat cycle. It would also be capable of operating continuously under HP heaters out of service condition generating rated output. The design of the turbine would be based on the maximum pressure and temperature it is subjected to. The rotors would be dynamically balanced and heat stabilized with thermal deflection within prescribed limits of relevant codes.

Scope of supply of the Steam Turbine and Generator would be inclusive of, but not limited to, suitable emergency stop valve, reheat stop valve, interceptor valve, turbine control valves, HP-LP steam turbine bypass system, piping, all special insulation, paints etc. Other protective devices i.e., emergency governor, emergency trip, unloading gears, vacuum breaker etc. as required for a modern utility plant would be provided. The sets would be complete with self-contained governing fluid, lube oil, seal oil, hydrogen filling, purging and pressure/purity monitoring/control system etc. as required for continuous safe and trouble-free operation. Besides these, a fully automatic gland steam sealing system and electric motor driven/hydraulic turning gear would be provided.

The electric generator would be three-phase, directly coupled, two-pole machine capable of generating 660 MW at generator terminals after meeting power requirement for excitation at a power factor 0.85 (lag). The generator would deliver power at 21 KV, 3 pH, 50 Hz with short circuit ratio not less than 0.48.

The rotor and the stator windings shall be hydrogen and DM water cooled respectively. The generator would be suitable for connection by

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means of isolated phase bus duct to the low voltage winding of the step-up transformer. The generator would have Class-F insulation but rated for Class-B temperature rise.

The TG set would be capable of delivering continuously the rated power at 0.85 (lag) power factor when the voltage variation is within ±5% of rated value and also when frequency variation is within 47.5 Hz and 51.5 Hz. Generator excitation system would be of brushless and capable of maintaining steady generator terminal voltage under variable load conditions and also ensure generator stability under transient conditions.

5.5 CONDENSING EQUIPMENT & ACCESSORIES

The thermodynamic cycle would be complete with divided flow, single or multiple pass, horizontal, surface type, clarified water-cooled condenser(s). The condenser unit(s) would be transverse mounted and would condense exhaust steam by circulation of clarified water (design inlet temperature 33°C) in a recirculating cooling water system using wet type cooling tower. Condenser outlet water temperature will be maintained within 42 °C. Clarified water would be the cooling medium in the condenser and in other auxiliary coolers. Condenser with Stainless Steel heat exchanger tubes, with steel tube sheet, baffle plates, etc. are envisaged for clarified water application. Cathodic protection with Zn or Al sacrificial anode would be provided, if required. The condenser would be designed as per HEI code or equivalent. The design heat load of the condenser will consider the turbine operating condition at VWO having 105% MCR steam flow, maximum expected make-up, 90% tube cleanliness factor and a condenser cooling water inlet temperature of 33°C to maintain rated condenser pressure(s). The condenser should also be capable of accepting full HP-LP bypass steam flow safely without undue pressure rise, vibration, noise or other detrimental effects. Oxygen content of condensate leaving condenser hot well will be less than 0.015 cc per litre over the entire load range.

The condenser(s) of each unit would be provided with 2 x 100% capacity (1 working + 1 standby) vacuum pumps to remove non-condensable gases and maintain vacuum in the condenser at the desired level during normal operation. For start-up both the pumps shall be operated simultaneously. The condenser would be spring mounted with rigid connection to the turbine exhaust. Alternatively, condenser may be on solid footing with corrosion resistant flexible metallic bellow connection with the turbine exhaust.

Condensate Extraction Pumps:

The condensate cycle would comprise three nos. (2W + 1S) 50% capacity motor-driven, vertical condensate extraction pumps of CAN-type construction. Connection between condenser and each pump suction will be through a block valve and removable strainer. The pumps will discharge through check valve and motor operated stop valves into a common discharge header. Connection for condensate supply to the following major services will be tapped off from this condensate discharge header.

a. LP bypass de-superheating spray.

b. Turbine exhaust hood spray.

c. Gland sealing system de-superheating.

Condensate will then pass in series through the condensate polishing system, gland steam condenser and drain cooler before being passed through the low pressure feed water heaters. Condensate polishing system shall have 3 x 50% mixed bed polishers for each 660 MW unit

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along with an external regeneration system common to both units. Condensate will be finally pumped to the deaerator.

5.6 BOILER FEED WATER PUMPS

The feed water system will comprise three (3) nos. (2 working + 1 standby) boiler feed pumps of centrifugal, multi-stage, horizontal, barrel type construction. Out of the three (3) pumps, two (2) pumps with rated capacity of 50% of total feed water flow per boiler, would be steam turbine driven and would normally be in operation while the third pump with 35% capacity rating would be electric motor-driven through a variable speed hydraulic coupling (with step-up gearing) which would act as standby and also to facilitate start-up of the unit. The head, capacity and net positive suction head (NPSH) would be so selected as to permit parallel operation at all loads and be compatible with the heat cycle considered to meet the boiler MCR condition without encroaching on normal margins. Booster pumps shall be considered to ensure appropriate head at main pump inlet. The pumps will be provided with mechanical seal and flushing arrangement as per API 610. The supply would be complete with and inclusive of variable speed hydraulic coupling, lube oil system, automatic leak-off, minimum flow recirculation valves, bypass valves, base plates, foundation bolts, couplings and 11 kV, 3 pH, 50 Hz electric motor drive.

5.7 DEAERATING HEATERS & CLOSED HEATERS

The regenerative feed heating system would comprise vertical or horizontal shell and tube-type feed water heaters with suitable bypass arrangement and a direct contact type heater, which shall serve the additional purpose of deaerating the feed water. The low pressure feed water heaters will be horizontal U-tube type and equipped with condensing and drain cooling zones. Besides these, separate drain cooler, gland steam condenser etc. as per manufacturer's standard are

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envisaged. A horizontal spray-cum-tray type deaerator with integral vent condenser will limit the oxygen content in the feed water to a maximum value of 0.005 cc/litre at all operating conditions with minimum loss of steam. The deaerator storage tank should be adequately sized to accommodate at least 6 minutes' water requirement of the boiler at BMCR condition. The high pressure heaters will be of horizontal U-tube type having desuperheating, condensing and drain-cooling zones. All steel construction of condensate/feed water wetted surfaces is desired to facilitate uniform chemical conditioning of steam-condensate-feed water system.

5.8 STEAM GENERATORS

The supercritical once-through steam generator units for the station will be semi-outdoor, pulverized coal fired, balanced draft, single reheat, dry bottom type with two pass or tower type arrangement as per manufacturer's standard. For improved efficiency at part loads and flexible operability, Benson type boiler, capable of sliding pressure operation, is favoured. An added advantage is that Benson type boilers feature Boiler circulation pumps which shorten the start-up time and heat loss during start-up period.

Furnace design requires special consideration in sliding pressure supercritical boilers owing to the requirement of once-through operation. The mass flow in the furnace-wall tubes must be sufficiently high to avoid overheating or departure from nucleate boiling (DNB) while generating steam at sub-critical pressures and to avoid excessive metal temperatures and uneven steam outlet temperatures when operating at super critical pressure at higher boiler loads. To accomplish these objectives, the spiral-wall design is usually adopted for this type of units. The principle of the spiral- or helical-wall furnace is to increase the mass flow per tube by reducing the number of tubes needed to envelope the furnace without increasing the

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spacing between the tubes. This is done by arranging the tubes at an angle and spiralling them around the furnace. For instance, the number of tubes required to cover the furnace wall can be reduced to one half by putting the tubes at a 30-degree angle. The centre line spacing or pitch is made the same as on a vertical wall to prevent fin overheating. Additionally, by spiralling around the furnace, every tube is part of all the walls, which means that each tube acts as a heat integrator around the four walls of the combustion chamber. As an alternative to spiral wall design, some manufacturers advocate a tangentially fired unit with vertical water-walls consisting of rifled tubes for ease of fabrication, erection, and maintenance. A stable fireball is formed in the centre of the furnace with tangential firing, with essentially equal distribution of the lateral heat absorption on all furnace walls. Unbalances are minimized and lateral heat absorption patterns are predictable over the entire load range. Rifled tubing is used in the furnace walls to avoid overheating or DNB at subcritical pressures. Proper selection of materials for the water wall tubes and other pressure parts is of prime importance for trouble-free operation of the units. The working pressure and temperature shall be given due consideration during material selection. Preferably, high creep strength steel alloys shall be used for longer life.

The improvement in cycle efficiency due to supercritical steam parameters will reduce the coal consumption per unit power generation and consequently, the emission levels will go down. CO_2 emission from supercritical plants is at least 2-3% less than that from a subcritical plant of same power generation capacity. The amount of NO_x emissions will be around 300 – 600 mg/Nm^3 when unit is operating at TMCR load.

Steam generating plant complete with all auxiliaries, accessories and controls for supplying steam to reheat and regenerative turbine generator set of nominal capacity 660 MW operating on unitised basis

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is envisaged. The steam generator parameter shall match the TG set requirement. Capacity of steam generating unit would be approximately 2100 TPH so as to ensure adequate margin over the requirement of turbine at VWO condition in order to cater to:

(a) Auxiliary steam requirement for soot blowing operation
(b) Fuel oil heating
(c) Deaerating of the steam generating unit after prolonged use.

The steam generators would be designed to operate with "the HP heaters out of service" condition (resulting in lower feed water temperature at economiser inlet) and deliver steam to meet the turbo-generator requirement at base load. Economiser section of the boiler would be non-steaming type with provision for recirculation during start-up, chemical cleaning etc. Superheater section would be divided in convection and radiant zones and designed so as to maintain rated steam temperature of around 565°C (± 5°C) at the outlet over a control range of 60% TMCR to 100% BMCR load. The reheater section would be designed to maintain rated steam temperature of around 593°C (± 5°C) at the outlet over a control range of 60% TMCR to 100% BMCR load. Main steam de-superheating station would be provided with arrangement for spraying water tapped off from feed water piping. The steam generator will be conservatively designed for satisfactory, continuous and reliable operation at high efficiency with the range of coal expected for this station with minimum requirement of auxiliary fuel oil for flame stabilization etc. within its control range. Furnace would be conservatively designed to allow adequate residence time for the fuel to burn completely. The design air and flue gas velocities would be carefully selected to minimise erosion of pressure parts and other vital components. The pressure parts will be designed as per ISO/ASME Sec.1 and would conform to the current Indian Boiler Regulation. Each boiler would be provided with a set of automatic sequential electrically operated type steam soot blowers with provision of manual retraction in emergency for on-load cleaning of the heat

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transfer surfaces. Air pre-heaters of rotary bisector/trisector regenerative type of 2 x 60% capacity would be provided for the boiler. The regenerative type air heaters would be designed for minimum leakage and be practically maintenance-free with provision of air bypass. Cold start-up operation using steam coil air pre-heater (SCAPH) would be provided. The boiler furnace and flue gas passages would be designed for low gas velocities in order to minimise erosion or slagging. The basic parameters of steam generator are furnished in **Annexure-5.1**.

The Steam Generator Control would include Burner Management System (BMS), Master Fuel Trip, Secondary Air Damper Control, Soot Blower System etc. Flame monitoring systems and field instruments including process switches & transmitters would be provided for the above controls. Final control elements for modulating and on-off duty control valves and dampers would also be provided to achieve remote control of the steam generating unit from central control room.

Draft system is envisaged to have two (2) sets each of Forced Draft (FD) fans, Induced Draft (ID) fans and Primary air (PA) fans, each set rated for 60% of BMCR capacity. The FD fans and PA fans will be of variable pitch control axial flow type with silencer at air inlet. The ID fans would also be axial type with variable blade pitch control. The equipment would be complete with lube oil, hydraulic regulations and all other accessories required for continuous operation. All equipment would be suitable for outdoor installation.

The Steam Generator unit would be equipped with suitable pulverized coal firing arrangement comprising coal bunkers, gravimetric raw coal feeders, pulverizing mills, primary air fans and seal air fans, fuel and air pipes, burners etc. as necessary. Pulverizing plant consisting of adequate nos. of vertical spindle type mills is envisaged to be located on either side of the furnace. With design coal firing, one mill will

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remain standby at BMCR condition considering loading of individual mill limited to 90% of rated capacity. Coal feed size is assumed to be (-)20 mm. The feed control for coal would be done through selector switch either on manual mode or automatic mode and controlled as per the plant load and composition of the fuel. The firing system would employ latest low NO_X burners and permit load variation from 30-100% BMCR without auxiliary stabilizing fuel. The steam-generating unit will be provided with arrangement for start up by light diesel oil.

Light diesel oil is envisaged to be used for cold start-up, while Heavy Fuel Oil will be used as secondary fuel for coal flame stabilization at low loads and for supporting purposes. Heavy Fuel oil system will be designed to cater up to 30% BMCR of the Steam Generator and will comprise of oil storage tanks, unloading pumps, pressurizing pumps, strainers, piping, controls etc. Four (4) nos. HFO pressurising pumps and three (3) nos. LDO pressurising pumps have been considered for feeding the oil burners of two steam generators. Fuel oil will be dumped to the Storage tanks from unloading header through the unloading pumps of the existing 2 x 210 MW units. Oil from the Storage tank would be pumped through suction strainers to the burners by the pressurising pumps and excess oil re-circulated back to the storage tanks. Oil burners will be complete with tips, extension pipes, atomizers, burner shut-off valve, flexible hoses and accessories. A good turn down ratio for the fuel oil system will be possible through burner turn down and selective use of a number of guns in steps.

The complete boiler will be top supported type and would be provided with all supporting steel structures, platforms, galleries, elevator and stairways for easy approach and maintenance of the unit. Adequate weather protection would be provided for instruments and operating personnel. Necessary lining and insulation along with fixing materials to limit outside surface temperature to a safe level would be provided.

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Monorails and hoists required for handling heavy equipment, motors, fans etc. would be supplied along with the steam-generating unit for ease of maintenance.

Each steam-generating unit would be provided with one set of Electrostatic Precipitators (ESP). Each ESP will have two parallel passes, any of which can be isolated for maintenance as and when required, keeping the other path in operation. Each path will have multiple fields in series for collection of fly ash. The overall efficiency of ESP should not be less than 99.98% with one field remaining as operational standby. The ESP would have adequate number of ash hoppers provided with electric heaters. The control of ESP would be based on microprocessor using semi-pulse device. The design of ESP will be such that the outlet dust-burden does not exceed 50 mg/Nm^3 at 100% BMCR with worst coal firing and one field out of service.

To reduce the NO_X emission from the Steam Generator necessary provisions in the Steam Generator design and fuel firing system, will be made. Maximum NO_X emission from the unit would not be more than 650 mg per Nm^3 (as per World Bank standard) including thermal NO_X produced during the entire operating range of Steam Generators.

In addition to the foregoing, the 275 m high stack is expected to bring down the ground level concentration of SO_2 based on 24- hourly average to a minimum. One (1) no. steel twin-flue chimney with concrete windshield has been envisaged for this project. The chimney does not fall in the flight path of any airlines. The nearest domestic airport is at Bhubaneswar.

The Steam Generator and auxiliaries will perform continuously within noise limits as per relevant standard specification but not more than 85 dB(A) at 1 meter from any equipment or sub-equipment.

Brief Technical Features of Power Generating Equipment

1. Turbine Generator & Auxiliaries

Type	:	Single reheat multi cylinder tandem compound, regenerative, condensing steam turbine directly driving a 3000-rpm, 2-pole, 50 Hz, electric power generator.
Nominal Capacity	:	660 MW at 33°C condenser cooling water temperature.
Normal Operating Frequency Range	:	47.5 to 51.5 Hz.

Inlet Steam Parameters :

		Main Steam	**Hot Reheat**
• Pressure, Kg/sq.cm (abs.)	:	247	50
• Temperature, °C	:	565	593
• Steam flow at MCR T/hr. (approx.)	:	2100	1700

Exhaust Pressure	:	76 mm of Hg (abs.) preferred.
Steam Extractions	:	CRH + 6 to 7 Nos. stages from HP, IP and LP turbines for condensate / feed water heating (depending on manufacturer).
Type of governing	:	Electro-hydraulic governing with fire resistant fluid.

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	Turbine HP-LP bypass system	: Capacity : 60% of BMCR steam flow.
	Condensing Equipment	: Shell and tube type surface condenser(s) operating on recirculating cooling water with evaporative cooling towers.
	Regenerative feed heating arrangement	: Two/Three nos. Shell & tube type HP heaters and three/four nos. LP heaters and one (1) spray-cum-tray type deaerator.
	Boiler feed water pumps	: 2×50% capacity steam turbine driven and 1×35% capacity motor driven barrel type horizontal, centrifugal.
	Condensate extraction pumps	: 3×50% capacity vertical, centrifugal CAN type construction, electric motor driven.
	Generator	: 777,000 kVA output at 0.85 power factor (lagging) 3 pH, 50 Hz and 21 kV voltage.
2.	Steam Generator & Auxiliaries	
	Type	: Pulverized fuel, once through, two-pass/tower type, semi-outdoor type, and dry bottom, coal-fired unit preferably with tangential firing and with associated auxiliaries suitable

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		for both constant pressure and sliding pressure mode of operation.	
Nominal Capacity	:	2100 Tones/Hr	
Nominal Outlet Steam Parameters at BMCR:			
		Main Steam	**Hot Reheat**
• Pressure (Kg/cm^2), abs	:	255	50
• Temperature, °C	:	565	596
- Steam temp. control range	:	60-100% BMCR or better (to be decided in design stage).	
- Superheater/Reheater Temperature control	:	Attemperation and tilting burner control	
Nominal Air Heaters Capacity	:	2 x 60% of BMCR (if trisector type) / 2 x 60% for Primary air and 2 x 60% for secondary air (if bisector type)	
Draft Fans	:	2 x 60% BMCR capacity axial flow forced draft (FD) fans with variable blade pitch control/inlet guide vane control. 2 x 60% BMCR capacity induced draft (ID) fans, axial type with variable blade pitch control. 2 x 60% BMCR capacity axial flow primary air (PA) fans with variable blade pitch control.	

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Pulverizing Mills	: Vertical spindle type mills in N+1 configuration. (Refer note below.)
Coal Firing System	: Direct suspended firing with state-of-the-art low NO_X burners giving stable fire above 40% TMCR load.
Start-up/auxiliary fuel	: Light diesel oil for cold start and for support (capacity up to 10% BMCR) and heavy fuel oil (HFO) for load carrying purpose (capacity up to 30% BMCR) and flame stabilization for unit loads below 40% BMCR heat load.
Ash removal	: **Bottom Ash**: Extraction in wet form and disposal by slurry pumps to the existing Ash Pond. **Fly Ash:** Evacuation in dry form through vacuum & pressurized air conveying for ultimate disposal from silos by special wagons for filling mines. Provision for emergency disposal to ash pond through HCSD system is kept.

Note : N-denotes the number of mills required to reach boiler MCR with design coal and 90% mill loading.

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SECTION-6
AUXILIARY SYSTEMS

6.1 INTRODUCTION

The philosophy of design of the auxiliary system would be pre-dominantly guided by the site features, technology, basic design parameters, infrastructure etc. Adequate redundancy shall be adopted to ensure high availability of the plant.

All the systems and system components would be designed for simplicity of operation and ease of maintenance so as to call for minimum manual labour and low degree of supervision. Redundancies in systems and sub-systems would be considered taking into account the operating experience of similar capacity units being operated elsewhere.

6.2 PLANT WATER SYSTEM

The Plant water System for 2 x 660 MW units 3 & 4 of OPGC would be drawn from Hirakud Reservoir. The consumptive water requirement of the 2 × 660 MW units 3 & 4 is estimated at 4100 m^3/hr considering fly ash disposal through HCSD System and bottom ash disposal through lean ash slurry System. The raw water would be drawn through an intake channel of 5.6 Km length from Hirakud reservoir to the existing in-plant Raw water pump house.

Recirculating cooling water system using wet evaporative cooling towers would be deployed for the expansion units. The cooling circuit would cover condenser and auxiliary equipment cooling in a semi-open cooling water circuit. The choice of cooling water system is guided predominantly by the GOI guidelines on use of sweet water for cooling purposes.

In this system, cooling water is circulated through the condenser and the auxiliary coolers of TG and SG to dissipate heat through cooling tower with a small percentage of total water in circulation to be discharged as blow down to maintain the total dissolved solid in water within permissible range which in turn will avoid deposition and fouling on heat exchanger surfaces. With less initial investment cost, less pumping head, less space requirement induced draft cooling tower has an edge over the natural draft towers particularly for this project, though auxiliary power consumption will be more, more maintenance requirements and chances of recirculation and fogging under adverse weather conditions. However, for the units 3 & 4 with 660 MW units, the choice of technology tilts towards induced draft cooling tower.

The tentative Raw water analysis is furnished in Annexure-3.1 earlier. During detail engineering stage year round water analysis data will be available for establishing appropriate design basis for finalising the plant water system. For the purpose of the present study a single line diagram is presented in **Drawing No. K8B09-006-DWG-DPR-001** showing plant water system.

For the 2 × 660 MW units 3 & 4 the total water requirement is estimated at 4100 m^3/hr on the basis of losses in clarification & filtration system, 1.5% heat cycle make-up, make-up to cooling towers and other consumptive requirements like potable water, make-up requirements for air-conditioning and ventilation, usual design margin as per good engineering practice etc. All the above quantities are usually associated with average daily plant load factor apportioned on hourly basis. It is envisaged to utilise blowdown from the cooling tower in ash handling system and blowdown quenching pit. The break-up is

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detailed in Annexure-3.2 furnished earlier and the water balance diagram is given in **Drawing No.K8B09-006-DWG-DPR-002** enclosed. Existing raw water pump house has six (6) Nos. of 1400 m3/hr capacity pumps installed. Out of these, two pumps are presently dedicated to supply raw water for existing units 1 & 2, two pumps are dedicated to supply water for Mahanadi Coal Fields Limited (MCL) and balance two nos. of pumps shall be utilized for units 3 & 4. Two (2) additional new pumps shall be installed to cater the requirement of 2 x 660 MW units 3 & 4. Raw water from raw water sump would be pumped to the Clarifloculation Plant.

Raw water will be clarified to remove sand, other suspended solids and Colloids. Coagulation, Flocculation and Sedimentation by means of Flash Mixer and Clariflocculator has been envisaged for treatment of Raw water. The clarification system consist of the hook-up as follows : Two (2) nos. Stilling Chambers – Two (2) nos. Parshall Flumes – Two (2) nos. Distribution Boxes – Two (2) nos. Reactor type Clarifiers. Stilling Chamber helps in reducing the turbulence providing laminar flow at the downstream. To remove incidental growth of Organisms in raw water, chlorine will be dosed in the Stilling Chamber as required. From Stilling Chamber, water will flow through dedicated Parshall flumes and Distribution Boxes by Gravity. From Distribution Boxes, water will flow to two (2) nos. Clariflocculators. However, Hydraulics shall be such that 20% overloading of clarifier is achieved. Chemicals such as ferric or non-ferric alum, lime and polyelectrolyte will be added as per tests to raw water in Clariflocculators. The clarified water from Clariflocculators will flow through channel and be stored in a Clarified Water Reservoir.

Two (2) Nos. of 3125 m^3/hr capacity Clariflocculator units have been envisaged for this project. In case one Clariflocculator unit is under maintenance, the other Clariflocculator unit will be capable to deliver the requirement of Clarified Water @3860 m^3/hr.

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A part of Clarified Water from each of the Clariflocculators, will be led to the inlet of the existing Twin Bed type Gravity Sand Filters. Five (5) nos. (4W + 1S) Gravity Filters, each of rated capacity 500 m^3/hr. have been there in the existing Plant of 2 × 210 MW units and the same can be used for the 2 × 660 MW units. Filtered water will be stored in the existing Filtered Water Storage Tank.

Then Filtered Water will be fed to the following services :

- Potable water for Plant and Colony.
- DM Plant Feed.

The primary cooling water would be subsequently cooled in plate type heat exchangers using clarified water from cooling tower basin through a set of auxiliary cooling water pumps in the secondary circuit.

Cooling water in circulation is estimated at 84,300 m^3/hr under valve wide open condition (VWO) considering temperature rise across condenser as 9 °C including the requirement of auxiliary cooling circuit. The makeup water requirement for cooling circuit at full load is estimated at 3364 m^3/hr. The cooling tower blow down is expected to be about 462 m^3/hr. The system design will take into consideration recycling of waste water for achieving zero liquid discharge.

Sludge from the clariflocculator and Side Stream Filtration (SSF) unit would be transported to Ash Handling Plant (AHP) sump for using in ash handling plant. Regeneration effluent from DM plant would be neutralised before discharge to Central Monitoring Basin (CMB). The water from CMB after suitable treatment would be recycled for use in CHP dust suppression system, to clarified water reservoir, gardening and horticulture.

There will be two DMCCW circuits - one primarily for TG auxiliaries etc. and other for SG auxiliaries etc. DMCCW for SG will have 2 × 100% Plate type Heat Exchanger & DMCCW pumps while TG and auxiliaries will have another 3 × 50% Plate type Heat Exchanger & DMCCW pumps.

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Demineralisation Plant & Heat Cycle Make-up System :

The scheme selected for is shown in **Drawing No. K8B09-006-DWG-DPR-003.** The basic functions of DM Plant are to meet the inventory and make-up requirements of

- Heat Cycle Make-Up.
- Hydrogen Generation Plant.
- Aux. Cooling Service.
- Chemical Feeding System.
- Condensate Polishing Unit.

The Demineralisation (DM) Plant hook up consists of the following major items :

DM Plant Feed Pump - Activated Carbon Filter – Strongly Acidic Cation Exchanger – Degasser Tower, Degasified Water Storage Tank and Degasified Water Pump – Strongly Basic Anion Exchanger - Mixed Bed Exchanger – Feed Tank for Ultrafiltration – Ultrafiltration Feed Pump - Ultrafiltration Unit - DM water Storage Tank. Two (2) nos. DM Chains, each of 125 m^3/hr. capacity (Net) will be provided and installed in the existing DM Plant Building for the 2 x 660 MW units 3 & 4. Among two (2) nos. of DM Chains, one (1) will be working and the other chain will be remain as regeneration cum maintenance standby. A provision for another DM chain of 125 m^3/hr. capacity for future 2 x 660 MW units would be kept in the existing DM

Plant building along with the DM chains. When the future chain will be installed, then two (2) nos. of DM chains will be working and the third one will remain as regeneration cum maintenance standby.

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Period of continuous service run between two (2) successive regenerations of each of Activated Carbon Filter, Strongly Acidic Cation Exchanger and Strongly Basic Anion Exchanger Units shall be eighteen (18) hours. However, each Mixed Bed Exchanger Unit will be regenerated after 126 hours of continuous service run.

Demineralized water will then stored in two (2) nos. of DM Water Storage Tank, effective capacity of each tank shall be 1200 m^3.

Separate Acid and Alkali unloading, storage and injection system will be used for the regeneration of ion exchange resins of DM streams.

DM Water from DM Water Storage Tanks will be transferred to the Condensate Storage Tank by DM Water Transfer Pumps for further downstream uses.

6.3 COAL HANDLING SYSTEM

Coal from Manoharpur and Dip side of Manoharpur coal fields of Mahanadi Coalfield Limited (MCL) is considered as the primary fuel for the 2 x660 MW units 3 & 4. For the units 3 & 4 crushed coal (-20 mm) would be supplied from the mine end by railway wagons and would be unloaded into the Track hopper. From there crushed coal would be conveyed either directly to the coal bunkers or stockpile. From stockpile, crushed coal would be reclaimed and conveyed to the coal bunkers through belt conveyors. The scheme of the Coal Handling System is shown in **Drawing No. K8B09-006-DWG-DPR-004**. Adequate redundancy has been adopted to ensure uninterrupted operation of the system.

The coal handling system of the plant would be designed considering:

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		Design Coal
i)	Gross Calorific Value of received coal (design coal)	3200 Kcal/Kg.
ii)	Hourly coal consumption (max.)	880 TPH.
iii)	Received Crushed coal size	(-) 20 mm.
iv)	Maximum daily consumption of coal with MCR condition (Considering 100 % Transmission)	21120 TPD.
v)	Annual coal requirement for 1320 MW Units 3 & 4 (Considering 90 % PLF)	6.94 Million Ton / year.
vi)	Mode of receipt of coal in plant	Rail Wagon.
vii)	Mode of coal transportation to Coal Bunker	By belt conveyor from CHP area to Power Plant area.
viii)	Coal Stock pile capacity	10 Days.

The system design would ensure receipt of crushed coal from coal mines to the Coal Handling Plant site by railway wagons. For coal receipt section, three-shift operation is envisaged to avoid demurrage. The equipment of CHP would be designed for two-shift operation for the units 3 & 4. The design capacity of Coal Handling System at receiving end would be 3000 TPH and that for the handling plant feeding to bunkers would be 3000 TPH. The capacity of Stacker and the reclaimer should be sufficient to cater the coal requirement for Units 3 & 4 and future Units 5 & 6 under any exigency condition. Coal, on receipt at coal handling plant, would be fed to the stack yard with sizes (-) 20 mm. One (1) no. reversible stacker-cum-reclaimer would be rail-mounted, self-propelled unit with 41 m boom length having adequate slewing and luffing provision to stack coal upto a height of 10 m and reclaiming the same afterwards. Crushed coal after reclaiming from stack pile would be fed to the powerhouse coal bunkers. This arrangement would be operational under normal conditions during daylight hours till the bunkers are full. During emergency (when direct

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feeding is not possible and Stacker reclaimer is out of service) Reclaiming Hoppers will be there to reclaim the coal from the stockyard by dozers to Bunker by means of Vibrating Feeders and Reclaim Conveyor. Excess quantity would thereafter be stacked in the yard. Twin 100% capacity stream conveying system is utilized to ensure availability. Bunkers would have a storage capacity of about 14 hours' coal requirement for the boiler. The bunkers will be provided with rod and slide gates, arch breakers, etc. to facilitate operation. Necessary belt weighing at conveyors, electronic type level indicators, coal sampling units, flap gates etc. would be provided in the system as required.

Special precautions will be taken for pollution control by providing dust extraction and dust suppression systems in different transfer points and ventilation system for underground tunnels. In addition, roof extraction fans will be provided in key areas like boiler bunker floors. Pressurized ventilation system with unitary air filtration unit will be provided for electrical rooms. Split type air conditioning machines will be provided in the CHP Control rooms.

Necessary water distribution network for drinking and service water will be provided for distributing water at all transfer points, control rooms etc.

A centralized control room with microprocessor based control system is envisaged for operation of the Coal Handling Plant. Except locally controlled equipment like dust extraction / dust suppression / ventilation equipment, sump pumps, water distribution systems etc. all other in-line equipment would have the provision of remote control. However, provision of local control would also be provided. All necessary interlocks, control panels, MCCs, mimic diagrams etc. will be provided in the control room for safe and reliable operation of the Coal Handling Plant.

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The major equipment for the coal handling plant are listed below :-

1.	Conveyors	:	Twin stream conveyor of 2800 TPH capacity.
2.	Paddle Feeder	:	Capacity 1400 TPH.
3.	Stacker-cum-reclaimer (reversible)	:	One (1) No. of 2800 TPH capacity.
4.	Reversible conveyor And belt feeders	:	As required.
5.	Belt weighers	:	Four (4) Nos.
6.	Coal sampling unit	:	One (1).
7.	Flap gates, rack & pinion gates, etc.	:	As required.
8.	Level indicators	:	Electronic type.
9.	Chute liners and chute supporting structures	:	One Lot.

Fire Protection System

Fire hydrants would be provided at all junction towers, bunker gallery and along the overhead conveyors. Fire hydrants would also be provided along the periphery of the Coal stockpile for fire protection.

Control system

Dedicated PLC based system would be provided for operation of Coal handling plant. Dust control systems like Dust extraction and Suppression systems would be operated from local control panels.

6.4 ASH HANDLING SYSTEM

Ash generated in the furnace by burning coal needs to be removed periodically/continuously to avoid undue build-up in the furnace bottom/flue duct hoppers and resultant obstruction.

- For bottom ash, extraction through water impounded bottom ash hopper and lean slurry disposal through slurry pump series has been considered.

- For fly ash, a complete dry extraction up to intermediate silos and from intermediate silo to ash disposal area through High Concentration Slurry Disposal (HCSD) system has been considered.

The quantum of ash generation would depend on the plant load factor and the quality of coal being fed. In keeping with the design system capacity envisaged for Coal Handling Plant, worst coal parameters from the source mentioned earlier is used for equipment selection of the Ash Handling Plant. It has been estimated that 419 Te/Hr ash would be generated from the station per 660 MW unit. Assuming the ratio of ESP fly ash , Bottom ash as 85 : 30 usual for such application, about 335 TPH ESP fly ash, 84 TPH Bottom ash are required to be removed from one 660 MW unit.

In Drawing No.K8B09-006-DPR-005-R-0 the scheme for the Ash Handling Plant is shown.

Bottom Ash Conveying System :

Bottom Ash from the boiler would be collected in water impounded bottom ash hopper. Water impounded bottom ash hopper will have a design capacity to hold about eight (8) hours BA and Economiser ash generation at BMCR operating with worst coal. Bottom ash generated

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in the boiler will be cleaned periodically thorough jet pumps fitted below water impounded bottom ash hopper and will be conveyed to in plant ash slurry sump.

Water impounded bottom ash hopper will be cleaned twice in a shift of eight hours at an interval of four (4) hours. Cleaning time of bottom ash & economizer hopper ash generated in a boiler unit in four hours will be around 1 Hr 10 minutes including purging and down time. Thus total cleaning time of bottom ash & economizer hopper ash generated in a boiler unit in eight hours will be around 2 Hr 20 minutes including purging and down time.

It is envisaged that ash disposal area distance from boilers center line (i.e. center line of boiler of unit #3 & #4) will be approximately 10 KM. Lean bottom ash slurry disposed in ash in plant ash slurry sump will be conveyed to ash disposal area by two series of slurry pumps. Keeping in view of garlanding of ash disposal pipe along the periphery of ash disposal area and ash bund height 15 M from plant grade level, it is envisaged that each slurry pump series shall have four slurry pumps in series. Two such series of slurry disposal pump shall be employed to cater the requirement of two boiler units. Among these two series, one will be working for two units and another will be as stand by.

Two cross country slurry disposal pipes will be provided to dispose lean bottom ash slurry from in plant ash slurry sump to ash disposal area.

Ash from economizer hoppers will be discharged into water impounded bottom ash hopper in slurry form, preferably by gravity.

Overflow water from water impounded bottom ash hopper during non de-ashing period will be re-circulated through adequately sized in plant clarifying unit, common for two units. In clarifying unit, fine ash particles

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will settle down through coagulation and comparatively cleaner water will be conveyed to ash water sump preferably by gravity. This will ensure re use of water & thus overall consumptive water requirement will be kept optimum. Sludge from clarifying unit will be taken out from time to time and will be discharged to ash slurry sump for onward disposal to ash pond.

Fly Ash Handling System (Base System) :

Fly Ash Conveying System

All air pre-heater hoppers and ESP hoppers will be provided with fly ash vacuum conveying systems having capacity to evacuate fly ash generated in a shift of eight (8) hours within five (05) hours twenty (20) minutes including air purging and downtime. The vacuum conveying system shall have four (4) streams operating in parallel (for one unit) , each stream having a conveying capacity of not less than 40 TPH. Thus for two units, total eight number vacuum conveying stream shall operate in parallel to evacuate fly ash. Below each hopper one ash intake valve will be provided to discharge fly ash into the ash-conveying pipeline to be conveyed pneumatically. The ash-air mixture flows through the pipeline for collection of fly ash in dry state into intermediate surge cum buffer hoppers. The fly ash and air mixture flows into a highly efficient bag filter system where almost entire fly ash is removed and discharged into above said intermediate surge cum buffer hoppers located below filter bags in the filter-separator unit.

Necessary transfer hopper with airlock valves will be provided below the filter separator unit to ensure continuous discharge of fly ash without affecting the operation of the upstream vacuum system. Intermediate surge cum buffer hopper will have fluidizing pads distributed properly at the bottom to allow smooth flow of fly ash into the downstream pressure conveying system.

Necessary vacuum for the system will be created by water ring type vacuum pumps. Air discharged from bag filter separator will be flown to the vacuum pumps. Total eight (8) nos. vacuum pumps will be provided (4 no. working for two units + 4 nos. as standby) for each boiler unit.

Four (4) Nos. (20 Tons capacity each) Intermediate Surge cum buffer Hoppers shall be provided (for each boiler unit) close to the ESP, one dedicated for one vacuum conveying stream, which will be of MS construction. From intermediate surge cum buffer hopper, fly ash would be conveyed through pressurised pneumatic system using air compressor to the terminal silos located on the fringe of the plant boundary.

Dry fly ash from the intermediate surge cum buffer hoppers will be conveyed to the terminal fly ash silos by a positive pressure conveying system. Ash feeder vessels shall be installed beneath the intermediate surge cum buffer hopper and fly ash shall be transported to the terminal fly ash silos thru' pipeline from the surge hopper via feeder vessels. For the unit, total six (6) conveying line for two units shall be provided (4 working and 2 common stand-by), each having capacity to transport fly ash at the rate around 80 TPH. Oil free Screw compressors shall provide pressurized air required for conveying. Total six no screw compressor (4 working for two units + 2 stand-by) shall be provided to cater conveying air for pressure conveying system.

Fly Ash Conveying System to Silos

Arrangement shall be made such that each fly ash conveying line can dump fly ash to any of the four fly ash silos. The total storage capacity of terminal fly ash silos shall be to store fly ash generated in 24 hours in two units. Each of the four silos, will have a capacity around 950 to

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1000 Ton each depending upon final design. It is thought that all four silos should be situated side by side in a suitable location with railway access and nearer to plant boundary.

Each fly ash silo shall be provided with suitably sized pressure/vacuum relieving equipment and adequately sized vent filter. This arrangement is elaborated in the flow diagram.

Arrangement shall be made so that all fly ash of two units can be discharged to any one of the four silos.

Fly Ash Unloading from Silos

Each silo shall be provided with four outlets. One outlet will feed dry fly ash into a high concentration slurry disposal (HCSD) unit which will convey concentrated mixture of fly ash and water into ash disposal area, approximately ten kilometer away from silo. These high concentrated slurry disposal pipes (three pipes from four silos, 2W+1S/B) will run along the same corridor through which lean bottom ash cross country slurry pipe line . One outlet will be provided in each silo to discharge dry ash in closed railway wagons through telescopic spout arrangement. This ash will be transported to coal mines for back-filling. Unloading capacity of telescopic spout shall be around 100 TPH (dry ash basis). One outlet will be provided in each silo to discharge moist ash in open trucks through rotary un-loader arrangement. This moist ash has subsequent use like mine fill, landfill etc. Unloading capacity of rotary un-loader arrangement shall be around 100 TPH (dry ash basis). One blank outlet will be provided in each silo for future slurry disposal system. This arrangement is elaborated in the flow diagram.

Broad guideline on high Concentration Slurry Disposal System

Total Three high concentration slurry disposal units shall be provided for two boiler units. Among these three units, two will be working for

ODISHA POWER GENERATION CORPORATION LTD BHUBANESWAR two boiler units and one will be common stand by. Capacity of each high concentration slurry disposal unit shall be around 90 TPH (dry fly ash basis). Slurry concentration for high concentration slurry disposal unit shall be 60% (minimum). Total three disposal pipes shall emerge, (one from each HCSD unit) from three HCSD unit. Flushing arrangement will be provided to cater flushing requirement of HCSD system before starting and stopping of same.

Ash Water Recirculation System:

In-plant clarifloculation system is to be provided to reuse bottom ash overflow water, recovery water and vacuum pump drain water. Two number (1W+ 1S/B) bottom ash overflow transfer water pump shall be provided near water impounded bottom ash hopper of each unit to discharge bottom ash hopper overflow water to clarifying unit. Vacuum pump house area drain pumps shall discharge vacuum pump drain

water to clarifying unit. Recovered water from ash disposal area will also be disposed in plant clarifying unit. This clarifying unit will ensure zero water wastage for the ash handling system. Cleaner water from clarifying unit shall be feed into ash water sump for reuse in ash handling system.

Ash Water System

Ash water system would comprise of following:

Three (2W for two units+ 1 common S/B) HP ash water pump.

Three (2W for two units+ 1 common S/B) LP ash water pump.

Four (1W + 1 S/B for each unit) economiser water pumps.

Two(1W + 1 S/B for two unit) LP SW pumps.

Two(1W + 1 S/B for two unit) HP SW pumps.

Two(1W + 1 S/B for two unit) Dust conditioning water pumps in silo area.

Two(1W + 1 S/B for two unit) HCSD LP water pumps in silo area

Fluidizing Air System :

Continuous supply of fluidizing air during ash evacuation has been envisaged in all the hoppers of the ESP, stack and intermediate surge hopper and silos to facilitate smooth and effective ash flow. For this, fluidizing air blowers of adequate capacity and pressure will be provided. Two no fluidizing blowers for each unit (1W + 1S) for supplying fluidising air to ESP hoppers and buffer hoppers of corresponding unit and six no silo fluidizing Blowers (one working for each silo and two common stand by) will cater system requirement. Fluidizing pads are distributed properly at the bottom of intermediate surge cum buffer hopper and each fly ash silos to allow smooth flow of fly ash into downstream system.

The fluidizing air system would be complete in all respects with necessary electric air heater, insulated piping, valves and instruments to ensure satisfactory system operation. The in-plant surge hopper will also receive fluidizing air from the ESP hopper-fluidizing blower.

Compressed Air System :

Compressed air system for operation of different equipment and control instruments of Ash Handling System would be complete in all respects with necessary compressors (screw type, 1W +1S), air drying system, piping, valves and instruments.

MCC & Control Panel :

415 V MCC and control panel for the Ash Handling Plant would be located inside a separate room annexed to the ESP control room. Ash Handling System operation can be done in automatic sequential manner and/or remote manual mode from the PLC based control panel. One common ash handling system control room is envisaged for two units.

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6.5 FUEL OIL HANDLING SYSTEM

The fuel oil system to be used for the units 3 & 4 is shown in **Drawing No.K8B09-006-DWG-DPR-006**. From the existing unloading headers both HFO and LDO would be delivered to respective storage tanks by means of the transfer pumps. HFO storage tanks will be provided with mat coil heaters to maintain the oil temperature in the tank and suction heater to heat the oil before sending it to the Pressurising and Heating unit.

Pressurising pumps will supply oil from the storage tanks to the burners. There will be two (2) nos. of LDO pressurising pumps, each of 100% capacity and four (4) nos. of HFO pressurising pumps, each of 100% capacity to meet the requirement of the two units. Each HFO pressuring pump will be provided with a heater at its downstream side to heat the oil before sending it to the boiler.

Steam required in mat coil heaters, suction heater and oil heaters would be supplied from the boiler auxiliary steam header. The entire HFO pipelines and all the HFO pumps and strainers will be steam traced and properly insulated.

All instrumentation and control facilities including tank level controllers, pressure/temperature gauges, control valves etc. along with a local control panel in the fuel oil pump house will be provided for safe and reliable operation of the system.

The fuel oil system and its facilities will be designed as per Pollution Control/Petroleum Rules/Explosion Acts/Fire Rules of Govt. of India.

HFO and LDO analysis are given in Annexures 3.1 & 3.2 of **Section-3** earlier.

6.6 VENTILATION & AIR-CONDITIONING SYSTEM

Right environment for operation and maintenance of the plant as well as for proper functioning of the equipment, controls and accessories is an important aspect which has been given due consideration in the Ventilation and Air-conditioning System.

Ventilation System :

Adequate ventilation system has been considered for the power house building ESP control building and other areas like air compressor room, AC plant room.

elevator machine rooms, Switchyard Control building and various pump houses like CW pump house, filter water and Treated water pump houses, Toilets and Pantries of different buildings etc. to achieve the following :

i) Dust-free comfortable working environment.

ii) Scavenging out structural heat gain and heat load from various equipment, hot pipes, lighting etc.

iii) Dilution of air polluted due to generation of obnoxious gaseous/aerosol contaminants like acid fumes, dusts etc.

Ventilation system for important areas are described below :

a) **Powerhouse**

Supply/exhaust ventilation system with evaporative cooling has been recommended for the powerhouse building. Ambient air would be drawn through air intake louver, water flooded SS-mesh filter, fill-Deck (wetted with water dripping) and moisture eliminator. Air will be supplied by means of centrifugal fans to powerhouse through ducting and grilles to achieve proper distribution. The sprayed water will be re-circulated by means of centrifugal pumps, valves and other accessories. Exhaust system consists of axial flow wall/ roof-mounted exhaust fans with rain protection cowl/hood, short ductwork, etc. Part of the supplied air will be exhausted and the rest will ex-filtrate through the various openings in the structure, preventing infiltration of dusty air. This arrangement also ensures 3 °C less dry bulb temperature inside the powerhouse with respect to design outside conditions of summer.

Various rooms in powerhouse e.g. cable spreader room, switch-gears room etc. will be ventilated by means of transfer fans or by extending duct as required and found suitable.

Coal tripper floors are to be provided with exhaust system to eliminate building-up of hazardous gases like carbon monoxide, methane etc.

b) **ESP Control Building**

For ventilation of this building (except the control room), ambient air will be drawn through unitary air filtration unit comprising fresh air intake louvers, automatically cleanable SS-mesh filter (with water spray) and GI moisture eliminator and supplied to the space by means of a centrifugal fan. In addition to filter cleaning, the water spray will have an evaporative cooling effect too. This will produce some cooling as an added advantage.

The supplied air will be exhausted through wall mounted gravity operated dampers to maintain an overpressure of 1-2 mm of water column to reduce dust ingress.

c) **Other Buildings**

Other buildings like ash plant, compressor house, air compressor room, AC plant room, pump houses, Water Treatment plant, Switch yard Control building etc. will be ventilated by means of dry system comprising axial flow fans, dry filter (wherever required), rain protection cowls with bird screen, ducting (wherever required) etc. Inside dry bulb temperature is expected to be higher than ambient by amount 3°C. Fire dampers will be provided as per code wherever there is electrical installation. Dry pressurized ventilation system shall

be provided for the associated electrical rooms of the aforesaid auxiliary buildings, by means of fan filter unit and back draft dampers, DG set room will be ventilated with the air drawn by its radiator fan in case of air cooled DG set. For water-cooled DG set, exhaust fans shall be provided.

Airconditioning System :

Various control rooms and computer rooms in power station, housing a group of sophisticated and precision control panels, computers and desks call for controlled environment for proper functioning and for personnel comfort.

The following areas are to be air-conditioned :

a) Central Control room, control equipment room, computer room, shift-in-charge room, SWAS dry panel room, battery charger room, AVR room and other office area, laboratory located in the TG building and UPS room.

b) Electrostatic Precipitator Control Room

c) Switchyard Control Room

d) CHP Control Room

e) Office area, Lecture Rooms etc. in the Service Building.

g. Ash Handling Plant Control Room

h. Any other electrical room housing PLC panels

To cater to the above requirements the following systems are :

i) A central chilled water plant for the AC areas of TG building and Service Building mentioned under (a) & (f), comprising water cooled screw chilling unit (suitable for R-134a refrigerant), condenser cooling water circulating pumps, cooling towers, chilled water circulating pumps, cooling water piping with valves, accessories, fittings, non-chemical water treatment equipment, MCC, control panel, cabling, earthing etc. have been envisaged.

The chilled water produced in the said central plant will be circulated through the coils of air handling units serving the AC areas. Ducting system for air distribution will incorporate high efficiency filter of efficiency 99% down to 5 microns, electric strip heater and necessary grilles and diffusers made of power coated extruded aluminium. Pan type humidifier and fresh air unit with pre-filter and fine filter and centrifugal fan shall be installed in each AHU room.

ii) Water-cooled packaged air conditioners (Precision type) with scroll-compressor of R407c duty will be used for air-conditioning of ESP control rooms. Condenser cooling water will be supplied to these units from the main cooling towers of the AC system of TG Building.

iii) Water-cooled packaged air conditioners (Precision type) with scroll compressor of R-407c duty will be used for air-conditioning of Ash Handling Plant control room. Water for

condenser cooling of such PAC units will be tapped from the ACW supply system and shall be returned to the ACW return header.

iv) Air-cooled duct able split /Packaged air conditioners will be provided for the air conditioning of Switch yard Control room, Desalination and Post –treatment plant Control room and CHP Control room.

v) Air-cooled duct able split air conditioners will be provided for the Administrative building and dining hall of canteen building.

vi) Non-duct able Split Air Conditioners will be used for other small electrical rooms/cubicles housing PLC panels.

6.7 COMPRESSED AIR SYSTEM

Three (3) nos. of screw type instrument air compressors would be required for the 2 × 660 MW expansion units to take care of continuous and intermittent demand. Normally two (2) compressors will continuously run to meet the sustained demand and will also serve on automatic mode and will run to meet the intermittent peak demand. The third compressor will be kept as maintenance standby. The estimated capacity of each instrument air compressors is 44 Nm^3/min. (normal) at 8.0 Kg/Cm^2(g) pressure rating. The instrument air compressors will be oil-free type, and will be provided with individual air receivers to absorb pressure pulsations and for acting as reserve supply of compressed air to permit continued operation following failure of the operating compressor until the standby one comes into service. Heat of Compression (HOC), rotary drum type air dryer with 100% standby, automatic regeneration facility etc. will be provided for the unit for supply of clean, dry air to Control and Instrumentation system.

The station service air requirement for normal cleaning purposes, atomising air medium for warm-up guns and ignitors, motive power for burner drive mechanism etc. of air pre-heaters will be met from separate plant-air compressors. It is envisaged to install two (2) plant air compressors, each of capacity 44 Nm^3/min. (normal) at 8.0 Kg/Cm^2(g) pressure rating. The plant air compressors would be identical to the instrument air compressors and would run in a manner, similar to that described above for the instrument air compressors. Capacities of all the instrument and plant air compressors selected are same, so as to achieve inter-changeability of parts. Independent air receivers will be provided for each compressor. Plant service air system will have suitable interconnection with the instrument air header for augmenting instrument air supply in emergency. A single line diagram of Compressed Air System is given in **Drawing No.K8B09-006-DWG-DPR-007** enclosed.

6.8 FIRE PROTECTION SYSTEM

For protection of the plant against fire, all yards and plant will be protected by any one or a combination of the following systems :

a) Hydrant system
b) Gas Flooding system
c) Automatic fixed foam system
d) Portable and mobile extinguishers

The system will be designed as per the recommendation of Tariff Advisory Committee (TAC) of the Insurance Association of India. Applicable Codes and Standards of National Fire Prevention Association (NFPA), USA, would also be followed.

In view of vulnerability to fire and its importance in the running of the power station, effective measures are to be taken to tackle fire in the following susceptible areas :

i) The cable galleries, and

ii) Coal handling areas, mainly coal conveyors, transfer points, crusher house and tunnels.

For containment of fire and preventing it from spreading in cable galleries, unit-wise fire barriers with self-closing fire resistant doors will be provided. The ventilation systems, if provided in the cable galleries, would be so interlocked with the fire alarm system that in the event of a

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fire the ventilation system is automatically switched off. Also to avoid spreading of fire, all cable entries/openings in cable galleries, tunnels, channels, floors, barriers etc. would be sealed with non-inflammable/fire resistant sealing material.

The source of water for the firewater pumps of the hydrant system, water spray and sprinkler system etc. will be clarified water. Three (3) nos. electric motor driven firewater pumps with one (1) diesel engine driven pump as back up for hydrant and one (1) electric motor driven fire water pump with one (1) diesel engine pump will be provided in the firewater pump house. In addition to these, two (2) jockey pump sets, hydro-pneumatic tanks, compressors, pipes and fittings as required will be provided. The hydrant system will feed pressurised water to hydrant valves located throughout the plant and also at strategic locations within the powerhouse.

Spray system network would be interconnected with hydrant network so that in case spray system network demands water can flow from hydrant network to spray network but not the vice-versa.

Automatic medium velocity spray system will be provided for cable galleries, cable trenches/vaults, coal conveyors, main fuel oil/LDO storage tank etc. Automatic medium velocity sprinklers will be used for protection of burner zone of boiler front.

Category-A type automatic high velocity spray system would be provided for the following equipments :

a) Generator transformers
b) Unit auxiliary transformers
c) Station reserve transformers
d) Auxiliary Power transformers

Category-B type automatic high velocity spray system would be provided for the following areas :

a) Turbine oil storage tanks
b) Turbine bearing
c) Boiler burner front
d) Other transformers (less than 10 MVA)

Suitable fire detection system as necessary for all the above-mentioned fire fighting system with adequate supervisory circuitry will be provided. Automatic fixed foam installation is envisaged in fuel oil storage and handling areas. In addition to these, adequate number of portable and mobile (wheel mounted) chemical fire extinguishers of DCP, Foam, Gas expelled water type & carbon dioxide type will be provided. Portable units would be placed at suitable locations throughout the plant area. The extinguishers may be used during the early stages of fire to prevent spreading.

One centralized total flooding clean inert gas extinguishing system shall be provided for Control Equipment room and Unit Control room.

6.9 PIPING, VALVES, FITTINGS & SPECIALTIES

The scheme of various systems such as, steam, condensate, water, oil, air etc. have been explained above. Piping, valves, fittings, hangers, anchors, supports, guides etc. would be provided as required. All high pressure, medium pressure and low pressure lines will be of proven quality and suitable for conditions of operation encountered at the specific points. Pipelines running outside the powerhouse will be routed over trestles as far as practicable in order to avoid maintenance and other problems encountered with trench piping and buried piping. However, for rail culvert crossing piping inside trenches and for large diameter water lines buried pipes with proper coating and waterproofing would be adopted.

6.10 MISCELLANEOUS AUXILIARIES

Turbine Oil Purification System :

A suitable centrifuge or other type of turbine oil purification plant will be provided as an auxiliary of the turbo-generator to condition the turbine oil continuously, in order to remove the water and other impurities from the system to maintain the turbine oil at the optimum condition. In addition to the above unit system, one tank comprising one clean oil compartment, one dirty oil compartment, one purifier unit and necessary pumps, vent fans etc. will be kept. This would also receive the refill of turbine oil from outside. The system would comprise one centrifuge or other facility to condition the unit turbine oil as per requirement, one central lube oil purification unit consisting of one purifier, clean and dirty oil compartment, pump, vent fans etc. catering to the needs of both the units.

Circulating Water Treatment System

Cooling Water (CW) and Auxiliary Cooling Water (ACW) Booster pumping Systems for the 2 × 660 MW Units, need to have treatment systems for inhibition of micro biological fouling as well as scale formation and corrosion with reference to Circulating Water. Further the control of suspended impurities in CW and ACW Systems should also be given due consideration.

To inhibit scale formation in the CW and ACW systems, it is envisaged to dose Sulphuric Acid (to convert calcium and magnesium bi-carbonate into sulphates which have higher solubility) and a suitable scale inhibitor in the circulating water. Sulphuric Acid and Scale Inhibitor will be dosed at the fore bay of CW Pump House. For this purpose one (1) no. skid mounted Scale Inhibitor Dosing System for both the units has been envisaged.

To inhibit corrosion in the CW and ACW systems, it is required to dose a suitable corrosion inhibitor in the circulating water. Corrosion Inhibitor will be dosed at the fore bay of CW Pump House. For this purpose one (1) no. skid mounted Corrosion Inhibitor Dosing System for both the units has been envisaged.

To provide additional protection (in addition to Chlorine dosing) against micro biological growth in CW and ACW Systems, it is required to shock dose a suitable Biocide in the circulating water at least once in a week for an hour. Biocide will be dosed at the fore bay of CW Pump House. For this purpose one (1) no. skid mounted Biocide Dosing System both the units has been envisaged.

Side stream filtration for the CW system of each unit to the extent of 2.0% of recirculating water flow for CW and ACW Systems is required in order to control of suspended impurities in the system.

Condensate Polishing System :

On line Condensate Polishing Treatment System has been envisaged to ensure quick start-up of the unit, decrease water consumption as well as to continue the unit operation without any restriction by maintaining desired quality of condensate water. The Condensate Polishing System will also prevent the quality of steam and water worsening when little leakage occurs in condenser.

The condensate polishing treatment system for each unit shall have 3 × 50 % streams i.e. the total output capacity of two (2) mixed bed units shall be 100% of condensate flow at maximum TG Output condition with all HP Heaters out of service.

The common inlet and outlet headers of three mixed bed units shall be connected to an emergency automatic bypass line. In case of emergency, 100% condensate can be passed through the emergency bypass line without treatment.

Condensate polishing treatment system shall be comprised of service vessels (Mixed Bed Units), external regeneration system, auxiliary system and control unit. Each unit shall be equipped with service vessels with all accessories. One set of external regeneration system, auxiliary system and control unit will be used for two units in common.

Each unit shall consist of three (3) medium-pressure and high velocity service vessels each complete with all accessories, 2 × 100% re-circulation pumps etc and one set of bypass system.

The external regeneration system shall include one resin separation & anion resin regeneration vessel, one cation resin regeneration & storage vessel, one resin isolation vessel and one regeneration water heater (electrical type) vessel.

One set of auxiliary unit shall comprise of two sets of roots blowers, two sets of backwash water supply pumps, one compressed air storage vessel and one set of acid & alkali transfer pumps, acid & alkali storage tanks, acid & alkali measuring tanks, acid & alkali metering pumps, neutralization pit and effluent transfer system etc.

The service vessels with accessories will be located inside the Power House Building and the common external regeneration system will be located outside the Power House Building in the vicinity of service vessels.

The operation of Condensate Polishing Treatment System will be semi-automatic, remote / manual.

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For each unit, normally two high velocity mixed beds will be put into service. When resin in either of mixed beds is exhausted, the mixed bed will be shut down automatically, and the other mixed bed will be put into service. The exhausted resin in the mixed bed will be hydraulically transferred to external regeneration system for regeneration and the resin in regenerated form and stored in cation resin regeneration & storage vessel will be sent back to the mixed bed.

When the pressure difference between inlet bus pipe and outlet bus pipe or the temperature of inlet water exceeds the preset value, the bypass with the capacity of 100% condensate flow will be opened automatically, and both of two mixed beds will be shut down automatically.

Chemical Feed System :

Oxygen Injection System

Complete Oxygen Dosing System shall be installed. Oxygen to be dosed at two (minimum) locations in the Condensate and in Feed water circuit of each unit, i.e. one at outlet of condensate polishing Plant and another at the outlet of deaerator (suction line to feed water pumps).

All Volatile type of Treatment (AVT) Systems

LP Chemical Feed System

Residual dissolved oxygen present in feed water at downstream of Deaerator can be detrimental to feed cycle equipment. In order to control the same, continuous injection of dilute solution of hydrazine is envisaged at outlet of Deaerator (suction of Boiler Feed Pumps). Provision shall be kept to inject hydrazine at outlet of Condensate Polisher & Closed Cooling Water System for Boiler House/Turbine

House also. However, injection shall be done at one place at a time. For this purpose two (2) nos. [One (1) no. for each 660 MW Unit] skid mounted Hydrazine Injection Systems have been envisaged.

Condensate water or Boiler feed water should have proper pH in order to protect the system from corrosion. In order to control the same, continuous injection of dilute solution of Ammonia is envisaged at outlet of Condensate Polisher. Provision shall be kept to inject ammonia at outlet of Deaerator also. However, injection shall be done at one place at a time only. For this purpose two (2) nos. [One (1) no. for each 660 MW Unit] skid mounted Ammonia Injection Systems have been envisaged.

Closed Circuit Chemical Dosing System

Sodium Hydroxide from Sodium Hydroxide Preparation/Storage Tank will be dosed by gravity into CCW Make up Tank/CCW Pump Suction as required to raise the pH to the desired value.

For this purpose two (2) nos. [One (1) no. for each 660 MW Unit] skid mounted Sodium Hydroxide Injection Systems have been envisaged.

Each Skid for Sodium Hydroxide Injection System shall include but not limited to:

One (1) no. Solution Preparation Cum Storage Tank, complete with agitator as well as its drive motor and all other accessories.

Hydrazine Dosing System

Residual dissolved oxygen present in feed water at downstream of Deaerator can be detrimental to feed cycle equipment. In order to control the same, continuous dosing of dilute solution of hydrazine is envisaged at outlet of Deaerator (suction of Boiler Feed Pumps). Provision shall be kept to inject hydrazine at discharge of Condensate Extraction Pumps. However, dosing shall be done at one place at a time. For this purpose one (1) no. skid mounted Hydrazine Dosing System for each unit has been envisaged.

Each skid mounted Hydrazine Dosing System shall be as follows:

For preparation of diluted hydrazine solution, technical grade concentrated hydrazine liquor will be fed from Barrel to the two (2) nos. Hydrazine Mixing / Metering Tanks by means of a electrically operated Hydrazine Barrel Pump (complete with flexible hose) to be mounted on a Hydrazine Barrel/Drum. Hydrazine will be diluted if necessary, in the Hydrazine Mixing / Metering Tanks with the DM water. For preparation of dilute solution each Mixing / Metering Tank will be provided with stirrer.

From the Hydrazine Mixing / Metering Tanks the hydrazine solution will then be dosed at outlet of Deaerator by means of 2 × 100% Hydrazine Metering Pumps. Duplex Strainers (2 × 100%) shall be provided and common for both pumps.

Provisions for dosing of hydrazine solution at discharge of Condensate Extraction Pumps will also be provided.

Ammonia Dosing System

Condensate water or Boiler feed water should have proper pH in order to protect the system from corrosion. In order to control the same, continuous dosing of dilute solution of Ammonia is envisaged at outlet of Deaerator (suction of Boiler Feed Pumps). Provision shall be kept to inject Ammonia at discharge of Condensate Extraction Pumps.

However, dosing shall be done at one place at a time only. For this purpose one (1) no. skid mounted Ammonia Dosing System for each unit has been envisaged.

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Each skid mounted Ammonia Dosing System shall be as follows:

For preparation of diluted ammonia solution, technical grade concentrated ammonia liquor will be fed from Barrel to the two (2) nos. Ammonia Mixing / Metering Tanks by means of a electrically operated Ammonia Barrel Pump (complete with flexible hose) to be mounted on a Ammonia Barrel/Drum. Ammonia will be diluted if necessary, in the Hydrazine Mixing / Metering Tanks with the DM water. For preparation of dilute solution each Mixing / Metering Tank will be provided with stirrer.

From the Ammonia Mixing / Metering Tanks the ammonia solution will then be dosed at outlet of Deaerator by means of 2 × 100% Ammonia Metering Pumps. Duplex Strainers (2 × 100%) shall be provided and common for both pumps.

Provisions for dosing of ammonia solution at discharge of Condensate Extraction Pumps will also be provided.

Hydrogen Generation Plant :

A hydrogen generation plant is being provided in the station in order to fill up high pressure hydrogen cylinders which are required for cooling the generator. Hydrogen generation plant capacity of 2 × 5 m^3/hr have been required. The plant would be located at a safe distance from other installation as per statutory requirements of the Explosive Act.

Elevators :

As mentioned earlier, one goods-cum-passenger elevator will be installed for the boiler. In addition, one passenger elevator will be installed in the powerhouse building. Stack Elevator and mill building elevator shall be provided.

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Cranes & Hoisting Equipment:

Two EOT crane having 130 T/25 T capacity (without tandem operation) is required to be provided in the turbine hall and will be used for maintenance of the TG hall equipment. Jacking/rigging is required for lifting generator stator and heavy equipment.

Conventional and special type of cranes required for maintenance of certain SG and TG equipment such as FD/PA/ID fans, condenser water box, ESP transformer rectifier sets etc. will be supplied by the respective equipment supplier. For clarified water pump house a crane of 7.5 Tons capacity (pendant operated) and for circulating water pump house a pendant operated 25 Tons capacity electric travelling crane have been considered. Two pendant-operated 10 Tons EOT cranes are required for ash slurry pump house and store building.

Maintenance cranes/handling devices of suitable capacities have been considered for all other pump houses and other places such as coal handling plant transfer points, DM plant, etc. Monorails for lifting heavy motors and other equipment within the powerhouse not covered by EOT crane such as air compressors, miscellaneous pumps, heat exchangers etc. will also be provided. Suitable rails will be provided, if necessary, on floor for bringing the horizontal feed water heaters under the approach of EOT crane.

6.11 ASSOCIATED FACILITIES

Repair Workshop :

For achieving higher availability of the plant, the plant maintenance would be done following a concept of unit exchange system for repair and maintenance.

Under this system, the defective components would be replaced immediately by sound ones from the stores. The defective components would thereafter be repaired in the workshop and sent back to the stores. Following this system, two types of activities namely maintenance and reconditioning would be physically separated thereby speeding up maintenance activity.

In order to carry out the repair activities, it is envisaged to provide the following shops :-

a) Main workshop near the main powerhouse building.

b) Instrument repair shop housed within the powerhouse building or in the workshop.

c) A repair shop for mobile equipment would be located near the coal storage yard.

d) Motor vehicle repair shop.

Necessary machinery, tools and tackle required for the nature of repair involved would be provided at all the above shops.

General Stores :

Both covered and open space will be required for storage of various materials required for construction as well as operation and maintenance of the plant. While the construction stores will be temporary, the other stores will be permanent. Consumables, tools and tackle and other relevant items required for the 600 MW units will also be kept in the stores.

The stores will broadly have the following divisions to house material of different categories :

1. Heavy materials store will house boiler tubes of various sizes, boiler and auxiliary parts, turbine heavy parts, stainless steel plates, conveyor belt and other coal handling equipment spares, dumper and dozer spares, motors, transformer windings, fire

fighting equipment, insulators and hardware connectors, copper and aluminium conductors and similar heavy items.

2. Mechanical, electrical and instrument stores will accommodate small spare parts for mechanical and electrical equipment and instruments respectively.

3. Fast moving spares store will house electrodes and welding materials, blow lamps, bulbs and light fittings, grease, soap, battery, cotton waste and cloth, brooms, motor vehicle spares, gas cylinders, gloves, aprons, safety belts, goggles, ropes, refill for the fire fighting equipment etc.

4. Chemical stores will house alum, lime, morpholin/hydrazine resin, spirit and other chemicals required for steam, feed water and condensate system and chemical laboratory.

5. Civil engineering store will accommodate cement, sanitary materials, filtering sand and filters, pipe and pipe fittings etc. for water supply.

6. Refractories and lubricants will be stored under separate covered sheds.

Open storage-yard will be provided to store structural steel, rail, sleeper, heavy castings, cable reels etc.

Suitable enclosures will be provided for storing the insurance spares. Arrangements will be made for storing items like relays, motors, and instruments under controlled atmospheric conditions.

Chemical Laboratory & Testing Facilities :

A central chemical laboratory in the service building is envisaged for the station. This will have necessary equipment and facilities to test

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and analyse steam, water, oil, fuel etc. required to ensure satisfactory operation and maintenance of the station. The testing and calibration laboratories for C&I and relay-metering will also be housed in the same building, with necessary equipment and standard instruments for chemical analysis of various items, testing of electrical items and testing/calibration of instruments.

Thermal Insulation:

Adequate insulation will be provided to reduce heat losses from the equipment, piping and ducts and to ensure adequate personnel protection in critical areas. Insulation would be so selected that the covering jacket surface temperature does not exceed the surroundings ambient temperature by more than 15 °C.

Pollution Monitoring System :

Monitoring of various environmental aspects is of prime relevance in setting-up the unit. The following aspects would be critically monitored:-

- To keep watch on the state of pollution
- To generate data for predictive and corrective measures
- To quantify environmental impacts

The important area requiring periodic/conditions monitoring are :-

- Stack emission
- Ambient air quality
- Disposed water quality

Electronic smoke density analyser and gas analyser equipment is required to be provided for continuous monitoring of particulate matters at the outlet of ESP. Sample analysis of SO_2 and other pollutants from

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chimney would be carried out. Wastewater would be checked for any harmful pollutants before discharging to outfall.

An oil/water separation unit has been envisaged near fuel oil day tank/ pump house area in order to keep plant drains free of oil and to reclaim waste oil as far as practicable. Oil thus separated would be returned to the fuel oil tank and used or disposed off by incineration.

Coal Handling and Ash Handling Plants will be equipped with dust extraction/suppression system to combat fugitive dust.

SALIENT FEATURES OF AUXILIARY PLANT & EQUIPMENT

1. **Plant Water System :**

Raw Water Pumps:

Type	:	Vertical wet pit mixed flow multi-stage.
Fluid Handled	:	River water.
Capacity	:	1400 m^3/hr each
Head	:	25 mlc
Number	:	Two (2)
Drive	:	Electric motor, 11 KV, 3 Ph., 50 Hz.

Clariflocculator :

Type	:	Clarifier with concentric flocculator.
Capacity	:	3125 m^3/hr/each.
Number	:	Two (2).
Construction	:	RCC

Clarified Water Storage Tank :

Type	:	RCC, Semi-underground portioned.
Volume	:	2 hours' storage capacity.
Number	:	One(1)

Filtration Plant :

Type	:	Twin Bed Type Gravity Sand Filter.
Number	:	Five (5) [4 working + 1 standby]
Design Flow	:	500 m^3/hr.
Filter Medium	:	Sand
Supporting Medium	:	Graded Gravel

Filter Water Storage Tank :

Type	:	RCC, Semi-underground portioned.
Volume	:	4 hours' storage capacity.
Number	:	One(1) with twin chamber

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Filtered Water Pumps :

Type	:	Vertical wet pit mixed flow multi-stage.
Fluid Handled	:	Clarified water
Capacity	:	550 m^3/hr. each
Head	:	35 mlc
Number	:	Three(3) [2 working + 1 standby]

DM Plant :

Type	:	Outdoor
Control Room	:	Indoor
Capacity	:	Two (2) streams of 125 m^3/hr, each stream consisting of Mixed Bed exchanger. The system would also include acid and alkali handling and storage facilities for exchanger regeneration.
Operation	:	Semi-automatic PLC based.

DM Water Storage Tanks :

Type	:	Vertical cylindrical steel tank with inside rubber lining/ painting.
Capacity	:	1200 m^3
Numbers	:	Two (2).

Condensate Storage Tank :

Type	:	Vertical steel tank with inside rubber lining.
Capacity	:	750 m^3/each.
Numbers	:	Two (2)

Cooling Water Circuit :

Cooling Tower :-

Type	:	Induced Draft
Nos.	:	Two (2)
Cooling Water Quality	:	Clarified river water
Total circulating water flow	:	82,000 m^3/hr.
Design Cooling range	:	42 °C to 33 °C i.e. 9 °C.

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Approach (max.)	:	5 °C

Cooling Tower make-up Pumps :-

Type	:	Vertical wet pit installation.
Fluid Handled	:	Clarified river water
Capacity	:	1,800 m^3/hr. each
Head	:	15 mlc
Number	:	Three(3) [2 working + 1 standby]

Circulating Cooling Water Pumps :-

Type	:	Vertical wet pit installation.
Fluid Handled	:	Clarified river water
Capacity	:	45000 m^3/hr each.
Head	:	28 mlc
Number	:	Two (2) [all working] per unit plus one common standby

Circulating Water Line Fill Pump :-

Type	:	Vertical wet pit installation.
Flow	:	4,550 m^3/hr each
Head	:	45 mlc
Fluid	:	Clarified river water
Number	:	One (1) (for both units).

Auxiliary Cooling Water Pumps :-

Type	:	Vertical wet pit installation.
Flow	:	4,550 m^3/hr each
Head	:	40 mlc
Fluid	:	Clarified river water
Number	:	Three(3) (2 working + 1 standby).

DM Closed Cycle Cooling Water Pumps (TG) :-

Type	:	Horizontal volute casing, indoor.
Flow	:	1450 m^3/hr/each.
Head	:	60 mlc.
Fluid	:	DM water.

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Number : 3x50% (2 working + 1 standby)

DM Closed Cycle Cooling Water Pumps (SG) :-

Type : Horizontal volute casing, indoor.

Flow : 450 m^3/hr./each

Head : 60 mlc.

Fluid : DM water.

Number : 2x100% (1 working + 1 standby)

Plate Type Heat Exchanger (TG) :-

Primary Coolant : DM water

Flow : 1,750 m^3/hr. each

Secondary Coolant : Clarified water

Flow : 1,750 m^3/hr each.

Plate Material : Titanium

Number per unit : Three (3) (2 working + 1 standby) per unit.

Plate Type Heat Exchanger (SG) :-

Primary Coolant : DM water

Flow : 470 m^3/hr.

Secondary Coolant : Clarified water

Flow : 470 m^3/hr.

Plate Material : Titanium

Number per unit : Two (2) (1 working + 1 standby) per unit.

2. **Coal Handling Plant**

Conveying System:

Type : Twin stream conveying system.

Capacity : 3000 Tons/hr (Inplant).

Received Crushed Coal size : (-)20 mm

Stacker and Reclaimer :-

Type	:	Reversible Boom stacker with Bucket wheel Reclaimer.
Stacking Capacity	:	3000 TPH
Reclaiming Cap	:	3000 TPH
Number	:	One (1)
Coal size	:	(-) 20 mm

3. **Solid Waste Handling System Equipment**

Ash Handling System :

Basic Design Parameters	:	Max. Bottom Ash generation – 84 TPH/unit. Max. Fly Ash generation – 335TPH/unit.
Type	:	Wet extraction and dry disposal for Bottom Ash and dry extraction and HCSD/dry disposal of fly ash.
Bottom Ash cleaning	:	Continuous.
Fly Ash cleaning	:	Auto-sequential operation with 3 hours of operation per shift.

Fly Ash Handling System :

Intermediate Surge Hopper :-

Type	:	MS construction
Number	:	Four(4) for two units.
Capacity	:	150 T, considering approx.
Outlet	:	Two (2) [1W + 1S) for Pneumatic conveying to terminal silos from each ISH cum buffer hopper.

Fly Ash Terminal Silo :-

Type	:	RCC construction
Number	:	Two (2)
Capacity	:	24 hours' storage capacity each considering fly ash generation for the station with worst fuel.

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Outlet : Four (4) - two for truck disposal one for belt conveyor to convey dry ash to cement plant & one for future use.

4. **Main and Start-up Fuel Oil System**

HFO Storage Tanks :

Capacity	:	4000 m^3 (Each).
Number	:	Two (2).

LDO Storage Tanks :

Capacity	:	Combined Capacity 12,000 m^3.
Number	:	Four (4) (Existing).

LDO Unloading/Transfer Pump :

Type	:	Positive displacement.
Number	:	Three (3) [2 working + 1 standby] (existing)

HFO Unloading /Transfer Pumps :

Type	:	Heat traced positive displacement pumps.
Number	:	Five (5) [4 working + 1 standby]

5. **Auxiliary Equipment**

Turbine Hall EOT Crane :

Capacity :-

Main Hook	:	115 Tons
Auxiliary Hook	:	30 Tons
Number	:	Two (2)

Elevators :

Type	:	Cabin type, AC electric drive
Location & Number	:	Boiler Area - 2 Powerhouse - 2 Stack - 1 Mill Building - 2

Fire Protection System :

Fire Hydrant System :-

Type	:	Pressurised piping network both under-ground and overground kept pressurised by hydro-pneumatic tank and jockey pump etc. with hydrant valves as per the requirements of Tariff Advisory Committee (TAC) of Insurance Association of India.
Hydrant Pumps	:	Four (4) nos. of 410 m^3/hr capacity, (3 electric motor driven + 1 DG driven).

Spray System :-

Type	:	Pressurised piping network both under-ground and overground kept pressurised by hydro-pneumatic tank and jockey pump etc. with set of spray nozzles in different areas as per the requirements of Tariff Advisory Committee (TAC) of Insurance Association of India.
Spray Pumps	:	Two (2) nos. of 410 m^3/hr capacity, (1 electric motor driven + 1 DG driven).

Air Compressor :

Type	:	Screw type.
Number	:	5 (IA-3 & PA-2)
Free air capacity at normal pressure and temperature	:	44 Nm^3/min. each
Rated discharge pressure	:	8.0 Kg/Cm^2) (g).
Location	:	Indoor
Assumed inlet air temp.	:	45°C (max.).
Air Receiver	:	One(1) per compressor.
Air Drying Plant	:	One stream of capacity 44 Nm^3/min for each IA compressor. HOC Drum type & fully automatic.

Hydrogen Generation Plant :

Type	:	Bipolar Electrolysis module.
Electrolyte	:	KOH
Capacity	:	2 streams of 10 Nm^3/hr.
Accessories	:	Bottling arrangement of H_2 & O_2 in cylinders.

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Turbine Oil Purification Unit :

Type	:	BOWSER Dry oil type conditioner / Centrifuge type.
Capacity	:	20% per hour of total oil in TG network.

On-Load Condenser Tube Cleaning System :

Type	:	Continuous, sponge rubber ball type with some abrasive balls in recirculation arrangement.
Capacity	:	Ball recirculation pump with drive, ball collectors and regulators, automatic ball sorters, ball collecting strainers, debris filters, piping, valves etc.

Condensate Polisher :

Type	:	Ion Exchange type.
Capacity	:	100% of condensate flow per unit with by-pass. Three (3) units of mixed bed exchangers (2W + 1S) for each unit.

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SECTION-7

ELECTRICAL SYSTEM AND EQUIPMENT

7.1 INTRODUCTION

Units 3 & 4 of IB Thermal Power Station, at Banaharpalli in the Jharsuguda district of Odisha will be comprising of two (2) generating units each of 660 MW.

Power from the project will be evacuated through two numbers 400 kV double circuit transmission lines from plant switchyard. One D/C line will be connected to state grid substation at Lapanga and the other D/C will be connected to PGCIL substation at Sundergarh for interstate power transfer which are 19 KM and 50 KM respectively from plant switch yard. .

Each generator will be directly coupled to the respective steam turbine and will have a nominal rating of 660 MW at 0.85 power factor (lag). Generation voltage will be 21 kV (or as per the manufacturer's standard) at 50 Hz, 3 Phase with variation in frequency of +3% (51.5 Hz) and –5% (47.5 Hz). Each generator will be connected to the 400 kV Switchyard bus, through generator circuit breaker (GCB) and a three phase bank of three(3) nos. single phase step-up generator transformers (GT) of 270 MVA, 21 kV/420/√3 kV each. The connection between GT low-voltage terminal to the generator via. GCB will be done by isolated phase bus duct and high voltage terminals of GT will be connected to the 400 kV Switchyard through overhead ACSR conductor.

Scheme of the electrical arrangement at 400kV Switchyard has been shown in **Drawing No.K8B09-007-DWG-DPR-001** (Basic Key Single Line Diagram).

Three voltage levels viz. 11000 V, 3300 V and 415 V have been envisaged to supply power to unit and common auxiliaries. Scheme of the electrical power distribution arrangement to the plant auxiliaries has been shown in **Drawing No. K8B09-007-DWG-DPR-002** (Basic Electrical Single Line Diagram for Auxiliary Power Distribution) and a brief technical particular of major equipment is given in Annexure-7.1.

Generators will be provided with generator circuit breakers. During start up generator circuit breaker will remain off and power will be drawn from the grid through generator transformer. For normal operation generator will be synchronised with the grid by closing the generator circuit breaker and thus the generator will feed its auxiliaries and also the grid based on power demand of the grid. Each unit shall be provided with two (2) nos. unit transformers (UT) directly connected to generator through isolated phase bus ducts.

Two (2) nos. UTs of each generator will supply power to unit auxiliaries like ID fan, FD fan, PA fan, CW Pump, etc. having motors rating above 1500 kW through required number of 11 kV breakers from Unit Switchgears. The boiler feed pump (3x50% - 2 Steam driven working & 1 motor driven standby) will also be fed at 11 kV from one (1) of the unit transformer. Balance MV motors (of rating above 200 kW and upto 1500 kW) of the unit such as CEP, Mill, Air Compressor, etc. will be fed from 3.3 kV switchgears and LV motors (upto & including 200 kW) & LV loads through 415 Volt switchgears.

Total four (4) nos. UTs for two Units shall also cater the entire station load of the expanded plant (i.e. non-unitised load). Accordingly, rating of each such transformer is considered as 40/50 MVA with ONAN/ONAF cooling.

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In order to take care of voltage variation of the grid +5% to −10%, the UT's will be equipped with On-Load tap changer with 1.25% voltage per tap.

Power for various station loads such as Plant Water system, Coal handling System, Ash handling system, etc., shall be fed through 11 kV, 3.3 kV and/or 415 V switchgears depending on quantum of load, motor of highest power and distance from power house. Accordingly feeders of required quantity at suitable voltage rating are provided in the 11 kV or 3.3 kV or 415 V unit switchgears located in Power House.

In addition to four (4) nos. of such unit transformers, one (1) no. 400 /11.5 kV 40/50 MVA with ONAN/ONAF cooling reserve auxiliary transformer has been envisaged for both the units. The main purpose of this reserve auxiliary transformer is to provide the survival power for safe shutdown of one unit in the event of failure of any UT/GT as well as to act as standby in the event of outage of any one UT.

All electrical equipment shall be rated for 50 °C ambient air temperature.

7.2 POWER SUPPLY ARRANGEMENT TO UNIT & STATION AUXILIARIES

The power supply to unit auxiliaries will be from the 11 kV unit switchgears fed by the Unit Transformer (UT). The capacity of the unit transformer (UT) has been selected on the basis that the unit auxiliary load and common auxiliaries corresponding to the maximum continuous rating of the unit with due consideration to the starting of the largest motor, system fault level, available breaker capacity and voltage regulation requirement.

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The station auxiliary loads will be fed from the same 11 kV unit switchgears. Separate 3.3 kV and 415 V station auxiliary switchgear & station PCC will feed the common power house loads. Separate 11 kV, 3.3 kV and 415 V switchgears & PMCCs will feed the loads for Coal Handling Plant, Ash Handling Plant, Plant Water System, etc., located in the respective plants as required. All these 11 kV/ 3.3 kV switchgears having 2x100% incomers and bus coupler shall be fed from 11kV unit switchgears of the two (2) nos. units by cables. Separate 415 V PMCC will feed the loads for Switchyard, Fuel Oil System, Fire Water System, CT & CW System, Bunker floor area, etc., located in the respective plants as required. HV and LV power distribution scheme is shown in the above referred drawing.

Motors rated up to & including 200 kW will be supplied from 415 Volts system. For this purpose, 11 kV/433 Volts & 3.3 kV/433 Volts, 3 phase, 50 Hz, dry-type LV auxiliary transformers rated 2.5 MVA, 2 MVA, 1.6 MVA, 1 MVA and 630 KVA will be used as required. These transformers will receive power from the 11 kV/3.3 kV buses. The LV side of these transformers will be connected to the respective LV Switchgear/Power Control Centre (PCC)/Power-cum-Motor Control Centre (PMCC) through non-segregated phase bus duct. These transformers will be provided with off-circuit tap changing device in five (5) Equal steps to take care of voltage variation to the extent of ± 5% in steps of 2.5% per tap.

7.3 GENERATOR

The generator will be rated to deliver 660 MW at 21kV (or as per manufacturers' standard), 50Hz, 0.85 p.f. lag at 3000 rpm. The generator will be a two-pole, three-phase unit horizontal mounted, cylindrical rotor type directly driven by steam turbine.

The Generator shall be capable of continuous safe operation at rated output and power factor under any of the following conditions:-

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a) Terminal voltage variation of ± 5% of the rated value.
b) Frequency variation within 47.5 to 51.5 Hz.
c) Absolute sum of combined voltage and frequency variation of 5%.

The generator would be provided with Class-'F" insulation. However, temperature rise would be limited to Class-'B'. The generator stator winding will be wound to form double-star and the neutral will be grounded through a distribution transformer having a secondary loading resistor limiting the ground fault current within 10 amps.

The generator will be cooled by a combined system - stator winding will be cooled by demineralised water flowing through the hollow conductors and the rotor winding directly cooled by hydrogen. The stator core will be cooled by hydrogen flowing through the radial and axial ventilating ducts. The generator excitation system will be selected to provide the following basic requirements.

a) Maintain the generator terminal voltage constant within 0.5% of the pre-set value over the entire operating voltage, frequency & load range of the machine.

b) The response time must be short so that the automatic voltage regulator (AVR) can control the generator during system disturbances or transients in which rapid changes in excitation are required to maintain system stability margins both in steady state and transient condition.

Considering the commutation problem, sparking in slip-ring brushes, preference will be given to brushless excitation system. The ultimate aim of the excitation system selection will be to achieve an ideal

condition in respect of rate of response, simplicity, reliability, accuracy and sensibility. Excitation system shall be of state-of-the-art microprocessor based system of latest version.

7.4 GENERATOR CIRCUIT BREAKER (GCB)

Generator will be connected to Generator Transformer (GT) by a circuit breaker with a isolator alongwith earth switch (at the circuit

breaker side) at GT side and a earth switch at Generator side. The circuit breaker along with the isolator & earth switches shall be an assembly of 3 nos. single pole units mounted horizontally to fit into generator busduct system.

The circuit breaker will have SF6 interrupter. Depending on rated voltage and rated current of generator, the circuit breaker shall be of 21 KV rated voltage and 24000 A rated continuous current. Symmetrical breaking capacity of the breaker shall be based on the highest of the two fault contributions – one from the grid & motor contribution through UTs and the other from the generator.

7.5 TRANSFORMERS

Generator Transformer (GT):

The voltage generated at 21 kV will be stepped-up to feed 400 kV switchyard by a two winding Generator Transformer (GT) connected to the generator in delta through isolated phase bus duct via GCB. GT will be a bank of three single-phase units each rated for 270 MVA (OFAF rating), 21 kV/420/√3 kV; the total capacity of GT will be thus

810 MVA .The generator transformer will be capable of handling the gross output of the generator, with turbine in VWO condition and one unit transformer out of operation. During start up generator circuit

breaker will remain off and power will be drawn from the grid through generator transformer. Hence, the power flow in generator transformer will be in both directions. One identical spare 270 MVA (OFAF rating), 21 kV/420/√3 kV single-phase, 50 Hz generator transformer will be

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provided. The Generator transformer will have ONAN/ONAF/OFAF type of cooling with 'Off-circuit' tap change system having range of tap of ± 2 x 2.5%. Vector group will be YNd1. The high voltage terminal of the transformer will be connected to the 400 kV Switchyard. Lightning arresters will be provided near HV terminals of the transformers. The transformer shall be capable of withstanding the short circuit stresses

due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.

Unit Transformer (UT):

For power supply to all unit auxiliaries as well as common station auxiliaries, two (2) numbers Unit Transformers will be provided for each unit. During start up / shutdown power supply to unit auxiliaries will be taken from the grid through generator transformer and unit transformers and after synchronisation of the generator with the gird, generator will feed all the auxiliaries through unit transformer. UT will be directly connected to the bus-duct of generator transformer. The unit transformer will be of three(3) phase, 50 Hz, two (2) winding, outdoor type of 21/11.5 kV rated 40/50 MVA, with ONAN/ONAF cooling, provided with On load tap changer on the high voltage side to take care of voltage variation to the extent of ±10% in steps of 1.25%. Vector group will be Dyn11. The capacity of the unit transformer (UT) has been selected on the basis that the unit auxiliary load and common auxiliaries corresponding to the maximum continuous rating of the unit with due consideration to the starting of the largest motor, system fault level, available breaker capacity and voltage regulation requirement. The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.

Reserve Auxiliary Transformer (RAT):

In the event of occurrence of any fault in generator transformer and its bus duct, generator circuit breaker will trip and then unit auxiliaries need to be fed from this reserve auxiliary transformer for the survival of the unit so that after rectification/ replacement of fault/faulty transformer, unit can be put back into normal service in least possible time. Hence, for two units one reserve auxiliary transformer is envisaged with an idea that both the generator transformers will not pick up fault simultaneously. The reserve auxiliary transformer will be of 3-phase type rated 40/50 MVA, 400/11.5kV with ONAN / ONAF cooling and vector group YNyn0. In order to take care of grid voltage variation, this transformer will be provided with On-Load tap changer to for voltage variation of $\pm$10% @ 1.25% per tap. HV side of the transformer will be connected to 400 kV switchyard through ACSR conductor and the LV side of transformer will be connected to all the four (4) 11 kV unit switchgears through 11 kV segregated phase bus duct by a common tie connection with tap-off to each switchgear as shown in **drawing no. K8B09-007-DWG-DPR-002**, so that for trouble of any one unit transformer at a time, that can be replaced by this reserve auxiliary transformer. Lightning arresters will be provided near HV terminals of the transformer. The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.

Unit Auxiliary Transformer (UAT):

Two (2) nos. 16MVA, 11 kV / 3.45 kV Unit Auxiliary Transformers (UAT) will provide power supply to 3.3 kV unit auxiliary load for each unit. The transformers are sized on the basis of 2x100% rating. These transformers will be provided with off-circuit tap changer (OCTC) ($\pm$ 2 x 2.5%). The auxiliary transformers will be Dyn1 vector grouping and the neutral will be grounded through resistor limiting fault current to 300A. The transformers shall be oil filled type suitable for outdoor

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location. HV side of UAT shall be connected to 11 kV Unit Switchgear by 11kV cables and LV side will be connected to 3.3 kV Unit Auxiliary Switchgear by 3.3 kV segregated phase bus duct.

Station Auxiliary Transformer (SAT):

Two (2) nos. 16 MVA, 11 kV / 3.45 kV will provide power supply to all 3.3 kV common station loads of power house building and six (6) nos. (tentative) 12.5/7.5/5 MVA (depending upon requirement), 11 kV /3.45 kV Station Auxiliary Transformers (SAT) will provide power supply to all 3.3 kV common station loads other than power house building such as two (2) nos. (each of 100% capacity) each for plant water system, ash handling plant (AHP), coal handling plant (CHP), etc. These transformers will be provided with off-circuit tap changer (OCTC) (± 2 x 2.5%). The auxiliary transformers will be Dyn1 vector grouping and the neutral will be grounded through resistor limiting fault current to 300A. The transformers shall be oil filled type suitable for outdoor location. HV side of SAT shall be connected to respective system/plant 11 kV Switchgear by 11kV cables and LV side will be connected to respective system/plant 3.3 kV Auxiliary Switchgear by 3.3 kV segregated phase bus duct.

Low Voltage Transformer:

For supply of power to various unit and station low voltage auxiliary loads adequate number of LV transformers are required. Motors rated upto 200 kW will be supplied from 415 Volts system. For this purpose, 11 /0.433 kV and 3.3/0.433 kV, 3 phases, 50 Hz, dry-type LV auxiliary transformers rated 2.5 MVA, 2 MVA, 1.6 MVA, 1 MVA and 630 KVA will be used as required. These transformers will receive power from the 11 kV and 3.3 kV buses through cables. The LV side of these transformers will be connected to the respective LV Switchgear/Power Control Centre (PCC)/Power-cum-Motor Control Centre (PMCC) through non-segregated phase bus duct. These transformers will be provided with off-circuit tap changing device in five (5) equal steps to

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take care of voltage variation to the extent of ± 5% in steps of 2.5% per tap.

7.6 **BUS DUCTS**

Generator Isolated Phase Busduct (IPB):

The generator will be connected with its step-up generator transformer, unit transformers and generator circuit breaker through bus duct. Delta connection at GT end shall also be made by this IPBD. The bus duct will be of isolated phase, continuous type with aluminium conductor in aluminium enclosure. Lightning arrestors and surge protection cubicle (where recommended by generator manufacturer) of proper rating will be provided at a location as close as practicable to the generator terminals.

The main section of bus-duct from generator to generator transformer will be suitable for 23,600 Amp. The tap-off connection to the unit transformer will be suitable for 1500 Amp corresponding to 50 MVA rating of unit transformer. The continuous current rating for delta run of the busduct shall be 13600 Amp. Symmetrical breaking capacity of the main run of the IPBD will be based on the highest of the two fault contributions – one from the grid & motor contribution through UTs and the other from the generator & motor contribution through UTs. Symmetrical breaking capacity of the tap-off run of the IPBD will be the summation of fault contributions from the grid, the generator & motor contribution through UTs. Symmetrical breaking capacity of the delta run of the IPBD shall be same to that of tap-off run of IPBD. The maximum temperature of the bus conductor will be limited to 105°C for silver plated joints and 90°C for other joints and that of enclosure will be limited to 80°C.

11/3.3 kV Segregated Phase Bus Duct (SPBD):

The 11 kV side of Unit Transformers (UTs) and Reserve Auxiliary Transformer (RAT) & the 3.3 kV side of Unit auxiliary transformers

(UATs) & Station auxiliary transformers (SATs) will be connected with the associated switchgears through segregated-phase bus duct. The continuous rating of bus duct shall be based on Full Load Current (FLC) of associated transformers. However, 11 kV Busduct between UTs/RAT and unit switchgear shall be of 3150 A and 3.3 Busduct between UATs/SATs and unit/station auxiliary switchgears shall be of 3150 A, 2500 A, 1600 A & 1250 A for 16 MVA, 12.5 MVA, 7.5 MVA & 5 MVA transformers respectively. The symmetrical breaking capacity of all these SPBDs shall be 40 kA. The maximum temperature of bus conductor will be limited to 105°C for silver plated joints and 90°C for other joints. In case of enclosure, the maximum temperature will be limited to 80°C.

415 V Non-Segregated Phase Bus Duct (NSPBD):

The LV side of LV transformers will be connected with the associated switchgears/PCC/PMCC through non-segregated phase bus duct. The continuous rating of bus duct shall be based on Full Load Current (FLC) of associated transformers. However, busduct rating shall be of 4000A, 3150 A, 2500 A, 1600 A & 1000 A for 2.5 MVA, 2 MVA, 1.6 MVA, 1 MVA & 630 KVA transformers respectively. The symmetrical breaking capacity of all these NSPBDs shall be 50 kA. The maximum temperature of bus conductor will be limited to 105°C for silver plated joints and 90°C for other joints. In case of enclosure, the maximum temperature will be limited to 80°C.

7.7 SWITCHGEARS

The drives for auxiliary equipment, having capacity above 200 KW and upto 1500 KW will be fed from 3.3 kV system and those with capacity above 1500 KW will be fed from 11 kV system. All motors rated upto & including 200 KW will be fed from 415 V system. Suitable HV and LV switchgears, as described below, will be provided for operation of these motors. The distribution system for HV switchgears has been indicated in the **drawing no. K8B09-007-DWG-DPR-002**.

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11 kV & 3.3 kV Switchgears:

Power received at 11 kV will be fed to the respective 11 kV switchgear through circuit breakers for further distribution to high voltage motors and also to transformers intended to step down this voltage to 3.3 kV & 415 volts. These feeders will be controlled by vacuum circuit breakers.

The 11 kV & 3.3 kV system will be designed for 40 kA fault level. The interrupting capacity of 11 kV & 3.3 kV breakers and contactors has been selected as 40 kA considering the maximum possible fault contribution from the system and also the motors under the most severe fault condition. Short-circuit withstand capability of 11 kV & 3.3 kV equipment shall be 1 second. Inter-changeability will be possible with breakers having identical rating. Duplicate (each of 100% capacity) feed will be provided for 11 kV & 3.3 kV switchgears. For all switchgear other than 11kV unit switchgear shall have buscoupler.

415 V Switchgears:

415 volts supply from LV auxiliary transformers will be fed to the respective 415 V switchgear bus through air circuit breaker to facilitate distribution for different motors and other electrical loads at the downstream. LV Motors of rating higher than 100 KW will be controlled by 415 V Air circuit breakers. The rupturing capacity of all 415 V Air circuit breakers will be 50 kA. Short-circuit withstand capability of 415 V equipment shall be 1 second. Duplicate feed will be provided for 415 V switchgears where necessary.

Motor control centres (MCCs) will be provided for the control of LV motors up to 100 kW. Magnetic contactors with required protection and switch fuse will control the motors. MCCs are envisaged to be located at respective load centres as far as possible.

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7.8 ACSR CONDUCTOR AND TUBULAR BUS

ACSR 'MOOSE' conductor will be used for overhead bus work, bus tap, etc. 4" IPS aluminium tube (EH type) of grade 63401 WP conforming to IS:5028 will be used for all equipment interconnection, buses, etc.

7.9 CONTROL OF ELECTRICAL SYSTEM

In line with the present-day practice centralised control of the electrical system/equipment has been envisaged for the plant. There will be one common control room for both the units.

Generator synchronisation and its control will be done from Powerhouse Central Control Room. Bus selection for generator transformer breakers, outgoing 400 kV feeders and 400 kV incoming reserve auxiliary transformer feeder will be done from Switchyard Control Room as well as Central Control Room. Operation of 400 kV disconnecting switches shall also be done from switchyard control room. Accordingly, the 400 kV sub-station will be provided with complete sub-station automation system with connectivity with plant DDCMIS system.

Control and metering of generators, generator transformers, unit transformers & reserve auxiliary transformer will be from Central Operating Console located in Central Control Room. OLTC control for reserve auxiliary transformer, unit transformers and unit auxiliary & station auxiliary transformers will be done from central control room.

Control, indication, metering and monitoring of the electrical auxiliary power distribution system comprising of 11 kV and 3.3 kV circuit breakers (for incomers, bus coupler, line feeders and motor feeders), LV transformers, 415 V switchgear breakers for incomers and bus couplers, DG system etc. shall generally be achieved from operator's consoles through DDCMIS. For details relevant section of C&I shall be referred.

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Control panels for service system like coal, ash, C.W. pumps, plant water system, etc. will be located in the respective control room. In addition, some local panels will be provided near respective system/ equipment such as boiler feed pump, hydrogen seal oil system, electrostatic precipitator, etc.

7.10 PROTECTIVE SYSTEM

For protection of equipment against abnormal system conditions, adequate protective devices will be installed in the respective switchgears and/or control and relay panels. A group of such protective devices will be necessary to protect the equipment under different abnormal conditions arising in the system. Multifunction, numerical, communicable relays will be used for protection of equipment.

2 x 100% protection will be provided for each of the generators. For transformer, separate protection relays will be used for main & back-up protection. For line protection, relays with different algorithm will be provided as main-1 & main-2 protection. The following protections are envisaged for major electrical equipment:-

<u>For Generator:</u>

i) Generator differential
ii) Stator inter-turn fault
iii) 100% stator earth fault
iv) 95% stator earth fault
v) Rotor earth fault (2 stage)
vi) Loss of excitation
vii) Negative Phase sequence current
viii) Pole-slipping
ix) Back-up impedance
x) Over voltage

xi) Low forward power and reverse power

xii) Under-frequency and over-frequency

xiii) Generator overload

xiv) Check Synchronization

xv) Voltage Balance

xvi) Over Fluxing

xvii) Under Voltage

xviii) Dead Machine

xix) Split phasing protection / Zero sequence inter turn protection

The generator will also be provided with surge protection equipment comprising surge capacitor and lightning arrestor.

For Generator Transformer (GT):

i) Overall differential

ii) Generator transformer differential

iii) Restricted earth fault (HV Side)

iv) Standby earth fault (HV Side)

v) Overcurrent (HV Side)

vi) Open delta earth fault protection in generator main circuit

vii) Overfluxing

viii) Local breaker back-up

ix) Buchhloz protection

x) Winding temperature protection

xi) Oil temperature protection

xii) Pressure relief during protection

For Unit Transformer (UT):

i) Transformer differential

ii) Back-up over current with high set inst. unit (HV side)

iii) Restricted earth fault (LV side)

iv) Standby earth fault on LV-neutral

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v) Over Current (LV Side)

vi) Overfluxing

vii) Buchhloz protection

viii) Winding temperature protection

ix) Oil temperature protection

x) Pressure relief during protection

For Reserve Auxiliary Transformer (RAT):

i) Transformer Differential

ii) Restricted earth fault (LV side)

iii) Restricted earth fault (HV side)

iv) Back-up over current with high set inst. unit (HV side)

v) Standby earth fault on LV neutral

vi) Standby earth fault on HV neutral

vii) Over Current (LV Side)

viii) Local Breaker back-up

ix) Buchhloz protection

x) Winding temperature protection

xi) Oil temperature protection

xii) Pressure relief during protection

For 400 kV Line Feeder Protection:

i) Distance Main – 1 with back-up directional over current, earth fault, negative sequence, broken conductor, under/over voltage protection, distance to fault locator, etc.

ii) Distance Main – 2 with back-up directional over current, earth fault, negative sequence, broken conductor, under/over voltage protection, distance to fault locator, etc.

iii) Local breaker backup

iv) Check Synchronization

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For 400 kV Transformer Feeder Protection:

i) 2 stage directional phase over current protection

ii) 2 stage directional earth fault protection with negative sequence polarisation

iii) 2 stage non-directional phase over current & earth fault protection

For 400 kV Bus Bar:

i) Bus differential

For 11 kV, 3.3 kV & 415 V switchgears:

Incomer / Tie / Feeder:

i) Inverse time overcurrent protection for phase fault

ii) Inverse time overcurrent protection for earth fault

iii) Restricted Earth Fault & Stand-by Earth Fault (for incomer from Transformer only)

iv) Instantaneous short-circuit protection (where applicable)

v) Under-voltage protection (where applicable)

vi) Check Synchronization

Motors:

i) Comprehensive motor protection comprising Thermal over load, phase fault (short circuit), Unbalance (negative sequence), locked rotor, earth fault through core balance CT, prolonged start, etc.

ii) Differential protection for motors rated 1000 kW and above.

iii) Under-voltage protection (where applicable)

iv) Winding & bearing temperature.

LV Auxiliary Transformer:

i) Inverse time over-current relay with high set instantaneous unit

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for phase faults.

ii) Definite time over-current relay for earth fault.

iii) Winding and/or oil temperature.

220 V DC System:

i) Short-circuit protection by fuse.

ii) E/F alarm

Diesel Generator:

i) Voltage restrained over-current

ii) Reverse power

iii) Negative phase sequence

iv) Under frequency

v) Over voltage

vi) Under voltage

In all cases, proper discrimination would be achieved so as to isolate the faulty elements only, keeping the healthy part of the system in service.

7.11 PLANT LAYOUT

The station layout considers evacuation of power at 400 kV level from the 400 kV Switchyard located on the north side of the plot.
This 400 kV switchyard shall comprise of bays with eight (8) circuits for expansion project Units 3 & 4 and another four (4) diametric bays with eight (8) circuits for future Units 5 & 6.

There is a existing 220 kV Switchyard on the west side of the 400 kV Switchyard.

7.12 ILLUMINATION SYSTEM

Suitable illumination is necessary to facilitate normal operation and maintenance activities and to ensure safety of working personnel. This would be achieved by artificial lighting. Required illumination levels in different areas as per standards/code of practice would be provided. Light fitting for illumination system shall be energy efficient light and lighting transformer shall be provided for lighting.

For outdoor yard illumination, floodlights would be installed at suitable locations to provide requisite level of illumination. Pole-mounted high-pressure sodium vapour lamp fixtures will be used for approach and work roads.

Generally fluorescent fixtures will be used for indoor illumination. Combination of sodium vapour, fluorescent and incandescent fixtures would be used for turbine hall and boiler platforms/galleries as may be necessary. For hazardous location, appropriate type of fittings would be used.

The lighting system design would ensure uniform illumination at working levels. Illumination levels as per standard will be followed for illumination system design.

Power for the illumination system would be supplied from 415V switchboard through lighting distribution boards and lighting panels. Lighting distribution boards would be located in different buildings as per the requirements.

Suitable number of lighting panels will be located in each area, power to which will be supplied from lighting distribution boards. The lighting panels will be installed at convenient locations for ease of operation. In addition to normal illumination scheme, emergency AC and DC lighting scheme would be provided in the powerhouse complex. Emergency AC lighting would be supplied from AC emergency lighting boards, which would be connected to the AC emergency MCC. The AC emergency MCC would be energised from diesel generator during emergencies. The station emergency DC lighting will be provided in

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critical and safety related areas and would be fed from station 220 Volt DC distribution system during extreme emergencies. On failure of the AC supply, these lights will glow from DC system. For isolated buildings in remote areas where station 220 V DC is not available, DC

lighting will be derived from self-contained battery with charger units, energised upon loss of normal AC supply in such isolated areas.

7.13 POWER & CONTROL CABLES

Main factors which are considered for selection of sizes for power cables are as follows:

- System short circuit current and allowable withstand time
- Derating factors due to higher ambient temperature and grouping of cables depending on laying arrangement
- Continuous current rating
- Voltage-drop during starting and under continuous operation
- Standardisation of the cable sizes

11 kV & 3.3 kV cables will be of stranded aluminium conductor, XLPE insulated, extruded PVC inner sheathed, each core screened on conductor as well as on insulation, single round galvanized steel wire armoured (for multi-core cables only) and with fire resistant low smoke halogen free (FRLSH) PVC outer sheath. The cables will be suitable for non-effectively earthed system. For single core cables, single round aluminium armour wire will be used.

LV power cables will be 1,100 V grade with stranded aluminium/copper (depending upon size) conductor. XLPE insulated, extruded PVC inner sheathed, galvanized steel wire armoured (for multi-core cables only) and with FRLSH PVC outer sheath. The cables would be suitable for effectively earthed system. For LV motors JB with copper cable connection from JB to LV motors shall be utilized when the motor terminal box size is not adequate for terminating the power cable. For single core cables, single round aluminium armour wire will be used.

Control cables will be multi-core 1100 V grade PVC insulated, PVC sheathed, round steel wire armoured and with extruded FRLSH PVC outer sheath having 2.5 sq. mm stranded copper conductors.
Fire survival cables (FS) will be used for system, which are necessary for protection and safe shutdown of plant in case of fire.

7.14 PLANT DC SYSTEM

A reliable DC power source would be provided to supply those loads, which are required to function for security, protection and safe shutdown of plant in the event of failure of normal AC power supply. Each unit will have one (1) 220 V battery set of adequate capacity with a common standby 220 V battery set for both the units. Switchyard will have two (2) 220 V battery set of adequate capacity (each of 100% rating). CHP, AHP and water plant will have one (1) no. each 220 V battery set of adequate capacity.

In addition to 220 V DC system there will be a no. of 24 V DC system for Control & Instrumentation System of different areas. Separate DC system shall be provided for Main plant SG & TG loads, Station loads of BTG package, FO system etc. each having 2x100% capacity.

DC power supply system for each unit/system comprises:

- 220/24V Volt DC battery
- Battery charger (float and float-cum-boost charger for 220 V Battery & float-cum-boost charger for 24 V Battery)
- DC distribution and sub-distribution boards

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Basis of selection of the above items will be as follows:

Battery:

Normal requirement of the battery is to supply power for the following :

- Control and monitoring of the plant
- Alarm and annunciation of plant condition under emergency. During the first one minute after occurrence of emergency the battery will be called on to supply the following loads :
  - Tripping power for all major circuit breakers simultaneously
  - Starting of emergency drives to protect the machines from damage
  - Plant emergency DC illumination system
  - Other miscellaneous loads

Battery will be Lead Acid PLANTE type and the capacity of each of the 220 V battery sets would be such that it will meet the above requirement of one unit and the requirement of common services for main plant battery. Separate Lead Acid PLANTE type battery sets will be provided for control, indication of plant water system as well as for 400 kV switchyard, Ash Handling and Coal Handling System and battery sets would be such that it will meet respective plant requirement. For switchyard 2x100% and for AHP,CHP & water plant 1x100% each battery set will be envisaged.

24 V battery will be of Lead Acid PLANTE type and the capacity of each of the 24 V battery sets would be such that it will meet the requirement of that system for which it is intended. The capacity of 24 V battery shall so chosen that with one (1) battery out of service, the other battery shall be capable of carrying the total load of that group.

Battery Charger:

Battery chargers of suitable capacity will be provided with quick boost and trickle charging facility for each of the aforesaid battery sets. Completely automatic and self-regulating type of battery charger will comprise one float charger & one float-cum-boost charger for each of the 220 V battery set and one float-cum-boost charger for each of the 24 V battery set.

The float charger will be capable of floating the battery at 2.2 volts per cell for Lead Acid Plante type battery and at the same time supplying the normal DC load.

The boost charger will be capable of quick charging the battery at 2.75 volts per cell for Lead Acid Plante type battery and will have the capacity to restore a fully discharged battery to a state of fully charged condition within 10 hours.

DC Distribution Board:

One main DC distribution board for each of the battery sets will be provided with DC sub-distribution boards as required. The main DC distribution board will have two incomers having switch-fuse units and required number of outgoing switch-fuse units which will be selected to have a continuous current rating of not less than 125% of the nominal load current. DC distribution boards will be used to give DC power supply as required. In switchyard, CHP & water plant separate battery with charger will be used to cater the requirement of DC power supply to those areas.

7.15 EHV SYSTEM

The Basic Key Single Line Diagram (**Dwg. No. K8B09-007-DWG- DPR-001**) indicates the arrangement of evacuation of power from the 2x660 MW unit through 400 kV switchyard.

The 400 kV switchyard will be designed with one and a half-breaker scheme. The 400 kV switchyard will be provided with the following fully equipped bays:

a)	Generator Transformer Bays	-	2 Nos.
b)	Outgoing Line Feeders	-	4 Nos
c)	Reserve Auxiliary Transformer Bay	-	1 No.
d)	Bus VT	-	2 Nos.
e)	Spare Bay	-	1 No.

The salient technical features of the 400 kV Switchyard are as follows:

Sl. No.	Description of Parameters	400 kV System
1.	Nominal System Voltage	400 kV rms
2.	Highest System Voltage (Un)	420 kV rms
3.	Rated Frequency	50 Hz
4.	No. of Phases	3
5.	Rated Insulation Levels a) Full wave Lightning Impulse Withstand Voltage (1.2/50 µsec.) b) Switching Impulse Withstand Voltage (250/2500 µsec.) c) One minute Power frequency dry and wet withstand voltage	 1425 kVp 1050 kVp (Ph to E) 1575 kVp (Ph to Ph) 630 kVp
6.	Minimum Creepage Distance	31 mm/kV (13020 mm)
7.	Minimum Clearances a) Phase to Phase (Conductor to Conductor) b) Phase to Earth (Conductor to structure) c) Safety Working Clearances	 4200 mm 3400 mm 6400 mm 8000 mm
8.	Rated Short Circuit current for One (1) sec. Duration	40 kA rms
9.	System Neutral Earthing	Effectively Earthed

Protection:

High-speed bus bar differential protection with independent check feature is envisaged for switchyard. Each bay will be provided with local breaker back-up protection. Other protections envisaged are indicated under **Clause - 7.10** above.

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Control:

Relay and control panels for 400 kV feeders will be located in the 400 kV Switchyard control room.

Disturbance Recorder:

Microprocessor based disturbance recorders (DR) will be located in switchyard control room. DRs will record pre-fault and post-fault data, which are of use in analysing fault to recommend remedial measures.

7.16 GROUNDING & LIGHTNING PROTECTION

Comprehensive grounding system will be provided in the power plant. A ground mat will be laid below ground level in switchyard and powerhouse mainly. The mat will be laid 1200mm outside the fence of all electrical installations. Suitable ground electrodes shall be provided at intervals. All metallic part of switchyard equipment, structures of equipment and towers shall be connected to this ground mat by means of suitable risers. In other areas the type of grounding may be mesh type.

The grounding requirement of a power station complex could be divided into the following three main categories:

- System Grounding
- Equipment Body Grounding
- Electronic Equipment Grounding

The system grounding is adopted to facilitate ground fault relaying and to reduce the magnitude of transient over voltage. The system grounding involves primarily the grounding of the generator and transformer neutrals. The generator neutral will be high resistance grounded through distribution transformer and secondary loading resistor.

For 11 kV & 3.3 kV system of the 660 MW unit low resistance grounding will be provided to limit the fault current to the order of 300 Amp. 415 V power supply system will be solidly grounded. DC system will be ungrounded. Necessary annunciation will be provided for detection of first earth-fault on positive or negative pole. The equipment body grounding will be provided to protect personnel from potential hazard caused by ground faults and lightning discharges by providing a low resistance, conducting path to the ground. A suitable ground grid will be provided for grounding of equipment and structures maintaining the step and touch potentials within safe limits.

The earth mat as provided will be buried at a suitable depth below the ground and provided with ground electrodes at suitable intervals. All metallic parts of equipment supposed to be at earth potential will be connected to the ground mat including structures, buildings, transmission towers, plant rail-road tracks, the perimeter fencing, etc.

For grounding of electronic equipment, a separate earthing system consisting of a number of deep driven earthing rods interconnected with insulated cables and insulated risers are to be installed. This system will be totally isolated from the power equipment earthing mesh risers described above and will be located underground vertically below the electronic equipment room.

For lightning protection, lightning mast/shield wires would be provided on towers to cover the switchyard area for protection of the switchyard equipment against lightning. Similar protection will be provided for powerhouse transformer yard also. Besides this lightning arrestor at required locations will be provided to protect the outdoor equipment from lightning and switching surges. Lightning protection system will be installed for protecting the buildings/structures against lightning discharge. This would be achieved by providing lightning masts on stacks, powerhouse building, towers in switchyard, floodlight towers, etc. and connecting them with the ground grid below the ground by means of down conductors.

7.17 EMERGENCY POWER SUPPLY SYSTEM

The emergency power system provides power to essential auxiliary loads required, to permit a safe shut down of the unit in the event of a plant blackout. In addition, power is provided for auxiliaries and services required for personnel safety and equipment safety during the blackout. The bearing lub oil cooling pumps, seal oil pumps, barring gear, battery charger, emergency lighting for the station, etc. would be fed from the emergency power supply system.

In order to meet the above requirement three (3) nos., each having 50% capacity, diesel generator sets will be installed meeting the requirement of emergency load for the units. Two out of these three will run independently and the third one will act as common stand-by for both of these two DGs.

7.18 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

Two (2) sets of uninterruptible power supply (UPS) systems of continuous duty have been envisaged to supply regulated, filtered and uninterrupted 240 V, 50 Hz, single phase power within acceptable tolerances to critical AC loads like computerised data acquisition system, microprocessor based control and instrumentation system, analog control system, burner management system, annunciation system, indicators/recorders mounted on unit control boards and other critical loads of such nature. The system would comprise static inverters, static transfer switches, UPS system battery, float-cum-boost chargers for the battery, step down transformer, voltage stabilizer, DC distribution board, AC distribution boards, etc. Both automatic and manual mode of operation will be provided. A separate set uninterruptible power supply (UPS) systems of continuous duty have been envisaged for 400 kV switchyard control.

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Brief Technical Features of Electrical Equipments

1. Generator

- Type : Two-pole cylindrical rotor, preferably with brushless exciter
- Capacity : 660 MW, at 0.85 p.f. (lag)
- Generating Voltage : 21 kV
- Speed : 3000 rpm
- Cooling : Stator Winding - directly cooled by de-mineralized water
  Stator Core & Rotor - by Hydrogen
- Insulation : Class-F with temperature rise limited to Class-B.

2. Generator Neutral Grounding Equipment (NGE)

- Type : Metal-enclosed cubicle
- Components : Disconnecting link, grounding transformer and resistor
- Type of N.G. Transformer : Dry, AN type
- Resistor element : Cast-iron

3. Generator Circuit Breaker (GCB)

- Interruptor Type : SF6
- Nominal operating voltage : 21 KV
- Rated continuous current : 24000 A
- Symmetrical Breaking Current : As per system study
- Mounting : Horizontal, to fit into generator isolated phase busduct system
- Enclosure : Enclosed in cylindrical aluminium duct for each phase

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4. Generator Busduct (IPBD)

- Type : Isolated phase
- Material
  - Conductor : Aluminium
  - Enclosure : Aluminium
  - Insulators : Porcelain
- Nominal operating voltage : 21 KV
- Rated continuous current
  - Main Run : 23600 A
  - Tap-off Run : 1500 A
  - Common Tap-off Run : 3000A
  - Delta Run : 13600 A.
- Symmetrical Breaking Current
  - Main Run : As per system study
  - Tap-off Run : As per system study
  - Common Tap-off Run : As per system study
  - Delta Run : Same as that of Tap-off Run
- BIL : 125 kVp

5. Transformers

- **Generator Transformer (GT)**

  - Capacity : 3-270 MVA
  - Voltage ratio : 21 kV/(420/√3) kV
  - Phase : A bank of three single-phase units
  - Vector Group : YNd1
  - Cooling : OFAF
  - Tap changer : Off Circuit (OCTC) : range ± 2 x 2.5%
  - HV Neutral Grounding : Effectively earthed

- **Unit Transformer (UT)**

- Quantity	:	Two (2) nos. per unit
- Capacity	:	40/50 MVA
- Voltage ratio	:	21/11.5 kV
- Phase	:	3 Phase
- Vector Group	:	Dyn11
- Cooling	:	ONAN/ONAF
- Tap changer	:	On Load (OLTC) : Range (±) 8 x 1.25%.
- LV Neutral Grounding	:	Low resistance grounded limited to 300A

- **Reserve Auxiliary Transformer (RAT)**

- Quantity	:	One (1) no. for 2 Units
- Capacity	:	40/50 MVA
- Voltage ratio	:	400/11.5 kV
- Phase	:	3 Phase
- Vector Group	:	YNyn0
- Cooling	:	ONAN/ONAF
- Tap changer	:	On Load (OLTC) : Range (±) 8 x 1.25%.
- Neutral Grounding	:	Low resistance grounded limited to 300A

- **HT Auxiliary Transformer**

- Type	:	Oil filled with outdoor service
- Rating	:	16/12.5, 12.5/10, 7.5, 5 MVA
- Voltage ratio	:	11 /3.45 kV
- Phase	:	3 Phase
- Vector Group	:	Dyn1
- Cooling	:	ONAN/ONAF for 16 & 12.5 MVA ONAN for 7.5 & 5 MVA
- Tap changer	:	Off Circuit (OCTC) : range ± 2 x 2.5%

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- **LT Auxiliary Transformer**

- Type	:	Dry Type
- Rating	:	2500, 2000, 1600, 1000, 630 kVA
- Voltage ratio	:	11 kV/433 V and 3.3 kV/433 V
- Cooling	:	AN for Dry type
- Tap chang	:	Off Circuit (OCTC) : range ± 2 x 2.5%

6. **11 & 3.3 kV Switchgear**

- Type	:	VCB for 11kV and Vaccum contactor for 3.3kV
- Enclosure	:	Metal enclosed indoor drawout type
- Degree of Protection	:	IP-4X
- Rated voltage	:	11 kV & 3.3 kV
- BIL	:	75 kVp (for 11 kV) & 40 kVp (for 3.3 kV)

7. **415 V Equipment**

- **415 V Switchgear**

- Type	:	Air break
- Enclosure	:	Metal-enclosed indoor drawout type
- Degree of Protection		
- Inside Switchgear room	:	IP-52 for rating upto 1600A IP-42 for rating above 1600A
- In Other Areas	:	IP-54

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- **MCC & DB (AC & DC)**

- Type	:	Metal-enclosed indoor draw-out type with Air circuit breakers and motor starter units
- Components	:	SFUs, contactors, control fuses, thermal overload relays
- Voltage	:	415 V / 230 V for ACDB, 220 V / 24 V for DCDB

8. **DC System**

- **Battery**

- Type	:	Lead-acid
- Nominal Cell voltage	:	2.0 Volts
- Emergency load duration	:	1 hour

- **Charger**

- Type	:	Air-cooled, solid-state
- Service	:	Float and Float-cum-boost charger for 220V battery Float-cum-boost charger for 24V battery

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9. **Electric Motors**

- **Voltage**

  - **AC Motors**

    - $\leq$200 W : 240 V, 1 phase
    - >200W & $\leq$200 KW : 415 V, 3 phase
    - >200kW & $\leq$1500 KW : 3300 V, 3 phase
    - >1500W : 11000 V, 3 phase

  - **DC Motors** : 220 V DC

10. **Cables**

- **HT Power Cables (11 kV & 3.3 kV)**

  - Conductor : Stranded Al conductor
  - Insulation : XLPE insulated
  - Inner Sheath : Extruded PVC inner sheathed
  - Ammour
    - for multi-core cables : Single round galvanized steel wire
    - for single core cables : Single round aluminium wire
  - Outer Sheath : Fire resistant low smoke halogen free (FRLSH) PVC outer sheath

- **LT Power Cables (1100 V)**

  - Conductor : Stranded Al/Cu conductor
  - Insulation : XLPE insulated
  - Inner Sheath : Extruded PVC inner sheathed
  - Ammour
    - for multi-core cables : Single round galvanized steel wire

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- for single core cables : Single round aluminium wire
- Outer Sheath : Fire resistant low smoke halogen free (FRLSH) PVC outer sheath

- **Control Cables (1100 V)**

  - Conductor : Stranded Cu conductor
  - Insulation : PVC insulated
  - Inner Sheath : Extruded PVC inner sheathed
  - Ammour : Single round galvanized steel wire
  - Outer Sheath : Fire resistant low smoke halogen free (FRLSH) PVC outer sheath

11. **Diesel Generator**

- Type : 4-stroke, water-cooled, direct-injection, turbo-charged with after-cooler
- Speed : 1500 rpm
- Capacity : As per requirement
- Voltage : 415 V, 3 Ph., 50 Hz
- System : 3-phase, 3-wire ungrounded
- Insulation : Class B
- Exciter : Brushless

12. **400 kV Switchyard**

- **System Particulars**

  - Nominal System Voltage : 400 kV
  - Highest System Voltage : 420 kV
  - Frequency : 50 Hz +3% (51.5 Hz) and –5% (47.5 Hz).
  - Phase : 3

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- System neutral earthing : Effectively earthed
- BIL (Lightning/switching/PF): 1425 kVp /1050 kVp /630 kVrms
- Bus Bar Arrangement : One and half breaker system.
- System fault level : 40 kA (Sym)
- Short time withstand : 40 kA (Sym) for 1 sec

- **Lightning Arrester**

  - Type : Heavy duty station class, gapless
  - Voltage Rating : 360 kV
  - Nominal Discharge Current : 10 kA (Heavy Duty)

- **Voltage Transformer**

  - Rated System Voltage : 400 kV
  - Type : CVT
  - Ratio : $400kV/\sqrt{3} / 110V/\sqrt{3} / 110V$
  - Accuracy class
    - Protection : 3P
    - Metering : 0.2s
  - Installation : Outdoor

SECTION-8

INSTRUMENTATION AND CONTROL

8.1 DESIGN OBJECTIVE

The objective of this section of the detailed project report is to outline design philosophy to be adopted for Instrumentation and Control (I&C) systems for 2 x 660 MW (Units 3 & 4) of Odisha Power Generation Corporation Limited, IB Thermal Power Station, Banharpali, District. Jharsuguda, Odisha, which cover BTG (boiler, turbine, generator and their auxiliary systems and power cycle system) and BOP (balance of the plant). The objectives are as given below.

i) To allow safe start-up, synchronizing, loading & load runback, shut-down, emergency tripping, control and monitoring of all major plant areas.

ii) To maximize the availability and reliability of plant taking into consideration of proper redundancies at critical level as applicable.

iii) Failsafe design of I&C system considering the safety of personnel, process and equipment under the failure of Instrument air and / or Electric power.

iv) To incorporate a maximum level of automatic control, thereby minimizing operating manpower levels.

v) To provide facilities for comprehensive monitoring, storage and presentation of information concerning plant conditions.

vi) To provide facilities for comprehensive testing, presentation of information concerns to the systems and plant performance.

vii) To centralize plant monitoring and control facilities within the Central Control Room for BTG and local area control rooms for BOP.

viii) Achieve maximum life span of major equipment by condition monitoring systems.

ix) Optimization of the plant with high output and minimal consumption of fuel.

x) Maximum efficiency

The I&C system would be of the type which normally relieves the operator of continuous duties and would take pre-planned corrective actions in case of process drift or if unsafe trends / condition develop in any regime of operation during start up, shutdown, normal and emergency conditions.

8.2 PLANT CONTROL PHILOSOPHY

A safe, efficient and reliable operation of the Plant Instrumentation & Control System is envisaged for Control and Monitoring of all equipment of the Main Plant & Auxiliaries from the Central Control Room (CCR) which will be common for both the units. The I&C System would provide Control and Monitoring of all major systems and equipment and related subsystems so that the status of all parameters of the plant is made available at Central Control Room (CCR).

Offsite plants (BOP) will have their independent local controls. Major parameters of Offsite Plants like Raw Water facilities, DM Water facilities, Coal handling plant, Fuel Oil unloading & handling system, Ash Handling Plant etc. has also been considered in the CCR for remote monitoring of the respective off-sites facilities in addition to their local operation and control from their respective local control room. The implementation of I&C system for the BTG unit would be based on a state-of-the-art Microprocessor based Distributed Digital Control, Monitoring & Information System (DDCMIS) with functional & geographical distribution of various function groups.

Wherever required, Remote Inputs and Outputs (RIO) will be considered for the system & sub-system of the plant at different locations for optimization of the scope of cabling.

The DDCMIS will be of Open Architecture type having high system availability and reliability with redundancies at various levels.

It is envisaged to have a unified DDCMIS system for Steam Generator Controls, Steam Turbine & Generator Control and Power cycle equipment and system controls through same family of hardware and software. All critical protection signals related to safety tripping shall be hardwired to DDCMIS.

Automatic co-ordinated control has been envisaged for co-ordinated Boiler, Turbine and Generator Operation.

8.2.1 Steam Generating Unit And Auxiliaries

C&I shall include major Boiler controls like Burner Management System (BMS) including Master fuel Trip (MFT), Secondary Air Damper (SADC), Soot Blower Control and other controls like start, stop, automatic, interlock and Protective functions of coal mills, seal Air fans, scanner air fans, HP Bypass system etc. and other integral auxiliaries control.

8.2.2 Turbine Generator And Auxiliaries

C&I shall include controls and protective trips functions like Electro Hydraulic Governor (EHG) control, Automatic Turbine Run up System, Turbine Testing, Turbine Stress Evaluator, Turbine Protective Trip System, Turbine supervisory Instruments, LP Bypass system and Other closed loop & Open loop control of TG system and auxiliaries related to the integral performance and safety.

8.2.3 Station C & I System

This will Include the control & monitoring of all other balance controls in SG area, TG area and Power cycle & BOP system such as Boiler circulation water pumps, ID fans, FD fans, PA fans, Air pre heater, Fuel oil forwarding / pressurizing pumps, Boiler feed water pumps, Condensate extraction pumps, DM cooling water pumps, Condensate transfer pumps, Service water pumps, Pressure reducing & de-super heating stations and associated systems like Flue gas path, Feed water system, Condensate system, Heater drain system, PRDS system, Cycle make up & Boiler Fill system, CW & ACW system & Cooling Tower Fans, Raw water pumping system, DMCW system, Fuel oil pressurizing, heating and forwarding system etc. along with all equipment integral instruments and balance field instruments.

8.2.4 Offsite Plant Controls

Off Site (BOP) Plants shall be operated from their local control panels or monitors located in the respective plant area local control rooms. Some of the plant auxiliaries shall have operational facility both from central control room as well as from local panels / desk. DDCMIS based common system shall be operable from the operator stations of both units.

PLC based SCADA System

Redundant PLC based controls with their MMI unit will be provided for all major offsite plant controls as mentioned below. PLC & MMI will be located at their respective area control room. Major control shall have hardwired connection or digital communication link with the DDCMIS for monitoring of selected data & status in CCR. Considering the presence of electromagnetic interference prevailing in the plant, fibre optic cable would be provided for the above digital communication.

  - Demineralization Plant
  - Coal Handling plant
  - Ash Handling Plant
  - Compressed Air Plant,
  - Mill Reject Handling System
  - Condensate Polishing system
- Switch yard
- Raw Water Pump
- Hydrogen Generation Plant

Microprocessor Based Local Control Panel (LCP)

Microprocessor Based LCP system shall be envisaged for the following systems. Monitoring of critical parameters of these control system is envisaged in the DDCMIS.

a. Fire Alarm System
b. Compressor Integral Control

PLC Based Local Control Panel (LCP)

PLC Based Local Control Panel will be envisaged for the following systems.

a. Fuel Oil Unloading, Storage & Heating
b. Fire water pumps control,
c. Condenser On-load tube cleaning system,
d. Centralized Turbine Oil Purification system
e. Emergency Diesel Generator
f. Effluent treatment system,
g. HVAC

For the major systems the monitoring of selected parameter & equipment status will be provided in the DDCMIS either through serial link or through hardware.

Relay based Standalone LCP

Relay based control will be conceived for the non-critical systems like Chlorination, CW Treatment and HP / LP Chemical dosing system. Except for the Chemical dosing system all other systems will not have any interface with DDCMIS.

8.3 DESIGN BASIS REQUIREMENTS

The design of the control and monitoring system envisaged would be based on the following basic requirements :

- Complete control and monitoring of the Main Plant BTG unit & its Auxiliary systems and Electrical Systems will be performed from Central Control Room (CCR) through the PC based Operator stations of DDCMIS with Display Monitor and keyboard / mouse.
- Software integration of different PLC based controls of the plant including the offsite plants with DDCMIS
- Display and report generation of all relevant parameters in operator's guidance mode.
- DDCMIS connectivity with the switchyard SCADA has been envisaged for monitoring.
- Supervisory control for the electrical sub system will be realized in the DDCMIS. Monitoring of electrical parameters and status in the DDCMIS with graphic screen display has been envisaged.

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- Back up operations for safe shutdown of the power plant and electrical system from control desk has been envisaged.

- The system design will be aimed for safe, efficient and trouble-free functioning of the plant under start-up, synchronization, loading, unloading, shut down & emergency operation etc. The system will ensure high safety for man & machine.

- LCD type Large Video Screens unit wise has been envisaged.

- Automatic synchronization command has been envisaged from DDCMIS. Manual synchronization facility has been envisaged as back up.

- Sequence of Event Recording (SER) system has been envisaged as either separate or integral part of DDCMIS. SER shall be provided to record and print trip and causes of trip for quick diagnostic of fault and remedial action.

- Adequate number of operator stations will be provided to achieve flexibility in operation and it will also be ensured that any operational task can be carried out from any operator station. Printers shall be supported in the network and are common for log and report printing, graphic print, alarm and event printing.

- Control and monitoring of plant through Operator Stations shall be performed through different displays which shall include complete plant mimic displays, control displays, bar graph displays, alarm displays and messages, operator guidance displays, system status displays etc. Logs, summaries and reports will be displayed and will be printed on the printers.

- Drives shall have start / stop and open / close facilities from the

ODISHA POWER GENERATION CO. LTD. BHUBANESWAR operator stations. All drive shall have Emergency stop facilities through the Local Push Button stations.

- Ease of maintenance i.e. on line adequate diagnostic, fault isolation & identification, minimum down time would be given due importance at system design stage.

8.4 FUNCTIONAL DESCRIPTION

The following Control and Instrumentation Systems has been envisaged :

- Distributed Control System & Management Information System (DDCMIS)
- Programmable Logic Control system (PLC)
- Field instruments
- Vibration Monitoring System
- Master and Slave Clock system
- Sequence of Event Recorder System
- Steam and Water Analysis System (SWAS)
- Continuous Emission Monitoring System (CEMS)
- Control Desk, Panel, Cabinets, Local Panels and Transmitter Enclosures
- Power Supply System
- Control valve, actuators and accessories
- Instrumentation Cables & Accessories
- Process connection, piping & instruments installation
- Hart Management System

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8.4.1 **Distributed Digital Control, Monitoring & Information System (DDCMIS)**

An integrated and functionally distributed hierarchical control (both binary and modulating) and data acquisition system synthesized from one common family of hardware and software has been envisaged for the plant.

The DDCMIS hardware (Controllers, modules / cards etc.) shall be housed in cabinets located in Control Equipment Room (CER) except for operation interface which shall be located in Unit Control Desk in Central Control Room (CCR) common for both units.

The DDCMIS shall be configured to perform the following basic functions :

- Automatic sequencing of the start-up and shutdown of equipment and auxiliaries including group/plant level start-up to minimize Operator's intervention under normal operating conditions ensuring safety of man and machine as well as plant availability.

- Automatic regulation of various valves and dampers to achieve guaranteed performance of various controlled variables and to achieve most fuel-efficient operating regime.
- Acquisition, display, report generation and archiving of plant data and maintain historical data.
- On-line self-surveillance, monitoring and diagnostic facility
- System programming & documentation facility
- Data communication system

DDCMIS will have the following subsystems:

A. **Input / Output Signal Processing**

I/O modules for CLCS and OLCS will perform the task for collection and processing of analogue data and binary status from the field sensors and switches. Modules will have diagnostic for detection of any failure in the module and any signal goes off-limits.

All Inputs and Outputs would be galvanic ally or optically isolated.

B. **Closed Loop Control (CLCS) & Open Loop Control (OLCS)**

Multi-loop Controllers will have multi-functioning & multitasking facility and would be capable of handling both Closed Loop and Open Loop Controls. Central Processing Unit (CPU), Communication Processors and Power supply modules for all Controllers would be dual redundant types.

The CLCS will perform modulating controls with self-tuning facility under steady state condition and for load changes with permissible variation in parameters.

Redundant multi-loop controllers logically grouped for optimum, effective and safe Performance will be provided.

Redundant sensors ("2 out of 3" or "1 out of 2" philosophy) have been envisaged for critical measurements and control.

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Boiler and Turbine protection will be conceived in either 2 or 3 channel configuration with adequate diagnostic.

Electro-pneumatic type final control elements are considered for the regulating duty. However, for critical applications where first response is required such as HP/LP Bypass etc., Electro-hydraulic actuators have been envisaged.

All actuators with fail-safe condition mode under abnormal conditions have been envisaged.

C. **Data Acquisition System (DAS)**

DAS would be integral subsystems of DDCMIS. Inputs taken for CLCS and OLCS would also be used for DAS purpose.

The data collected will be used for display, alarm, graphics, trends, logging, historical storage and performance calculation.

D. **Historical Storage & Retrieval Subsystem**

The Historical Storage Unit (HSU) will archive data and parameters for logs and historical records including trends, alarms and events. Redundancy in the bulk storage medium will be provided for Historical Storage Unit.

E. **Performance Calculation**

Plant performance calculations and other complex computations will be achieved by automatically retrieving plant data from highways. All these data will be displayed on Operator's station. Performance calculation would be based on ASME PTC performance test code.

F. **MMI Subsystems**

Adequate number of Operator's stations configured with latest Pentium based PC, LCD colour monitors, keyboard, mouse etc. will be provided for man-machine interface. Any system / equipment of the unit can be operated and monitored from any Operator's Stations. In addition, engineering station, performance calculation & optimization package and shift supervisor station have been envisaged.

Adequate number of color & B/W laser and dot matrix printers will also be provided for alarm, SOE, reports, logs, graphic print.

High resolution Large Video Screen (LVS) from the state-of-the-art technology will be installed in the CCR to facilitate monitoring of the entire plant. The system will be interfaced with DDCMIS for Plant graphic & critical alarms.

G. **Alarm Facility**

Plant abnormal conditions will be alarmed and displayed in the Monitor of the Operator Stations with different levels of priority and colours to facilitate the type of action to be taken by the operator.

H. **Data Highway & Gateway for interfacing with other Systems**

Main Data Highway will be high-speed dual redundant type with a bus speed of minimum 100 Mbps. Control network will be redundant and will have speed of 10Mbps or more. Information network will be of 1000 Mbps. Communication gateway link between DDCMIS and other PLC based plant control system will be redundant.

The Control System based on open system architecture shall be modular, expandable and flexible so that expansion of the system is possible by adding extra stations on the data highway without disturbing operation of rest of the system. The system shall be able to communicate freely with any other system following standard protocol.

Comprehensive self-diagnostic features have been envisaged to facilitate easy fault location and detection of hardware and software while the unit is in operation.

The data communication systems with following minimum features have been envisaged :

- Redundant communication controllers have been envisaged to handle the communication between each functional group of controllers of Control System with the Main data highway. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the Data highway / control network shall not result in loss of any communication function to and from any other station / module.

- Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one network and changeover to the standby network shall be automatic and completely bump less and the same shall be suitably alarmed / logged.

- The design and installation of the data highway based on the environmental conditions and hazardous area classification as applicable have been envisaged.

- Sufficient Data transmitting speed has been envisaged to meet the responses of the system in terms of displays, control etc. Spare capacity has been also considered.

I. **Scan Time & Response Time**

As a guideline, the maximum permissible response time of DDCMIS for various functions are shown as follows :

- CLCS function - 250 –500 msec.
- Critical loops - 100 msec.
- For DAS function - 500 msec or more.

J. **Displays**

Following displays on the monitor have been envisaged:

- Plant Graphics
- Control Faceplate Display
- Individual and Group Display
- Real Time and Historical Trend Display
- Alarms Display
- SOE display
- Diagnostic Display of the Process and Control System

K. **Logs and Reports**

The following logs and reports have been envisaged :

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- Hourly, daily & monthly logs with freely assignable option of any parameter.
- Trip logs related to the unit and electrical system including pre-trip and post-trip.
- Alarm and SOE logs

L. **System Software**

The latest user-friendly version of all necessary software will be provided for the system. The software platform will permit interface with third party systems.

8.4.2 **Programmable Logic Control System**

PLC based control system shall consist of measurement system, interlock, protection and sequential control system, integrated annunciation system and data bus system for control and communication with the process. The microprocessor based PLC system shall consist of dual power supply modules, hot stand by processor modules and hot stand by communication modules with redundant communication link for communicating with operator station, Engineering station, remote Central control room DDCMIS and remote I/O panels with I/O card.

The system shall provide for sequencing of automatic start-up / shutdown bringing standby equipment into operation on failure of main equipment and manual intervention facility for all the equipment.

The PLC shall have all the facilities like dynamic graphics, alarm / event recording, real time and historical trending, control groups, overview pages, logging (hourly, shift, daily, weekly, monthly), Pre-trip, post trip reports etc., The design of the control system and related equipment shall adhere to the principle of fail safe operation of all system levels i.e. the failure of signal, failure of power or failure of any component should not cause a hazardous condition and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic condition.

8.4.3 Instruments & Systems

The transmitters and switch devices will be grouped together and will be placed in different local instrument enclosures in open and dust prone areas and in open type local instrument racks in covered areas at suitable locations. All field mounted instrumentation items shall be of IP 65 protection class.

The equipments shall be designed and constructed to withstand ambient temperature extremes and relative humidity conditions of the plant. The equipments shall meet all functional requirements and perform accurately and safely under the environmental and operating conditions without undue heating, vibration, wear, corrosion and aging.

Instruments will be of proven reliability, high accuracy & repeatability. They will comply with the acceptable international standards with following type and features:

- All field transmitters are envisaged with 4-20 ma DC signal output with high turndown ratio and with superimposed digital signal conforming to HART protocol.
- Instrument scale will be calibrated in engineering units and range will be selected in such a way that normal process parameter will lie in between 50-80% (approx.) of full scale.
- Instrument will have over pressure limit of about 150%.
- Accuracy of process transmitters is envisaged as +/- 0.1%. Accuracy of local gauges (PG, TG etc.) is envisaged as +/- 1% (approx.).

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- All temperature elements (RTD / Thermocouple) will be duplex type. Thermocouples will be mineral insulated & ungrounded type.
- Flow nozzles will be considered for auxiliary steam and feed water flow. For other water flow measurement orifice plates are required.
- Coriolis Type Mass Flow Meter or Positive displacement flow meters and totaliser will be used for oil flow measurement.
- Ultrasonic type level transmitter will be used for measurement of level of underground large sump.
- Radar type levels Transmitters will be used for vacuum services such as for Condenser hot well & LP heaters under vacuum. DP type level transmitters will be used for all other level measurement.
- Conductivity types Electronic Water level for boiler water separator with display facility locally as well as at Central Control Room have been envisaged.
- Boiler tube leak detection system will be envisaged.
- Discriminating type Flame Scanners will be considered for flame monitoring & failure trip. Flame intensity display will be available in monitor.
- O_2 analyzers at each economizer outlet
- O_2 analyzers at each Air Heaters outlet
- CO analyzer at each economizer outlet.
- Local gauges will be provided wherever any local adjustment and maintenance is required.
- Process switches for temperature, pressure and level as per requirements shall be provided for alarms / Trips.

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Pressure indicators, Pressure switches, Pressure transmitters, Level transmitters etc. will be connected with process piping through root valves having proper size instrument piping.

The necessary root valves, impulse piping, drain valves, gauge-zeroing valve, valve manifolds and all the other accessories required for mounting/ erection of field instruments (i.e. PI, PS, PT, LT, etc) will be provided.

8.4.4 Vibration Monitoring & Analysis System

Microprocessors based stand alone online vibration monitoring and analysis system have been envisaged for machine condition monitoring, analysis & diagnostic. On-line Vibration Monitoring System will be provided for all critical auxiliary equipments (200KW & above) like ID fans, FD fans, BFP, CEP, CW etc. The Vibration measurement shall be carried out in X and Y direction for the equipment and also for motor bearing. Vibration monitoring system will consist of Vibration transducers, Key phasor probes, Vibration monitors, Power supplies, Vibration monitoring system will have interface with DDCMIS for centralized monitoring. Vibration monitoring system will have capability of dynamic data analysis and provide complete information of machines diagnostic.

8.4.5 Master and Slave Clock System

A common redundant master and slave clock system is envisaged and this would be time synchronized with the Global Positioning Satellite (GPS) system. The master clock will synchronize the entire BTG control and other associated controls as required for uniform time stamping.

8.4.6 **Sequence of Event Recorder (SER)**

Sequence of Events Recording system (SER) integral to each unit DDCMIS will be provided to log trips, cause of trips and other important faults, to diagnose the cause of the plant trip in the sequence of occurrence with a resolution of 1 (one) millisecond. The system will have sufficient capacity to record all the important events.

8.4.7 **Alarm Annunciation System**

a) All the alarm points of DDCMIS will be annunciated on the OWS monitor. In addition group alarm / critical alarm shall be annunciated on the alarm fascia on the UCP in unit control room and also in LVS.

b) Alarm annunciation sequence for conventional window annunciator in PLC controlled areas shall be configured in their respective PLC and PLC output shall drive the alarm facia.

c) Conventional microprocessor based window annunciator shall be furnished for Local Control Panels.

d) Alarm sequence shall be as per ISA sequence with pushbuttons for Accept, Reset, Test and Silence.

e) Annunciator actuation contacts for either field-mounted or panel mounted annunciator systems shall be opened during normal operation and close on fault condition or loss of power. Annunciator sequence for all alarms shall be the first out, manual reset type facility.

8.4.8 **Steam and Water Analysis System**

Steam and Water Analysis System (SWAS) for continuous on-line monitoring of water quality and steam purity in the feed-water and steam cycle have been envisaged.

The analytical measurements of Conductivity, pH, Hydrazine, Dissolved Oxygen, Silica, Sodium, Phosphate etc. as per process requirement will be provided at strategic points on the power cycle and for boiler. Separate Sample Conditioning Panel (Wet Panel) and Analysers Panel (Dry Panel) will be considered. Industry proven microprocessor based analysers with displays and diagnostic features has been envisaged. Alarm contacts will be provided for each analyser. Isolated linear 4-20 mA DC output for monitoring of parameter in DDCMIS will also be conceived. Dry section panel will house window alarms and analyser monitors.

8.4.9 Continuous Emission Monitoring System

Continuous Stack Emission Monitoring System will be provided for on line monitoring of the pollutant exit from the stack. Analyzers will have required interface with DDCMIS for monitoring at CCR.

The system will consist of the following measurements:

- SOx, NOX, CO & CO2 analyser at stack.
- Opacity monitors at stack.
- CO analyzer at each Air preheater inlet.

The stack analyzers shall be mounted in-situ and the signal shall be repeated in DDCMIS for alarm & monitoring.

8.4.10 Boiler Tube Leak Detection System

Acoustic type Steam leakage system to detect steam leaks from boiler tubes shall be provided. Whenever steam leaks from a tube, large amount of sound shall be produced. This sound has a wide frequency band. Though high sound level exists outside the boiler, is intensity is more only at low frequency.

By selecting frequency band corresponding to steam leak, the system monitors and detects steam leaks.

8.4.11 Hart Management System (HMS)

HMS has been envisaged for centralized configuration, calibration, maintenance, diagnostic and record keeping of electronic smart transmitters from remote location. Smart electronic transmitter signals will be wired to DDCMIS termination cabinet. The 4-20 mA signal shall be used for control and monitoring in DDCMIS whereas digital signal will be used by HMS.

8.4.12 Plant Performance Analysis, Diagnosis & Optimization (PADO) Software

PC based on- line plant performance analysis, diagnosis & optimization (PADO) system for the station has been envisaged. The PADO system shall incorporate the complete thermal design model of each unit. The model of each unit shall work together from the same PC for the complete plant.

The system shall use the measured data from the DDCMIS through appropriate interface. Instruments, which are specifically required for implementation of PADO shall also be provided.

8.5 CONTROL ROOM / EQUIPMENT ROOM DESK & PANEL

One Central Control Room (CCR) common for two units of the plant, located adjacent to the turbine hall at the operating floor level of powerhouse building has been envisaged.

Centralized control of the plant has been envisaged from LCD based Operator's station located in the common Central Control Room. DDCMIS Electronic Cabinets, VMS cabinets, Master clock panel, Relay

Cabinets and other system cabinets will be housed in the Electronic Equipment Rooms. Computer Room in general will house the Engineering Consoles, Video copiers, historical storage units etc. All necessary computer furniture will be provided.

Operator Stations and Emergency shutdown push buttons will be installed on the Unit Control Desk (UCD). Control desk will be having aesthetically & ergonomically designed.

Back up instruments as recommended by the manufacturer for safe shutdown such as indicators, start & stop PB of critical drives, ammeters of critical drives, open & close PB for critical valves & dampers will be installed on vertical back up Unit Control Panel. Otherwise the panel shall house control insert for Electrically assisted safety valve, Remote electronic water level Indicators (EWLI) of Boiler water separator and critical alarm windows.

Separate Operator Interface Terminal with monitor, Keyboard and Printer will be provided in Shift In charge Room.

Control panels / system cabinets will be made of CRCA steel.

8.6 POWER SUPPLY SYSTEM

Redundant 24V DC Power supply system has been envisaged for the control part of DDCMIS. MMI, peripherals & other C&I systems require 240V AC will be powered through redundant 240V Uninterruptible Power Supply (UPS) System. DC power distribution for DDCMIS and loop-powered field instruments shall be derived from the DC-to-DC power supply modules and the required DC distribution boards shall be located within DDCMIS cabinets. Any other DC power supply required for the plant shall also be suitably derived and distributed.

Power supply to all other PLC based control systems in the major offsite plants has been envisaged from their own UPS system.

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8.7 INSTRUMENT AIR SUPPLY

The C&I will be supplied with adequate Instrument air supply from compressor, Air dryer Assembly. Moisture and oil free Instrument air at 6 Kg/cm^2 and minus (-) 40°C dew point will be used.

8.8 FINAL CONTROL ELEMENTS

Control valves, dampers and other final control elements will in generally provided with pneumatic type actuators. Hydraulic actuators have been envisaged for HP / LP bypass valves.

Regulating duty valve shall have electro pneumatic positioner HART compatible, position transmitter and air lock relay. On off duty valve will have solenoid valve and end position limit switch. All control valves shall be provided with handwheel.

All severe service control valves shall conform to leakage class V with metal-to-metal seating. Other will have leakage Class –IV. The sizing procedure will be as per latest edition of ANSI/ISA or equivalent standard.

8.9 INSTRUMENTATION CABLES & ACCESSORIES

Necessary Instrumentation cables including prefabricated cables, co-axial cable, fiber optic cable, compensating cable, communication cable etc. would be included.

Instrumentation signal cables are envisaged to be 0.5 sq. mm. (minimum) annealed tinned stranded copper conductor with PVC insulation, twisted pair, screened, armored and with FRLS PVC outer sheath.

Thermocouple extension / compensating cables will be provided for signal transmission from thermocouple. Twisted pair cable will be used for RTD signal connections.

All interconnecting cables between cabinets will preferably be prefabricated with connectors at both ends.

8.10 ERECTION HARDWARE

Erection hardware including all process connection and piping materials like impulse pipe, manifolds, fittings, condensate pots, siphons, isolation vales, pneumatic line tubes and pipes along with necessary fittings, instrument racks and enclosures, junction boxes, pull boxes, cable accessories like glands, flexible conduits, lugs, trays, supports etc. are envisaged. All erection hardware shall be of proper rating and sizes.

8.11 TOOLS & TACKLE AND I&C LABORATORY INSTRUMENTS

Special tools and tackle has been envisaged for the maintenance of the plant and machineries. A set of laboratory instruments consisting of standard measuring & calibrating instruments has been envisaged.

8.12 SPARES & CONSUMABLE

All electronic cabinets are envisaged to have installed spares to allow expansion and modifications. Spare capacity is envisaged in the form of rack space for augmentation and spares channels would be judiciously distributed.

All mandatory spares, commissioning spares and consumable are envisaged.

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8.13 FIRE DETECTION & ALARM SYSTEM

a) A fire detection system as per National Fire Protection Association (NFPA) standards / Tariff Advisory Committee (TAC) guideline would be provided. A Main fire alarm control panel located in the central control room will provide the alarm annunciation for the plant in case of fire.

b) Manifestation of fire shall be sensed by the following methods:

i) Multi criteria type / photoelectric type detectors.

ii) Thermal / heat detectors. Both the type of detectors shall be addressable from the panel and operator interface.

8.14 PLANT COMMUNICATION SYSTEM

A Plant Communication System will be provided to facilitate plant operations by establishing quick communication among operating personnel at various locations of the plant. The Plant Communication System will consist of the following:

- Telephone System
- Public Address (PA) system
- Wireless Communication System

(i) Telephone System

Telephone System will include a private telephone exchange. The telephone exchange shall be Microprocessor based Electronic Private Automatic Branch Exchange (EPABX). The EPABX should be fully digital and should employ Stored Program Control (SPC) using Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM), confirming to latest ITU-T (earlier CCITT) standards The exchange shall have facility to connect P&T (DOT/Trunk) Lines. The exchange shall also have facility for interconnection/tie-up with other telephone exchanges. It shall have fully non-blocking architecture.

(ii) **Public Address (PA) System**

PA System with two-channel voice communication shall use the digital technology. PA system shall comprise of a few separate and independent group of communication system, one each for Unit-1 and Unit-2 respectively. In addition there will be a number of common facility subscribers (e.g. CW pump house area, DM plant area, AHP area, Compressor building, DG building, Admin building etc.).

Speaking in 'Paging' mode will be heard all over the plant while the 'Private' mode will facilitate conversation between two or more stations through close talk channel.

(iii) **Wireless Communication System**

The wireless system shall operate in VHF/UHF frequency band and shall include radio base station and portable sets which will operate in simplex/half-duplex mode. The Wireless Communication System shall have optional facility to interface with EPABX System and Paging System.

SECTION – 9
STATION LAYOUT AND CIVIL ENGINEERING ASPECTS

9.1 INTRODUCTION

The layout of the plant and facilities for the 2 x 660 MW units 3 & 4 has been largely dictated by its location, contour, shape, road access, direction of coal conveyor and water source, the wind-rose pattern, land use pattern of adjoining areas and the direction of power evacuation. The plant has been laid out in such a way that construction work of subsequent units will not hamper operation and maintenance of the already commissioned unit.

9.2 PLANT LAYOUT

The area identified for locating the power plant is a virgin plot of land located just on the east side of the existing 2 x 210 MW Units. The plant layout of the thermal power station within the identified space is shown in **Drawing No.K8B09-009-DWG-DPR-001** enclosed.

A conventional layout for the boiler and the turbine has been envisaged for the power plant with TG set axis transverse to the boilers. The turbine bay is followed by the heater bay, the electrical bay, the boiler proper, electrostatic precipitators and lastly the chimney. Side mill configuration of the fuel preparation section has been adopted. The main plant area houses the turbine building, steam generator, 400 kV/220 kV switchyard, circulating cooling water (CW) system, water treatment and DM plant, coal conveyor from the coal yard and the ash disposal system. The disposition of the different elements has been decided on the basis of their functional inter-relations and the direction of incoming or outgoing materials.

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Unitised concept has been followed in the plant design as far as practicable. The unloading-cum- maintenance bays are considered at the middle of the unit. The coal conveyor entries suitably for side mill, configuration shall be from west of the unit. Since the units would be implemented with a time gap of four (4) months, this will not cause any hindrance in smooth implementation of the project. The main power block with the switchyard is located on the north of the plot with power evacuation to the North-west direction. On the west of the power block is the water treatment facility, which will receive raw water from the raw water intake channel from Hirakud dam. It is to deploy wet type Induced Draft Cooling Towers in the recirculating cooling water circuit. The coal stacks are located along the longitudinal direction of Power house building beyond the marshalling yard.

The coal yard along with other auxiliaries would be located on the south of the powerhouse beyond the marshalling yard. This location ideally suits the wind direction and conventional layout of locating the coal facility at the rear of the main plant. The ultimate mode of coal receipt is through Track Hopper. Two stacks of coal storage and handling facility have been implemented for the new units. However existing coal stockpile has to be used for emergency purpose. The coal yard will be equipped with reversible stacker-cum-reclaimers for mechanised handling suitable for such station size and configuration. The layout considers bunker feeding both from the coal yard and directly from the crushers. Auxiliary fuel viz. HFO and LDO will be received in road tankers and unloaded in tanks. Provision for the railway unloading system has to be kept. Oil tank farm area is located fulfilling the norms of Explosive Directorate.

The power plant along with the area earmarked for auxiliaries and accessories will be located within the common security wall of the complex. The access road will enter the plant from North, which is connected to the district road. Ash and coal gate will be located on the East wall, which will be isolated from the main plant for security reasons. The Administrative Building for the entire complex is located at the West side of Power Block. All the senior executives of the power station will be located in this building. The entry to the Power Plant will be flanked by security gate, time office and first-aid centre. The fire office is planned at a central location near workshop and store.

Provision of disposing fly ash by trucks from ash silos located on the south east side of the plot is kept for gainful usages.

9.3 CIVIL ENGINEERING ASPECTS

Plant Grading :

The contour survey of the plot is available with the Owner. On the basis of the survey, the grade variation is within 1-5 m locally. The plot for Main Plant area has a minor slope towards South. For the purpose of this report, a single terraced layout has been considered with main plant disposed at 199.50 m above MSL. This will involve little cutting and filling for land development.

Soil Characteristics & Foundations :

Based on the available soil data from the existing units. It was observed that the main plant area is predominantly covered with fine to medium grained sandy clay/clayey sand as topsoil with underlying sandy clay in a compacted form. Raft/Mat foundation has been envisaged for major plant and equipment supports. However detail soil investigation of the plot is necessary for deciding on the type of foundation before detailed foundation design and engineering.

Seismic Consideration :

The power station area is located in Zone-III as per the demarcation of IS:1893-1984 of Indian Code of Practice. Analysis and design of structures would be carried out accordingly taking into consideration the factors related to soil characteristics and importance factors of the structure together with the basic seismic co-efficient as per provision of Indian Code.

Wind Conditions :

The maximum wind pressure including winds of short duration as specified in Indian Standard Code of Practice IS:875-1987 (Part-3) will be adopted for the zone where the power station is located. The site is located in the zone as per above standard having basic wind speed of 44 m/s. The provision of Indian Standard Code of Practice IS:875 with appropriate co-efficient for variation of heights and shape will be considered for detail design.

9.4 DESCRIPTION OF BUILDING SUPERSTRUCTURE

Powerhouse Building Superstructure :

The superstructure of the powerhouse building is fabricated structural steelwork. All components will be of welded fabrication and the field connections will be with high-tensile bolts or welding as determined in design stage. The transverse frames will be of rigid type. In the longitudinal direction these rigid transverse frames will be braced to resist horizontal forces. Floors and roofs except the turbine hall roof will have cast-in-situ RC slabs. The turbine hall roof will be made of cast-in-situ RCC slab laid on metal deck formwork in order to reduce the period of construction.

Auxiliary Building :

All other buildings namely, Administrative building, Canteen, switchyard control room building raw water pump house, cooling water pump house, etc. are of reinforced concrete frames with cast-in-situ RCC roof and masonry cladding. In DM Plant building, provision of special anti-corrosive treatment would be made. In case of long span roof, however, steel truss with pre-cast slab/metal sheeting and side cladding would be adopted. Foundations in all cases would be of RCC.

Cable & Pipe Rack :

The cable and pipe rack supports would be of fabricated structural steel work. All steel components will be of welded fabrication with bolted/ welded joints for erection and assembly in the field. Grating supported on structural steel framing would be placed for walkway portion. Foundation for supports would be of RCC.

Civil Works for Plant Water System:

Circulating cooling water system using Induced Draft Cooling Tower is considered for condenser and auxiliary cooling by a separate set of CW pumps. The entire pump house, fore bay, CW channel shall be of RCC construction. There will be one new clarified water pump house with two RCC clarified water reservoir and clarifier. The reservoir is connected to a common header from existing raw water reservoir. This building would be RCC framed with brick wall cladding and cast in-situ RCC roof.

Civil Works for Coal Handling Plant :

For coal handling plant the in-plant conveyors, conveyor galleries, supporting trestles, superstructures of transfer houses would be of fabricated structural steel work. All components will be of welded fabrication with bolted/welded joints for erection and assembly in the field. Roofing will be of metal sheets and necessary windows/louvres will be provided for natural lighting and ventilation. All building/conveyor Foundation shall be of RCC isolated footing. The stacker cum reclaimer shall be supported over rail track over continuous non-yielding type foundation. The crushed coal storage yard shall be provided with properly sloped carpet coal over compacted sub grade.

Civil Works for Chimney :

One (1) twin-flue chimney with common windshield for the two units have been envisaged for the power station. The total height of the chimney has been considered as 275 m. The flues will be of mild steel construction with glass wool insulation. The chimney windshield would be of RCC slip-form construction. In **Annexure-9.1** the salient features of the major civil works in plant buildings are shown.

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SALIENT FEATURES OF MAJOR CIVIL WORKS
For IB TPS 2 x 660 MW Units 3 & 4

SL NO	ITEM	DESCRIPTION	FOUNDATION	SUPERSTRUCTURE	CLADDING	TENTATIVE VOL./ AREA/LENGTH
A.	**Power Generating Block:**					
i)	Power House	220 m X 44 m X 37 m 2/6 Nos Floor	RCC spread foundation	Structural Steel Frame with RC Slabs.	Brick/ Metal cladding.	358160 m^3
ii)	Boiler	-	- do -	-	-	-
iii)	Mill House	78m x 47m x 68m high x 2 line of mills per unit	- do -	Structural Steel Frame with RC Slabs.	Brick/ Metal cladding.	122400 m^3 x 2
iv)	Major equipment foundations, viz. TG, BFP, Draft Fans, Transformers, etc.	-	RCC Raft/ block	RC Pedestal/ RC Frame	-	-
v)	Chimney	275 m high Twin-Flue	- do -	RC shell with Steel Flue.	-	-
vi)	ESP Control Building	44mx15mx 4 floor 1 bldg. for each unit	- do -	RC Frame & Slab.	Brick Masonry	6600 m^3 x 2
B.	**Switchyard:**					
i)	Sub-station	400 kV and 220 kV Bays	RCC Spread Footings	Galvanized Structural Steel Work	-	-
ii)	Control Building	40mx15mx 2 floor	- do -	RC Frame with RC Slabs	Brick Masonry	6000 m^3 x 2

SL NO	ITEM	DESCRIPTION	FOUNDATION	SUPERSTRUCTURE	CLADDING	TENTATIVE VOL./ AREA/LENGTH
C.	**Plant Water System :**					
i)	Cooling Tower (IDCT)		RCC foundation.	RCC Work		-
ii)	CW Pump House with forebay and tunnel	Pump sumps, pump house and electrical annex.	RC Base raft & walls	Structural steel frame with RC slabs	Brick Masonry & metal sheet cladding	-
iii)	Water Pre-treatment	Clarifiers/Settlers, Storage Tanks, Pump House, Filters	RCC foundations	Tanks in RC, Pump House with RC Frame and RC Slabs.	Pump House in Brick Masonry	-
iv)	DM Plant	Plant Bldg. m x m, Acid / Alkali Tanks, Neutralizing Pit.	- do -	RC Frame with RC Slabs.	Brick Masonry	Plant Bldg. = m³
D.	**Coal Handling Plant :**					
i)	Track Hopper with tunnel		RCC Basement	Structural Steel Frame with floor grating	-	As per Existing size
ii)	Conveyor Tunnels	Twin Conv.= m x 5.5m Single Conv.= m x 3.5m	RC Construction	-	-	Twin Conv.= m³ Single Conv. = m³
iii)	Crusher Houses	m x m x m high	RC foundation	Structural Steel Frame with floor gratings.	RCC Floor Slab and Roofing.	-
iv)	Transfer Houses	Nos.	- do -	- do -	-	-
v)	Conveyor Galleries	m	RC foundation for Trestles	Structural Steel with chequered-plate Floor.	Sheeting	-
vi)	Stacker/Reclaimer	m travel	RC continuous footings.	-	-	-
vii)	Pent House	No.	RC Construction	-	-	-
viii)	Control Room	m x m – Two-storied	- do -	RCC Frame and Slab.	Brick Masonry	m²

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SL NO	ITEM	DESCRIPTION	FOUNDATION	SUPERSTRUCTURE	CLADDING	TENTATIVE VOL./ AREA/LENGTH
E.	**Ash Handling Plant :**					
i)	Bottom Ash Hopper	-	RC Raft	-	-	-
ii)	Bottom Ash Silo	1 No. RC/Steel Silo	- do -	RC Frame with RC Wall & Floor.	-	-
iii)	Fly Ash Silos	2 Nos. RC/Steel Silos 18 m dia. x 16 m Ht.	- do -	RC Frame with RC Wall, Floor and Roof.	-	-
iv)	Ash Pipe Bridge & Trestles	-	RC Spread Footings	Structural Steel.	-	
F.	**Misc. Buildings :**					
i)	Fuel Oil Pump House	45m x12mx5 m high	RC Spread Footings	RC Frame with RC Slab.	Brick Masonry	2700 m^3
ii)	Fire Station	Single-storied 6 m high	- do -	- do -	- do -	30 m x 13 m
iii)	Permanent Store	Single-storied 5 m high - 4 Nos.	- do -	RC Col. Truss with metal sheeting	- do -	50 m x 25 m x 4
iv)	H.F.O Storage tank foundation		RCC foundation	Steel tank		
v)	Gate House Complex	Single-storied 3 m high	- do -	Brick Masonry Structure	- do -	300 m^2
vi)	D.G. & Compressor House	Single-storied 6 m high	- do -	RC Frame with RC Slab	- do -	40 m x 18 m
vii)	Administrative Building	Two-storied 3.5 m high each floor.	RC Footing.	-do-	-do-	40 m x 12 m
viii)	H2 Generation Building	Single-storied	RCC footing	Structural steel	Sheeting	

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SECTION–10
ENVIRONMENTAL ASPECTS

10.1 INTRODUCTION

The project is located within the premises of the existing IB Thermal Power Station at Banaharpalli in Jharsuguda district. The Jharsuguda district falls in the Northwest part of Sambalpur district bordering Bargarh district in Southwest, Raigarh district of Chhattisgarh (erstwhile Madhya Pradesh) in West and Sundargarh in North.

Mahanadi, 'IB' (which is a tributary of Mahanadi), 'Vheden' and Lilari nala are the main rivers / streams in the area. The Mahanadi enters Jharsuguda district in the northwest and flows into the Hirakud reservoir, which covers, an area of 774.41sq. km. The river 'IB' flows along the western side of Jharsuguda town and the river 'Vheden' flows in the south. The river IB originating in Raigarh, Chhattisgarh, has a total length of 251 km and drains a catchment of 12447 Sq.km. It is rain-fed and hence nearly 80% of the runoff occurs during the monsoon months of June to October. The area has typical tropical climate with hot summer and moderate winter.

The effect of the units 3 & 4 on environment should be seen in the broader perspective of overall impact on the neighborhood. There is no sanctuary, national park or archeological monuments within 25 km radius of the site. Industrial growth is always associated with some effect on environment. Attempts will, however, be made both at macro level as well as micro level to minimize detrimental effect of the project on the surrounding area.

Whatever minor increase in pollution load would be there due to emission from the units 3 & 4, it would be tolerable. This is because all emissions and discharges from the project will be so controlled that they meet the prevailing Indian standards. As regards liquid effluents, 100% of wastewater will be treated and reused within the plant. So, with the implementation of the project, aesthetics is not going to undergo any notable change and ecology is not expected to be affected to any degree of concern.

10.2 ENVIRONMENTAL POLLUTION FROM A THERMAL POWER PLANT

To evaluate the effect of the 2 x 660 MW units 3 & 4 on the surrounding environment, various factors such as population distribution in the vicinity, type of land use, possibility of pollution from various sources etc. would be taken into consideration.

A thermal power station utilizing coal as its source of energy may pollute the environment in a number of ways. The major pollutants likely to affect the environment of the neighborhood are:-

a. Suspended particulate matters (stack emission & material handling plant)

b. Polluting gases viz. SO_x, NO_x (stack emission)

c. Thermal pollution (stack, cooling tower etc.)

d. Liquid effluent from cooling water system, plant services, boiler blowdown, power house drains, oil handling run off, run off from coal pile area, DM plant regeneration waste, filter backwash wastewater, raw water clarifier sludge, ash disposal area run off and Sanitary waste water from plant toilets.

e. Noise generated during plant operation

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f. Solid waste generation in terms of ash generated from the burning of coal and water treatment plant sludge.

The various pollution control measures envisaged for the project are as follows:-

i) **Emission from Stack**

Since maximum ash content of the fuel is expected to be in the range of 42%, a sizeable quantity of fly ash in the form of particulate matter would be generated. High efficiency electrostatic precipitator would be provided to limit emission of particulate matter to 50 mg/Nm^3. A properly designed steam generator would keep the stack emission of NO_x within 650 mg/Nm^3 conforming to present World Bank norm.

The stack height is chosen as 275 m, twin-flue, to limit ground level concentration of SOx, NOx, etc. within acceptable limits ensuring better dispersion. With a properly designed furnace and burner system, generation of CO will be practically eliminated and NOx generation would be minimised.

Heat loss through the stack is only about 8-10% of the total heat input to the furnace. This is nominal when compared with the capacity of earth as the heat sink and this would be adequately dispersed with the plume from the high stack. Moreover, majority of the heat in cooling tower is rejected in the form of evaporation loss. This does not cause any perceptible thermal pollution to the surrounding area. It may further be noted that the area has moderate wind speed and rainfall and reasonably high temperature.

ii) **Liquid Effluent from Water Treatment & Other Areas**

The waste water treatment and management plan is developed with Zero Discharge Concept. The heat cycle make-up water requirement for the power station would be of the order of 63 m^3/hr of demineralised water. The demineralising process would generate alternately acidic and alkaline effluents after regeneration of such type of exchangers. These effluents would be neutralised in a neutralising pit where proper neutralising arrangements for the effluent fluids would be provided and the neutralised effluent water would be discharged into an equalization basin termed Central Monitoring basin (CMB). In **Drawing No.K8B09-010-DWG-DPR-001** waste water generated from the plant and their treatment are shown schematically.

In the recirculating cooling water system, the make-up water would be clarified water. There will be blowdown from the circulating water system. This blowdown would be utilized in ash handling system.

Other wastes from the processes include clarifier sludge, backwash from filtration plant, Side stream filter backwash etc. which would be sent to ash slurry sump.

iii) **Noise Emission**

Noise emission from equipment will have to be controlled at source. Adequate silencing equipment will be provided at various noise sources to attenuate the noise to acceptable level. Also, green belt would be developed in plant area, which will help in abatement of noise before they reach the plant boundary.

iv) **Central Monitoring Basin (CMB)**

It is envisaged to develop a Central Monitoring Basin to be located suitably in the low lying area of the plot for collecting the liquid wastes. The capacity of the basin would be adequate to store of up to 24-hours design liquid effluent discharge from the station.

CMB will act as an equalization basin for all treated/ untreated liquid effluents. The total effluent reaching CMB is estimated to be 232 m^3/hr. From CMB water will be used for dust suppression system and Horticulture and green belt development. Balance treated water will be further purified in Reverse osmosis unit and sent to the clarified water reservoir for reuse.

v) **Rain Water Harvesting**

The storm water and catchment water, which is not effluent, would be drained by a separate drainage system. All such rain water will be collected in a suitably sized rainwater harvesting pond wherefrom the collected rain water will be used as raw water during dry period. Some basic treatment facility like chemical dosing and filtration system may be required for rendering the harvested water reusable within the plant.

vi) **Ash Handling & Management**

As suggested by CPCB in "Charter of Corporate Responsibility for Environmental Protection (CREP)" the project shall adopt dry fly ash extraction only.

a. The dry fly ash from the silos will be used for fly ash brick manufacturing; lightweight aggregates manufacturing, cement admixtures etc.

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b. In the event of disruption in off take of fly ash from the plant, unutilized fly ash will be disposed through High Concentration Slurry Disposal (HCSD) system to the identified plot as suggested in the CREP as an exigency measure. In HCSD system, the fly ash solidifies very quickly at the disposal site and this process offers no air or water pollution during disposal. After attaining the maximum height the mount will be covered with earth toping followed by greenery development.

c. Fly Ash will also be progressively back filled into Manoharpur mines which is the captive mine block of OPGC and any other mines which will be obtained from MCL. In doing this, the MoEF's guidelines of mixing fly ash in development of external OB Dump of OPGC's captive mine will be adhered to.

vii) **Green Belt**

Adequate green belt would be developed in and around the project area and the ash disposal area satisfying the requirement of State Pollution Control Board (SPCB) as well as of the Ministry of Environment & Forests (MoEF), Govt. of India. Plantation near coal stacks to arrest fugitive dust is also implemented. These green belts, apart from arresting air-borne dust particles and acting as noise- barrier, would help in improvement of ecology and aesthetics of the area.

10.3 COMPLIANCE OF BASIC ENVIRONMENTAL REQUIREMENTS

The site satisfies the following basic requirements laid down by the MOEF

1) The following do not exist within 15 km of the site :

- Metropolitan city

- National Park and Wildlife sanctuary
- Ecologically sensitive target

2) The site is more than 500 m away from the flood plain of river.

3) The stack does not fall within approach funnel of any airport.

4) No archaeological, historical, cultural or defence installation exists with 10 km radius of the site.

5) No forest or prime agricultural land will be utilised for the setting up of the project.

10.4 CLEAN DEVELOPMENT MECHANISM (CDM)

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

The current modalities and procedures for the CDM focus on activities that reduce emissions. A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy efficient boilers.

India has high potential for CDM projects, particularly in the Power Sector. The Baseline Carbon Dioxide Emissions from power sector have been worked out by CEA based on detailed authenticated information obtained from all the operating power stations in the country. The Baseline would benefit all prospective CDM project developers to estimate the amount of Certified Emission Reduction (CERs) from any CDM project activity.

India has a strong commitment to reduce its emissions of greenhouse gases. Ministry of Power has accorded high priority to the CDM projects in the power sector.

CDM Intent of the Project

The major advantages of supercritical power generation are:

- Decrease of the fuel cost due to the increasing heat efficiency;
- Decrease of CO_2 emission per electricity unit to more than 15% in comparison with the existed coal fired power plant.
- Decrease of pollutant including SO_X, NO_X and PM.

To qualify for consideration as CDM project activity, the project proposal should establish the following in order:

i) Emission Additionality: The project should lead to real, measurable and long term GHG mitigation. The additional GHG reductions are to be calculated with reference to a baseline.

ii) Financial Additionality: The procurement of Certified Emission Reduction (CERs) should not be from Official Development Assistance (ODA)

CALCULATION OF CO_2 EMISSION

The reduction of CO2 emission has been estimated based on the following consideration:

Station Heat rate = 2130 kcal/ kwh

Plant Capacity = 1320 Mwh

Calorific Value of Design Coal = 3200 kcal/kg

Specific Fuel Consumption = 0.666

kg/kwh Carbon % in design Coal =

38 %

Inter-regional and cross-border electricity transfers were also taken into account for calculating the CO_2 emission baseline (FY 2005-06 to 2008-09)

The reduction of CO2 emission has come out as 0.9331 kg/kwh and Average for the Eastern Grid reduction of CO2 emission is around 0.83 kg/ kwh (as per CAE guidelines"CO2 Baseline Database for the Indian Power Sector" /User Guide/Version 5.0/November 2009)

10.5 COMMERCIAL UTILIZATION OF FLY ASH

Fly ash has good pozzolonic property, good flowability and low permeability, which facilitate myriad utilisation of fly ash. Ash generated from the station would have sizeable quantum of inert oxides and carbonates of silica, alumina, magnesium, etc. Some of the commercially viable uses of such fly ash are as follows:-

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i) As fill materials in cement
ii) Backfilling of open cast mine
iii) Building blocks
iv) Light-weight aggregates
v) Partial cement replacement
vi) Road sub-base
vii) Grouting material
viii) Filler in asphalt mix for roads
ix) Partial replacement of lime aggregate in concrete work
x) Road embankment
xi) Land filling material
xii) Recovery of minerals namely Aluminium & Iron.

Bottom ash, which has a relatively large grain size, finds a ready market in construction of roads and embankments in rural areas. Review of the various application areas of fly ash reveals that some usage of ash generated in the station at Jharsuguda can be explored as mentioned below :-

i) As mine-fill of the captive mine supplying coal to the station
ii) As landfill in low lying areas
iii) For manufacture of fly ash bricks and other construction materials.

The captive mine would be ready to accept ash for mine filling only after 5 years. Till this situation arises, ash will be given to nearby cement plants for use as admixture in pozzolona cement.

However, a formal ash management plan would be adopted in an environment-friendly manner to contain the fugitive ash emission in the nearby areas to minimum.

In the meantime, the project authorities have already initiated action for use of ash by cement plants located in the region. Further it shall have a ready requirement in a large number of coal mines in the vicinity for soil filling. Accordingly, it is expected that a major portion of the ash generated at the plant will have ready users once the plant gets ready for commercial operation.

10.6 ENVIRONMENTAL LABORATORY

An environmental laboratory will be set up to monitor various environmental parameters as per statute. This will be in compliance with the Environmental Management Plan (EMP).

In **Annexure-10.1**, a list of basic equipment/instruments for environmental monitoring and testing for the thermal power station is given.

List of equipment/instrument for environmental laboratory

Sl.No	Item	Qty.
	Air Oven	One (1)
1.	Barometer, Fortins Barometer, Aneroid	One (1) One (1)
2.	B.O.D Incubator	One (1)
3.	C.O.D Digestion Unit	One (1)
4.	Colony Counter	One (1)
5.	Electronic balance, Top Loading (Digital)	One (1)
6.	Hot Plate with magnetic Stirrer	One (1)
7.	Hygrometer	One (1)
8.	Kjeldahal Digestion and Distillation Apparatus	One (1)
9.	Microscope	One (1)
10.	NOx Measuring Assembly Stack Monitoring	One (1)
11.	Refrigerator	One (1)
12.	Respirable Dust Sampler	Four (4)
13.	Stack Monitoring Kit with accessories	One (1)
14.	Sound Level Meter (Leq capable)	One (1)
15.	Automatic Weather Monitoring Station	One (1)
16.	Steel Cabinet	One (1)
17.	Water Bath	One (1)
18.	Muffle Furnace	One (1)
19.	Digital Conductivity Meter (Bench Top)	Two (2)
20.	Digital pH Meter	Two (2)
21.	Photo Electric Colorimeter	One (1)

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Sl.No.	Item	Qty.
22.	Flame Photometer	One (1)
23.	UV – VIS Spectrophotometer	One (1)
24.	ORSAT Apparatus	One (1)
25.	Standard glass wares and appliances	One lot

SECTION-11

CONSTRUCTION FACILITIES

11.1 INTRODUCTION

The 2 x 660 MW units 3 & 4 at IB Thermal Power station being adjacent to the existing 2 x 210 MW station, some of the construction facilities would be available. However, some construction infrastructure will have to be developed for timely and seamless implementation of the units 3 & 4. The plant layout has therefore been judiciously thought of to permit adequate space for construction offices, covered and uncovered storage, fabrication and pre-assembly yard etc. keeping in view the existing facilities and possibility of converting some of these into permanent facilities at the end of construction phase with suitable augmentation/modifications. As mentioned earlier, for this units 3 & 4 some construction facilities are available. Nevertheless, addition of some of the enabling facilities viz. construction of approach road, some of the in-plant roads etc. would be considered. The enabling work also includes the identifying the space for construction office of the contractor, temporary fire fighting system, construction water and construction power facility etc. prior to taking up any construction work.

11.2 CONSTRUCTION FEATURES

Approach Road:

As the main Plant of the units 3 & 4 is located adjacent to the existing 2 x 210 MW units, the existing roads can be used for access to the site for the 2 x 660 MW units 3 & 4 till the in-plant roads for the units are constructed. Only some diversion and extension of roads are required to be put in place to facilitate the interconnection of units 3 & 4 site to the existing roads. The existing main arterial roads will serve both the existing Plant as well as the units 3 & 4 and will be used for movement of materials and equipment during construction and erection stage.

Construction Buildings:

About 1800 m^2 of construction office space and 3000 m^2 of covered storage is envisaged to be provided in the identified area for construction of office, stores, etc. In addition to this, canteen, garage, toilets, etc. are also envisaged to be built within this plot for use during the construction phase. A suitable location inside the plot may be earmarked for batching plant and storage yard. Since construction housing facilities will be available in the existing township, no separate provision has been made for construction of any erectors' hostel in the extension stage. Space provision has been kept for the contractors' workmen to build temporary barracks/camp for their accommodation.

Construction Water :

The requirement of construction water for potable and service purposes may be tapped from existing plant water system. Construction water for the power plant complex shall be arranged as a part of enabling works and supplied to an overhead storage tank within the power plant area. Approximate construction water requirement is estimated at 60 m^3 per hour on apportioned basis during peak construction period. Construction water supply will be provided at a single point to the contractor for drawing necessary distribution system. A temporary fire hydrant network would be built during construction stage. Raw water for construction may be drawn from the raw water system of existing units by pumping water to an overhead reservoir.

Construction Power :

The peak demand of construction power is estimated as 5000 kVA, assuming certain quantity of site fabrication of steel structures and piping. The required construction power supply would be made available from the existing facility by suitably stepping it down to 11 kV level which would be further stepped down to 415 V. Each Contractor would be provided power connection at a single point at 415 V for them to distribute power to various work centres. A power line ring main at 11 kV level would accordingly be constructed encompassing the construction area for feeding construction power at pre-determined locations.

Construction Equipment :

The contractors would bring their own construction equipment. Construction equipment like Bulldozers, Road-rollers, Crawler, Tyre-mounted cranes, Tractor-Trailors, Winches Lifting-tackle etc. are to be procured by the Project authority, if they are not available in the inventory of existing units. Furthermore, sump-pumps, welding sets, air-compressors, Diesel Generators will also be procured. Miscellaneous tools, survey instruments and all other construction equipment will be brought by the Contractors. The road weigh bridge of existing Plant is to be utilised during construction of expansion units. A number of transport vehicles like Jeeps, Mini Buses, Trucks, Ambulance Van, Cash Van etc. are also to be procured by OPGC, if not available from existing units.

11.3 ORGANISATIONAL SET-UP FOR PLANT CONSTRUCTION

Being a units 3 & 4 and located in industrially developed area of the state, skilled/semi-skilled manpower would be available locally and from nearby districts. Unskilled workers would also be readily available in the area. Proper manpower planning both by the Contractor and the Project Authority needs prime attention, well in advance, to ensure smooth and timely execution of the project.

Implementation of the units 3 & 4 would be on EPC mode for Main Plant (MP) and Balance of Plant (BOP) packages. It is envisaged that the project wing of Owner be headed by an executive in the level of Chief Engineer/ General Manager, who will look after the overall activities in compliance with the project schedule. He would be assisted by a team of senior experienced engineers, Owner's Consultant and other personnel experienced in various disciplines including technical, administration, staff welfare, finance, safety and security, materials management, traffic and legal affairs, etc. Other staff on top of the available staff from existing setup will be recruited progressively as the project activity progresses. A total staff strength of 150 personnel from Owner's side is envisaged during construction stage, who would be ultimately absorbed in operation and maintenance teams after commissioning of the plant. In **Drawing No. K8B09-011-DWG-DPR-001**, a typical organisation set-up for project authority during construction period is shown. About 1200 workmen would be working on temporary role during construction of the project.

11.4 SAFETY & HEALTH HAZARD MONITORING

The Contractor is primarily responsible for safety and health hazard aspects of workforce engaged during project construction. In view of this, the Owner shall form a standing committee for the entire complex comprising their own officials and those of Contractors, who will constantly monitor safety and health aspects of the workforce on periodic basis. Designated safety officer(s) from Owner's side, with power to penalise for any deviation from the adopted safety norms, will make regular checks. These officers would be empowered to identify unsafe construction practices, non-use of safety gears, source of potential health and safety hazards viz. gas leakage, faulty electrical connections, unsafe excavations, unsanitary conditions, fire hazards, etc. in the work sites. They would suggest with the help of the designated committee, ways and means to prevent occurrence of accidents arising out of the aforesaid situations as well as bringing to task the erring personnel.

Apart from preventive measures, as detailed above, there would be a setup to deal with potential accident situations. This infrastructure will include first-aid centre, ambulance, fire-fighting system etc. and trained personnel to take care of these emergency services which will be used from the existing plant with proper augmentation by the Owner.

11.5 SECURITY

An elaborate system to secure the project site from theft, pilferage, obstruction to work, etc. shall be established for the whole perimeter, in general, and storage spaces, in particular, by installation of fencing/boundary walls and security gates manned by trained security personnel.

11.6 LABOUR WELFARE & STATUTORY REGULATIONS

The Contractor shall have the primary responsibility in this regard. The Contractor may form a separate cell to take care of these functions. The licenses required for project construction, but not limited to, license/clearance to engage labour under Contract Labour Regulation and Abolition Act, Workmen's Compensation Act, license for use of explosives under Indian Explosives Act, clearance from State Boiler Inspectorate, Factory Directorate, etc are to be arranged by the Contractor although the Owner would extend support to the Contractor in this respect to the extent considered necessary by the Owner. The Project Organization group of the Owner shall monitor the compliance of all the statutory regulations by the Contractor.

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SECTION-12

ORGANISATION STRUCTURE

12.1 PHILOSOPHY OF PLANT DESIGN & MANAGEMENT

With the introduction of the state-of-the-art instrumentation and control system including computerised Data Acquisition System (DAS) and failsafe mode of operation, the manpower requirement has been largely optimised.

With the advent of newer technologies and installation of larger units, management of high-energy system without human error has become the main objective not only to sustain high reliability but also to avert costly damages during any malfunction. Various safety supervisory systems like Burner Management System (BMS/FSSS) or Automatic Turbine Run-up System (ATRS) have become integral part of modern power station design with microprocessor-based control and Data Acquisition System (DAS). These facilities will be provided in the expansion project as part of the boiler, turbine and control system.

Automatic sequential steps will be provided to ensure safe start-up and shutdown with minimum operator intervention. High level of availability with optimum manpower deployment thus guides the philosophy of plant design and operation.

12.2 ORGANISATION SET-UP FOR PLANT OPERATION

For planning of manpower for operation of the plant, priority is set on design and operational philosophy of the plant. As discussed earlier, efforts have to be made to optimise on manpower requirement for the station through proper design, layout, control and instrumentation, etc. OPGC already has 2 x 210 MW units operating successfully under its

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aegis so it can be assumed that OPGC posses considerable expertise in Operation & Maintenance (O & M). OPGC may mobilize some of its existing staff members skilled in O & M and other fields along with fresh recruits to look after the needs of the expansion project. In the light of introduction of new super critical technology with super critical steam parameters of boiler and turbine, the existing staff members need to be enriched with modern technology in areas of water treatment, and chemical conditioning, metallurgical expertise, Instrumentation & Control System. The following paragraph describes an optimized manpower planning required for running 2 x 660 MW units. It may be noted that the designation and delegation of authority may have to be adjusted depending upon the prevalent practice of OPGC.

The station is to be headed by the General Manager, who would look after the day-to-day work of the station. In technical disciplines, he will be assisted by two Dy. General Managers, who will hold independent charge of the following departments and their functions.

- Operation
- Maintenance

The operation of the station would be the overall responsibility of the Dy. General Manager (Operation) who would directly report to the General Manager. The organisation set-up for operation of the plant is given in **Drawing No. K8B09-012-DWG-DPR-001** enclosed. The total man-power requirement is estimated as 400 of which nearly 210 would be deployed for plant operation in keeping with the design and operating philosophy for the station.

The maintenance wing will be headed by Dy. General Manager (Maintenance) and would be assisted by adequate number of Senior Engineers. Senior Engineers would have the required engineers and staff under them to look after the work under respective disciplines. Approximately 115 personnel would be deployed in maintenance of

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the plants and machineries. The periodic capital maintenance is envisaged to be carried out through contract labour in line with general practice being followed elsewhere. Besides, nearly 15 persons along with a Senior Engineer would look after the fuel supply and handling section. The above manpower deployment planning is based on the philosophy of minimising the manpower requirement during evening and night shifts and concentrating on maintenance efforts during the day shift when the Dy. General Manager (Maintenance) is available at the plant and is actively engaged in supervision. Lesser number of people, therefore, will be in attendance during the evening and night shifts on the assumption that only temporary and minor repair would be done during these shifts. With this approach the need for maintaining a large work force could be avoided.

An assessment of manpower for other services (administrative, general services and miscellaneous maintenance), directly under the control of General Manager, is shown in the drawing attached. These duties would involve deployment of about 60 personnel headed by senior officials of respective functions.

Other non-technical functions viz. labour welfare, safety and security, township maintenance, housekeeping of plant and township, afforestation, etc. would also be looked after by this group. The existing functions, like canteen, security, housekeeping, etc. would be suitably augmented for the units 3 & 4

Manager (Finance) would be responsible for all financial matters and will also have Accounts, Audit and Billing Sections under him.

The manpower estimates shown above may undergo some revisions as per the prevailing practices of the Project Authority.

12.3 TRAINING OF PERSONNEL

As per their prevailing practice, Odisha Power Generation Corporation (OPGC) Limited already has a Training Department to look after the training of technical and commercial trainees, supervisory staff, trade apprentices etc. to replenish the requirements of trained personnel for the existing 2 x 210 MW station. The strength of the training department and its programmes shall be suitably augmented to cater to the needs of the 2 x 660 MW units 3 & 4

The personnel for operation and maintenance of the expansion project will be of the following categories:

i) New recruits without appreciable experience
ii) Personnel directly recruited for the station having experience in power plant practices.

In case of new recruits, who do not have appreciable exposure to power station practices, the training programme will include:

i) General theoretical training in power station operation and maintenance.
ii) Actual in-plant training in Operation & Maintenance.
iii) Simulator training.

In case of the direct recruits with previous power station experience, part of the above mentioned training may be reduced.

If required, the personnel in the supervisory and operative cadre will be sent for training in National Power Training Institutes at Neyveli, Durgapur, Nagpur and Delhi run by the Central Electricity Authority and the training institution of Tata Electric Co, at Trombay, Vijaywada. The training programme for familiarisation with the new station will vary with the nature of duties as explained below:

a. Maintenance Personnel

Some of the personnel with previous experience in maintenanceof mechanical, electrical and control &

instrumentation would be employed and posted at the construction site immediately after the major civil work is over. This will enable them to be closely associated with the construction of all plant and equipment and thereby familiarise themselves with the components and methods of assembly/disassembly.

b. Operating Personnel

The key operating personnel would first go through the course at a thermal power plant training institute, if necessary, as mentioned above. Lectures by supplier's engineers and routine drills for various operations would be organised during this period. Training at Contractor's/Manufacturer's works, both within the country and abroad, would be organised. All operating personnel would be actively associated with all phases of the commissioning of the plant and equipment.

c. Supervisory Staff & Senior Officers

They will be employed and posted at the construction site about six (6) months before the commissioning of the first unit for familiarising themselves with the same. During the period, they will be given short orientation training on the operation of pulverized fuel-fired reheat power stations by visiting experts from the principal suppliers/manufacturers..

d. Chemists

The new recruits will be initially trained in the existing power station and then placed at the work site at least two months before the trial run, so that they could work in the chemical laboratory for water, steam, fuel and other tests to be set-up for 2 x 660 MW units 3 & 4

The training schemes mentioned above indicate the type and method of training, but the recruitment and general procedure of training would be in conformity with the detail training programme to be formulated by the project authority.

SECTION-13

EMPLOYEE FACILITIES AND RESIDENTIAL TOWNSHIP

13.1 EMPLOYEE FACILITIES

Apart from the main Power House building, the power generating equipments and other buildings required for running and maintaining the station, the following facilities are required to be provided inside the power station premises for the operation, maintenance and administration staff:

i) Administrative Office.
ii) Offices for Technical and non-Technical staff.
iii) Canteen.
iv) First-Aid Centre.
v) Car Parks and Motor Cycle Sheds.
vi) Gate House Complex including Safety and Fire Office.
vii) Toilets, wash rooms, change rooms, drinking water etc. provided in main buildings and yard to meet requirements of the Factories Act.

Of the above facilities, some of the buildings would be required during construction phase while the others will be required during operation of the plant. A well thought-out investment plan under these heads will ensure economy and expeditious construction and these would be converted to permanent facilities at a later date. The administrative building of existing plant will also cater to the requirement of the 2 x 660 MW units 3 & 4. The plant entry gate, which would be flanked by security office and safety office on one side and time office and first-aid centre on the other would be provided for the expansion project. A service building located adjacent to the main power house building of existing Units 1&2 will serve as technical office for the 2 x660 MW units 3 & 4. Car parks, cycle sheds of existing Plant would be suitably extended to cater the requirement of expansion project. Toilet, wash room, change room, Safety and Fire Office etc. will be provided as per requirement.

13.2 RESIDENTIAL TOWNSHIP

Residential Quarters :

An expansion of the existing township is necessary to accommodate the personnel required for the upcoming 2 x 660 MW units 3 & 4. It is estimated that a total of about 400 employees would be working for operation, maintenance and administration of the of 2 × 660 MW installed capacity. This excludes security and canteen staff, as these functions would be contracted out. A satisfaction level of about 80% is assumed for planning the residential township of the station. The rest of the employees are expected to come from the neighbouring villages/town. The residential requirements are to be built as per norms set by Bureau of Public Enterprise (BPE). It is, therefore, to build about 320 residential quarters for the employees for power station staff. Land is available at the existing township for the expansion.

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SECTION–14

PROJECT IMPLEMENTATION AND MONITORING

14.1 IMPLEMENTATION

M/s. Odisha Power Generation Corporation Limited is implementing the 2 x 660 MW units 3 & 4 on EPC concept through two number packages viz. Main Plant (MP) package and Balance of Plant (BOP) package which includes all equipment/systems inside the plant boundary. For each system and packages the battery limits shall be well defined to avoid any mismatch during execution.

Successful implementation of a project calls for joint participation of the Owner, the Consultant and the Contractor. The Owner plays the most important role in spelling out the objectives, setting out the priorities and time schedules, ensures timely flow of funds and constantly monitor to settle the bottlenecks. Depending on the in-house capability, the Owner may also undertake other responsibilities like monitoring and expediting the project. The Owner has already engaged Development Consultants Pvt. Ltd., Kolkata to advise and assist in the design, engineering and procurement of equipment and services required for the project. The Vendors and Contractors in turn, render the services required for them as per the intent and spirit of the specifications furnished by the Owner. The technical / engineering Consultant may prepare the specification to meet the Owner's objectives.

14.2 PROJECT ORGAINSATION OF THE OWNER

The units 3 & 4 is to be implemented under the overall direction of the General Manager and, in this assignment, he will be assisted by senior executives of different disciplines and the Planning & Projects Department.

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The Planning and Projects Department, assisted by other technical and commercial departments and supported by the Consultants, would be responsible for the project from its inception till all relevant clearances are obtained, financial packages are tied up and other preliminary work are completed. The Planning and Projects Department assisted by the Consultants will, thereafter, take-up the implementation of the project. They will be involved in various activities of the preliminary stage so that the changeover from the preliminary to the implementation stage becomes smooth. This department will be assisted by a senior executive who would be supported by a team of experienced engineers from various disciplines, such as, Civil, Mechanical, Electrical and Instrumentation.

In specialised areas, the Planning & Projects Department would also be assisted by the Estate, Legal, Industrial Relations, Security, Purchase and Finance Departments of the Owner in the process of execution of the project. Their roles, in brief, would be as follows.

The Estate Department would take-up the work of acquisition of land and resettlement of affected population in close coordination with the local bodies and Government Departments. All legal matters arising out of land disputes, etc. would be tackled by the Legal Department. Industrial Relations Department would assist in achieving good public relation and peaceful labour situation, which, in turn, will facilitate speedy implementation of the project. A senior official of the Purchase Department would be specially deputed for co-ordination of procurement of cement, steel, cables and miscellaneous standard items required for the project. Security Department's personnel would be deployed from the date of receipt of the building materials at site.

Besides, engineers in Testing and Operation & Maintenance Departments would be recruited at the appropriate time during construction and pre commissioning stages of various plants and equipments.

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14.3 PROJECT EXECUTION

The principal objective of the project execution team, to be formed by the Project Authority, is to liaise with the Contractor to ensure the design, procurement, construction and commissioning the power station within the scheduled time ensuring high availability of the generation equipments. These are broadly classified as under.

Basic Design & Planning

The basic design parameters firmed-up in the project report stage along with their implications on the cost of the project and the implementation schedule would form the basic guideline. The component systems and sub-systems of the power plant would be reviewed for compatibility with one another and conformity with environmental regulations.

Engineering & Procurement

The entire plant would be procured by EPC concept through two number of packages - Main Plant (MP) package and Balance of Plant (BOP) package. This will minimise the problem of coordination among the contractors in terms of interfacing between various systems/sub-systems. Procurement specifications for each package would be prepared by the Consultant and these would be finalised after review by the Projects Department.

Construction & Erection

The Contractor would be entrusted with the design, engineering, manufacture, supply, erection, testing and commissioning for the Main Plant package and Balance of Plant package.

Under the contract agreement, the Contractor would be bound to complete delivery and/or erection within the schedule. All corrective actions would be taken to keep the target as scheduled. Progress of activities by the Contractor, their resources and ability to adhere to the quality control would be supervised continuously. Arrangements would also be made for timely delivery of site drawings and working manuals from the Contractor.

To ensure quality control, teams of engineers in respective disciplines either of the project authorities or of the consultants would be deployed. Necessary help and service would be rendered to the Contractor for mobilisation before commencing erection/construction.

Necessary wired and wireless communication systems would be provided at site for internal and external use. The facilities would be extended to the Contractor at their site office also.

Testing & Commissioning

Testing & Commissioning group including Operation & Maintenance personnel would be deputed for pre-commissioning checks and final commissioning of various plants and equipments. Also commissioning network and procedure would be prepared jointly with all concerned, which would guide the team for execution of commissioning activities. Proper documentation of the commissioning activities would be made for safety and orderly commissioning of the plant.

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14.4 PROJECT MONITORING, CO-ORDINATION & CONTROL

Project Monitoring Information System

Progress of each activity at every stage would be physically monitored by respective supervising engineers.

All detailed information would be passed on to the Central Monitoring Cell to keep track of the work progress. Similarly, costing of individual items would be monitored and recorded preferably with the help of computer and software.

Central Monitoring Cell would monitor the progress and report to the senior executives for information and necessary action.

Co-ordination

Regular meetings would be held at site among the representatives of the Contractor, the Consultant and the Engineers of Projects Department to review the progress of each activity. In these meetings, slippages in progress would be identified and corrective measures taken. The problems arising out of site and material constraints would be promptly sorted out. The meetings would also be attended to by one of the senior executives of the company to facilitate on-the-spot decisions. Minutes of meetings would be circulated among all concerned for necessary follow-up action.

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Coordination meetings between the Consultants and the senior executives of the Owner would be held regularly for major decisions in regard to planning, designing of various plants and equipments, execution procedures, manpower deputations, industrial relations, security, etc. Steps would be taken to ensure regular interactions between the

contractors, vendors, the Consultant and Projects Department to finalise interface engineering.

Reporting

Various reports would be generated in regard to the physical and financial progress of the project on monthly, quarterly and yearly basis for forwarding to the various government departments, financial institutions as well as for internal use. The reports would be prepared manually and/or in computerised forms as necessary.

Daily progress of the major items of work and hold-ups if any, along with their monthly targets, would be reported to the project head.

Quality Control

Quality assurance in construction work constitute inspection of raw materials adherence to appropriate construction technology, stage-wise inspection of erected items, testing, analysis of test results and suggesting adequate measures to conform to the respective codes and standards. Record keeping of the quality system adhered and regular monitoring of the same would be done to ensure long life of the plant. To carry out both destructive and non-destructive testing, the Project Authority and/or Contractor would arrange for necessary testing equipment at site. Suitable storage facilities would also be arranged at the project site to ensure undesired deterioration of raw materials at site.

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Financial Control

Actual cost records would be regularly monitored against forecasts, which would be forwarded to Finance Department by the Projects Department on monthly, half-yearly and yearly basis, depending on the actual

progress of delivery and erection/construction. Fund requirements would be assessed and arranged accordingly.

14.5 ROLE OF CONSULTANT

The Project Authority has already engaged the services of Development Consultants Pvt. Ltd., Kolkata to provide technical support as Owner's engineers from inception stage of the project. The Owner's engineers will prepare the bid document, review the tenders and participate in tender negotiation. They will also review Contractor's design and drawings, monitor Contractor's work at site and finally participate during guarantee tests. The team will comprise engineers from various disciplines viz. civil, mechanical, electrical, instrumentation, planning etc. to fulfil the above functional requirements.

14.6 PROJECT IMPLEMENTATION SCHEDULE

The project schedule given in **Drawing No.K8B09-014-DWG-DPR-001** has been developed with the following considerations :-

a. Zero date has been taken as the day of placement of order to the EPC Contractor for the Main Plant (MP) package.

b. The land required for Main Plant and auxiliary systems for this units 3 & 4 was procured during the first phase of construction of units- 1 & 2. And now 80.97 ha land is to be acquired for disposal of fly ash during exigencies. For expansion of colony 19.4 Ha land shall be procured.

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c. Land development is almost complete and minor cutting and filling may be carried out if felt necessary.

d. Providing the required construction facilities will be the next major activity requiring earnest attention for smooth execution of the project. The construction water and construction power would be available after four (4) months from the zero date.

e. The existing roads could be utilised for entry to the stage-II site with some extension and addition of diversion roads.

f. For Main Plant (MP) package, the time period between issue of tender notice and issue of purchase order has generally been taken as four(4) months, giving a minimum period of one(1) month for each of the activities :

   i) Tendering time
   ii) Evaluation of bids including obtaining clarifications from tenderers.
   iii) Negotiations with tenderers and placement of order.

g. The foundation work for the boiler and power station building is scheduled to start seven (7) months after the project 'Zero Date' and would be completed in time to suit the erection schedule.

h. All technical particulars necessary for design of miscellaneous equipments and piping would be available three (3) months after issue of NTP to Main Plant package contractor.

i. The erection of the first boiler can starts from 12 months after NTP and the erection can be completed and boiler light up done by the end of 40^{th} month from NTP.

j. The erection of the first turbo-generator can start from (+) 25th month from NTP and that erection can be completed by the end of

(+)48th month.

k. Time envisaged between boiler light up and turbine synchronisation is eight (8) months.

l. As presently assessed Commercial Operation Date of both unit 3 & 4 are expected to be 31st January 2019.

m. It has also been assumed that the manufacture and delivery schedule of all other systems can be made to suit the erection and commissioning time for the turbine.

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SECTION–14

PROJECT IMPLEMENTATION AND MONITORING

14.1 IMPLEMENTATION

M/s. Odisha Power Generation Corporation Limited would implement the 2 x 660 MW units 3 & 4 on EPC concept through two number packages viz. Main Plant (MP) package and Balance of Plant (BOP) package which includes all equipment/systems inside the plant boundary. For each system and packages the battery limits shall be well defined to avoid any mismatch during execution.

Successful implementation of a project calls for joint participation of the Owner, the Consultant and the Contractor. The Owner plays the most important role in spelling out the objectives, setting out the priorities and time schedules, ensures timely flow of funds and constantly monitor to settle the bottlenecks. Depending on the in-house capability, the Owner may also undertake other responsibilities like monitoring and expediting the project. The Owner has already engaged Development Consultants Pvt. Ltd., Kolkata to advise and assist in the design, engineering and procurement of equipment and services required for the project. The Vendors and Contractors in turn, render the services required for them as per the intent and spirit of the specifications furnished by the Owner. The technical / engineering Consultant may prepare the specification to meet the Owner's objectives.

14.2 PROJECT ORGAINSATION OF THE OWNER

The units 3 & 4 is to be implemented under the overall direction of the General Manager and, in this assignment, he will be assisted by senior executives of different disciplines and the Planning & Projects Department.

The Planning and Projects Department, assisted by other technical and commercial departments and supported by the Consultants, would be responsible for the project from its inception till all relevant clearances are obtained, financial packages are tied up and other preliminary work are completed. The Planning and Projects Department assisted by the Consultants will, thereafter, take-up the implementation of the project. They will be involved in various activities of the preliminary stage so that the changeover from the preliminary to the implementation stage becomes smooth. This department will be assisted by a senior executive who would be supported by a team of experienced engineers from various disciplines, such as, Civil, Mechanical, Electrical and Instrumentation.

In specialised areas, the Planning & Projects Department would also be assisted by the Estate, Legal, Industrial Relations, Security, Purchase and Finance Departments of the Owner in the process of execution of the project. Their roles, in brief, would be as follows.

The Estate Department would take-up the work of acquisition of land and resettlement of affected population in close coordination with the local bodies and Government Departments. All legal matters arising out of land disputes, etc. would be tackled by the Legal Department. Industrial Relations Department would assist in achieving good public relation and peaceful labour situation, which, in turn, will facilitate speedy implementation of the project. A senior official of the Purchase Department would be specially deputed for co-ordination of procurement of cement, steel, cables and miscellaneous standard items required for the project. Security Department's personnel would be deployed from the date of receipt of the building materials at site.

Besides, engineers in Testing and Operation & Maintenance Departments would be recruited at the appropriate time during construction and pre commissioning stages of various plants and equipments.

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14.3 PROJECT EXECUTION

The principal objective of the project execution team, to be formed by the Project Authority, is to liaise with the Contractor to ensure the design, procurement, construction and commissioning the power station within the scheduled time ensuring high availability of the generation equipments. These are broadly classified as under.

Basic Design & Planning

The basic design parameters firmed-up in the project report stage along with their implications on the cost of the project and the implementation schedule would form the basic guideline. The component systems and sub-systems of the power plant would be reviewed for compatibility with one another and conformity with environmental regulations.

Engineering & Procurement

The entire plant would be procured by EPC concept through two number of packages - Main Plant (MP) package and Balance of Plant (BOP) package. This will minimise the problem of coordination among the contractors in terms of interfacing between various systems/sub-systems. Procurement specifications for each package would be prepared by the Consultant and these would be finalised after review by the Projects Department.

Construction & Erection

The Contractor would be entrusted with the design, engineering, manufacture, supply, erection, testing and commissioning for the Main Plant package and Balance of Plant package.

Under the contract agreement, the Contractor would be bound to complete delivery and/or erection within the schedule. All corrective actions would be taken to keep the target as scheduled. Progress of activities by the Contractor, their resources and ability to adhere to the quality control would be supervised continuously. Arrangements would also be made for timely delivery of site drawings and working manuals from the Contractor.

To ensure quality control, teams of engineers in respective disciplines either of the project authorities or of the consultants would be deployed. Necessary help and service would be rendered to the Contractor for mobilisation before commencing erection/construction.

Necessary wired and wireless communication systems would be provided at site for internal and external use. The facilities would be extended to the Contractor at their site office also.

Testing & Commissioning

Testing & Commissioning group including Operation & Maintenance personnel would be deputed for pre-commissioning checks and final commissioning of various plants and equipments. Also commissioning network and procedure would be prepared jointly with all concerned, which would guide the team for execution of commissioning activities. Proper documentation of the commissioning activities would be made for safety and orderly commissioning of the plant.

14.4 PROJECT MONITORING, CO-ORDINATION & CONTROL

Project Monitoring Information System

Progress of each activity at every stage would be physically monitored by respective supervising engineers.

All detailed information would be passed on to the Central Monitoring Cell

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to keep track of the work progress. Similarly, costing of individual items would be monitored and recorded preferably with the help of computer and software.

Central Monitoring Cell would monitor the progress and report to the senior executives for information and necessary action.

Co-ordination

Regular meetings would be held at site among the representatives of the Contractor, the Consultant and the Engineers of Projects Department to review the progress of each activity. In these meetings, slippages in progress would be identified and corrective measures taken. The problems arising out of site and material constraints would be promptly sorted out. The meetings would also be attended to by one of the senior executives of the company to facilitate on-the-spot decisions. Minutes of meetings would be circulated among all concerned for necessary follow-up action.

Coordination meetings between the Consultants and the senior executives of the Owner would be held regularly for major decisions in regard to planning, designing of various plants and equipments, execution procedures, manpower deputations, industrial relations, security, etc. Steps would be taken to ensure regular interactions between the

contractors, vendors, the Consultant and Projects Department to finalise interface engineering.

Reporting

Various reports would be generated in regard to the physical and financial progress of the project on monthly, quarterly and yearly basis for forwarding to the various government departments, financial institutions as well as for internal use. The reports would be prepared manually and/or in computerised forms as necessary.

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Daily progress of the major items of work and hold-ups if any, along with their monthly targets, would be reported to the project head.

Quality Control

Quality assurance in construction work constitute inspection of raw materials adherence to appropriate construction technology, stage-wise inspection of erected items, testing, analysis of test results and suggesting adequate measures to conform to the respective codes and standards. Record keeping of the quality system adhered and regular monitoring of the same would be done to ensure long life of the plant. To carry out both destructive and non-destructive testing, the Project Authority and/or Contractor would arrange for necessary testing equipment at site. Suitable storage facilities would also be arranged at the project site to ensure undesired deterioration of raw materials at site.

Financial Control

Actual cost records would be regularly monitored against forecasts, which would be forwarded to Finance Department by the Projects Department on monthly, half-yearly and yearly basis, depending on the actual

progress of delivery and erection/construction. Fund requirements would be assessed and arranged accordingly.

14.5 ROLE OF CONSULTANT

The Project Authority has already engaged the services of Development Consultants Pvt. Ltd., Kolkata to provide technical support as Owner's engineers from inception stage of the project. The Owner's engineers will prepare the bid document, review the tenders and participate in tender negotiation. They will also review Contractor's design and drawings, monitor Contractor's work at site and finally participate during guarantee tests. The team will comprise engineers from various disciplines viz. civil, mechanical, electrical, instrumentation, planning etc. to fulfil the above functional requirements.

14.6 PROJECT IMPLEMENTATION SCHEDULE

The project schedule given in **Annexure-14.1** has been developed with the following considerations :-

a. Zero date has been taken as the day of placement of order to the EPC Contractor for the Main Plant (MP) package.

b. The land required for Main Plant and auxiliary systems for this units 3 & 4 was procured during the first phase of construction of units- 1 & 2. And now 80.97 ha land is to be acquired for disposal of fly ash during exigencies. For expansion of colony 19.4 Ha land shall be procured.

c. Land development is almost complete and minor cutting and filling may be carried out if felt necessary.

d. Providing the required construction facilities will be the next major activity requiring earnest attention for smooth execution of the project. The construction water and construction power would be available after four (4) months from the zero date.

e. The existing roads could be utilised for entry to the stage-II site with some extension and addition of diversion roads.

f. For Main Plant (MP) package, the time period between issue of tender notice and issue of purchase order has generally been taken as four(4) months, giving a minimum period of one(1) month for each of the activities :

   i) Tendering time

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ii) Evaluation of bids including obtaining clarifications from tenderers.

iii) Negotiations with tenderers and placement of order.

g. The foundation work for the boiler and power station building is scheduled to start seven (7) months after the project 'Zero Date' and would be completed in time to suit the erection schedule.

h. All technical particulars necessary for design of miscellaneous equipments and piping would be available three (3) months after issue of NTP to Main Plant package contractor.

i. The erection of the first boiler can starts from 12 months after NTP and the erection can be completed and boiler light up done by the end of 46^{th} month from NTP.

j. The erection of the first turbo-generator can start from (+) 25th month from NTP and that erection can be completed by the end of $(+)46^{th}$ month.

k. Time envisaged between boiler light up and turbine synchronisation is eight (8) months.

l. The first unit (unit-3) is thus expected to be put into commercial operation by fifty four (54) months from 'Zero Date'.

m. It has also been assumed that the manufacture and delivery schedule of all other systems can be made to suit the erection and commissioning time for the turbine.

n. The commercial operation of the second unit (unit-4) will be by fifty six (56) months from 'Zero Date'.

Annexure-14.1

Progress Report Proforma

Name of the Project : IB Thermal Power Station
Unit No : 3 & 4
Capacity : 2 X 660 MW
Name of the Executing agency : M/s BHEL and M/s BGRE

IMPLEMENTATION STATUS					
Sl. No.	Packages/ Linked Project Milestones	Vendor/ Contracting Agency	Date of Award	Present Status	Date of Completion
1	Main Plant Package (BTG or EPC)	BHEL	26-Mar-14	Boiler 3: Boiler Drainable Hydro test completed on 26-Dec-17. Pressure part welding for Non-Drainable HT is in progress. Boiler 4: Drainable Hydro Test is completed on 30-Nov-17, Pressure part welding for Non-drainable **HT** is in progress. ESP 3 and ESP 4 Erection in progress. Turbine 3: TG Box up done. Unit#3 Auxiliary Equipment- Bunker ,APH, Duct, LP and HP piping,TDBFP, Fans-FD & PA , IPBD, Auxiliary Boiler and other major auxiliaries erection in progress ID Fans , Mills, 11,3.3 and 0.4 KV switchgear (11 KV and 0.4 KV board charged), Deareator, Condenser erection and MDBFP erection completed Turbine 4: IP and HP boxup done and LP erection in progress, Generator boxup done. Unit#4 Auxiliaries Equipment- Bunker ,APH, Duct, FD, PA, TDBFP, Condenser, LP & HP piping,Electrical panels erection in progress ID Fans , MDBFF, Deareator and Mills erection completed	Erection: Unit 3 : 26-Mar-18 Unit 4 : 26-May-18 Commissioning: Unit 3: 14-Sep-18 Unit 4: 24-Nov-18

2	Main Plant Civil & Structural Work	Civil - BGRE Structural – BHEL	26-Mar-14	Civil – All main PHB, Boiler, Bunker, and ESP foundation works completed Unit # 3 & 4. TG Deck # 3 & 4: Casting completed. Power House Building#3: Structural - Major structure erection and Floor casting completed. Unit # 4: Structural – Major structure erection and Floor casting completed, room Readiness in progress. FD and PA Fan Foundation, ESP CR unit# 4, ACW pump house 4, CPU Building, Pipe Rack in progress. ID Fan#3 and # 4 civil work completed. ESP control Room 3, Air compressor house & Auxiliary Boiler and Duct support foundation for Unit 3 Civil work completed	Erection: 31-Mar-18
3	FGD plant	-	-	Consultant finalized. Technology selection completed	-
4	Coal Handling Plant	BGRE	26-Mar-14	Civil works: Track Hopper, Stacker reclaimer rail foundation, Coal Stock Pile and TPs Foundation in BTG area in progress. MCC Room, ERH ,Crusher, Tunnel, TPs in BoP area civil work completed Structure Work: Structural erection work in progress at TPs & Galleries. Mechanical: Technological structure erection in progress. Stacker Reclaimer ,Crusher, Peddle Feeder, ERH erection, TP and Gallery in BOP area are completed Electrical: Major erection for MCC panel, Transformer, Battery erection completed at CHP MCC Building.MCC and transformer erection in progress at Track hopper MCC Building. Cable laying in progress.	Commissioning : 30-Sep-18

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5	Ash Handling Plant	BGRE	26-Mar-14	Civil work: Surge Hopper, Silos, Ash Route pipe, Chemical House, Clarifier, Ash Compressor House, Pipe rack civil work in progress. Ash water & Ash Slurry Pump House civil works completed. Mechanical: Ash Slurry and water Pumps erection completed, HCSD and Surge hopper erection in progress Electrical: Panel erection completed at Ash water pump house MCC . Ash route piping from Ash handling plant to Ash pond in progress	Commissioning :: 30-Aug-18
6	Cooling Towers	BGRE	26-Mar-14	IDCT 3 - Major Civil, Mechanical and Electrical work completed IDCT 4 -Civil work completed, mechanical erection in progress.	Commissioning: 30-Apr-18
7	Chimney	BGRE	26-Mar-14	Shell concreting and Roof slab casting done Flue can erection for Unit 3 and Unit 4 is completed Other work like elevator, minishell, electrical work in	Erection: 30-May-18
8	PT Plant	BGRE	26-Mar-14	Civil :All civil work completed Mechanical: All mechanical work completed Commissioning: 1. Raw water Commissioning completed 2. PT Plant Testing and Commissioning in	Commissioning: 31-Jan-18
9	DM Plant	BGRE	26-Mar-14	DM Plant one stream commissioned.	Comm completed

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10	CW System	BGRE	26-Mar-14	Civil works: All civil work completed Mechanical Work: CW Chlorination work in progress CW structure, CW EOT, CW Pump, CW Pipe Completed.	Erection: CW Pump House: Completed, Chlorination - 28-Feb-18 Commissioning: 28-Feb-18
11	Switch Yard	BGRE	26-Mar-14	Unit#3 and Unit # 4: All civil, erection and testing work completed	Erect: completed Comm: Completed
12	Fire Protection System	BGRE	26-Mar-14	Pump House: Commissioning work completed. Fire hydrant and Spray pipe laying work in progress.	Commissioning FWPH-Completed
13	Air Conditioning & Ventilation	BGRE	26-Mar-14	HVAC work completed for Switchyard control room. Ventilation and Air conditioning works in progress at Power House Building #3. AC erection and commissioning is in progress at all fronts	Commissioning 30-Mar-18
14	Fuel Oil System	BGRE	26-Mar-14	Major civil and mechanical work completed for HFO system, pipe erection continue for LOO and HFO line on pipe rack. [illegible]	Commissioning: 30-Apr-18
15	Control & Instrumentation	BHEL	26-Mar-14	Material Receipt at site Instrumentation work completed at OM Plant OCS Charged for Unit 3 and erection in progress for Unit 4. Instrumentation work in progress at all fronts	Commissioning 30-Mar-18
16	LT Switchgears	BHEL	26-Mar-14	Material delivered at site. LT Panel placement completed at Power house 3 & 4, Fire water, Fuel Oil,Ash water pump house, OM water Pump house, IOCT, Compressor House, Ash water pump house, CHP control room. Testing and Commissioning work in progress at all	Commissioning 28-Feb-18

17	HT Switchgears	BHEL	26-Mar-14	Material delivered at site. Erection work completed for Power House 3, IDCT, Fuel Oil, Fire water, Ash water pump house, Power house 4	Commissioning 15-Feb-18
18	Cables (Power / Control)	BHEL/BGRE	26-Mar-14	Cables supply completed Cable laying completed for switchyard, DM Water System and Fire water pump house. Cable laying in progress for all major drives in BTG and BOP areas	Erection: 30-Mar-18
19	Air Compressors	BHEL	26-Mar-14	Erection work completed	Erec-Completed Comm-28-Feb-18
20	Station Transformers	BHEL	26-Mar-14	All Material received 2 Nos station transformer erection and testing	Commissioning 30-Jan-18
21	LT Transformers	BHEL	26-Mar-14	Material delivered at site. Transformer erection in progress	Commissioning 28-Feb-18
22	Generator Transformers	BHEL	26-Mar-14	Unit # 3 : 3 Nos GT erection and testing completed Unit # 4: 4 Nos GT erection and testing completed	Commissioning: 15-May-18
23	Unit Transformers	BHEL	26-Mar-14	Material delivered at site. Erection in progress.	Commissioning: 31-Mar-18
24	Insulation	BHEL	26-Mar-14	Insulation receipt is in progress. Insulation erection started in ESP 3 and Boiler 3.	Erection 30-May-18
25	Bus Duct	BHEL	26-Mar-14	IPBD and SPBD erection work in progress	Erection : 28-Feb-18
26	DC Batteries & Chargers	BHEL	26-Mar-14	Material Received. Erection completed for Switchyard, DM Plant, Fuel oil, Fire water, CW system, Power House 3. DCS erection, PT plant for Unit 3 started. Erection in progress at all fronts	Commissioning : 30-Mar-18

COMMISSIONING STATUS - UNIT-3

Blr civil works start	Blr Erec -tion Start	Blr Drum Lifting	Blr Hyd. Test (Drainable)	TG civil work start	Condenser Erection Start	TG Erection Start	Blr. Hyd. Test (Non-Drainable)	Availability of start up power	Readiness of DM plant	Readiness of F.O system	Blr Light Up	TG Box Up	TG Oil Flushing	SBO	SVF	Synchro-nisation (on Oil)	FGD plant	Coal Firing	Full Load	COD
Original Schedule																				
20-Jun-14	21-Nov-14	NA	11-Sep-16	26-Mar-14	13-Nov-15	20-Jan-15	30-Mar-17	14-May-16	13-Jul-16	9-Jan-17	09-Apr-17	09-Apr-17	08-Jun-17	07-Jul-17	03-Aug-17	07-Aug-17	-	09-May-17	20-Aug-17	6-Sep-17
Actual/ Anticipated																				
26-Nov-14	20-Jan-15	NA	26-Dec-17	26-Mar-14	30-Mar-16	30-Jul-15	15-mar-18	10-Jan-18	13-Sep-17	30-Apr-18	1-Apr-18	5-Sep-17	7-Mar-18	28-May-18	30-Jul-18	28-Jun-18	-	20-Jun-18	3-Aug-18	17-Sep-18

Critical Areas/Assistance Required:

Remarks:

SBO: Steam Blow Off

SVF : Safety valve floating

CF: Coal Firing

FL: Full Load

COD: Commercial Operation Declaration

ODISHA POWER GENERATION CORPORATION LTD.
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COMMISSIONING STATUS-UNIT-4

Blr civil works start	Blr Erection Start	Blr Drum Lifting	Blr Hyd. Test (Drainable)	TG civil work start	Condenser Erection Start	TG Erection Start	Blr. Hyd. Test (Non-Drainable)	Availability of start-up power	Readiness of DM plant	Readiness of F.O. system	Blr light Up	TG Box Up	TG Oil Flushing	SBO	SVF	Synchronisation (on Oil)	FGD Plant	Coal Firing	Full Load	COD
Original Schedule																				
25-Jul-14	21-Mar-15	NA	09-Jan-17	19-Jun-14	14-May-16	19-May-16	30-Jul-17	14-May-16	13-Jul-16	9-Jan-17	07-Aug-17	07-Aug-17	06-Oct-17	08-Nov-17	10-Dec-17	15-Dec-17	08-Sep-17		30-Dec-17	14-Jan-18
Actual/ Anticipated																				
26-Dec-14	29-May-15	NA	2-Dec-17	19-Jun-14	15-Sep-16	15-Jan-17	8-Apr-18	10-Jan-18	13-Sep-17	30-Apr-18	8-May-18	31-Jan-18	29-Apr-18	21-Jul-18	14-oct-18	9-Sep-18	-	31-Aug-18	15-Oct-18	29-Nov-18

Critical Areas/Assistance Required:

Remarks:

SBO: Steam Blow Off

SVF : Safety valve floating

CF: Coal Firing

FL: Full Load

COD: Commercial Operation Declaration

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

PROJECT CLEARANCES / OTHER INPUTS

1. Power Purchase Agreement: Signed with Gridco Ltd on 4th July 2011.
2. Power Evacuation System: Signed with PGCIL on 11th Sep 2013.
3. Coal Linkage/Fuel Supply Agreement (FSA): Coal will be sourced from Manoharpur & Dip Side Manoharpur allocated to OCPL, A JV Subsidiary Company of OPGC.
4. Boiler, TG & Generator Makes: M/s BHEL
5. Land Possession: Land is in possession of OPGC except 97acres of land for MGR work.
6. Water allocation: Agreement signed with water resource department on 26.08.2013
7. MOE & F clearance: EC for the project granted on 04.02.2010, ammended on 22.01.2014 and validity extended on 16.01.2015.
8. State Pollution Control Board Clearance: Consent to establish granted on 28.08.2010 and revalidation was done on 27.11.2015
9. Civil Aviation clearance: Clearance obtained from Airport Authority of India on 15.03.2010.
10. Financial Closure: Agreement signed with Power Finance Corporation Ltd and Rural Electrification Corporation Ltd on 23rd Nov 2012.
11. Zero Date: 26th March 2014
12. Original / Latest Estimated Project Cost (Rs in lakhs): 1196500 Lakhs.

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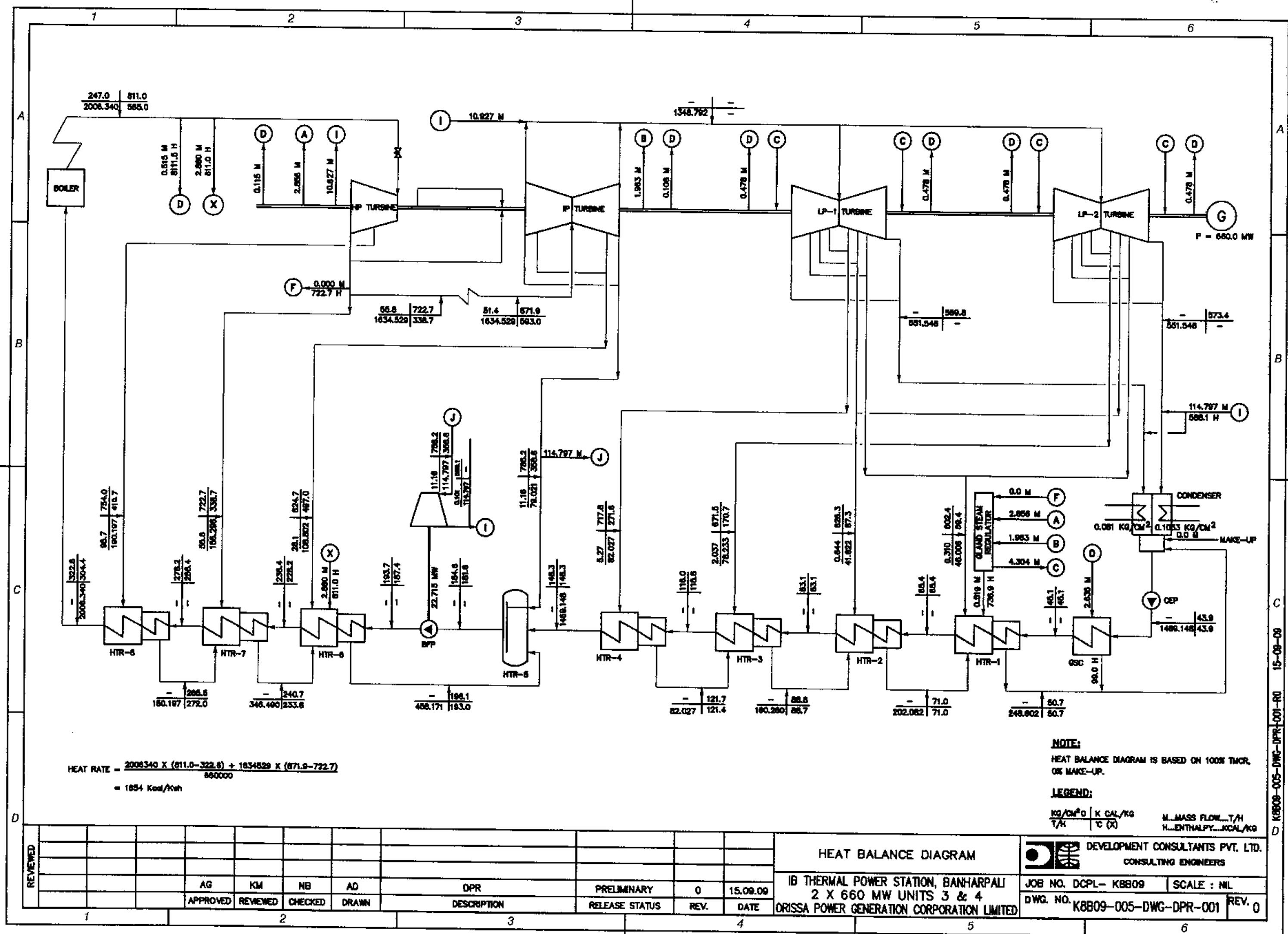
HEAT BALANCE DIAGRAM
IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS
JOB NO. DCPL- K8809
SCALE : NIL
DWG. NO. K8809-005-DWG-DPR-001
REV. 0
AG APPROVED
KM REVIEWED
NB CHECKED
AD DRAWN
DPR DESCRIPTION
PRELIMINARY RELEASE STATUS
0 REV.
15.09.09 DATE
REVIEWED
K8809-005-DWG-DPR-001-R0 15-09-09
NOTE:
HEAT BALANCE DIAGRAM IS BASED ON 100% TMCR, 0% MAKE-UP.
LEGEND:
KG/CM²G | K CAL/KG
T/H | °C (X)
M...MASS FLOW...T/H
H...ENTHALPY...KCAL/KG
HEAT RATE = 2008340 X (811.0-322.6) + 1634529 X (871.9-722.7) / 660000
= 1854 Kcal/Kwh
BOILER
HP TURBINE
IP TURBINE
LP-1 TURBINE
LP-2 TURBINE
P = 660.0 MW
CONDENSER
MAKE-UP
CEP
GSC
GLAND STEAM REGULATOR
BFP
22.715 MW
HTR-1
HTR-2
HTR-3
HTR-4
HTR-5
HTR-6
HTR-7
HTR-8
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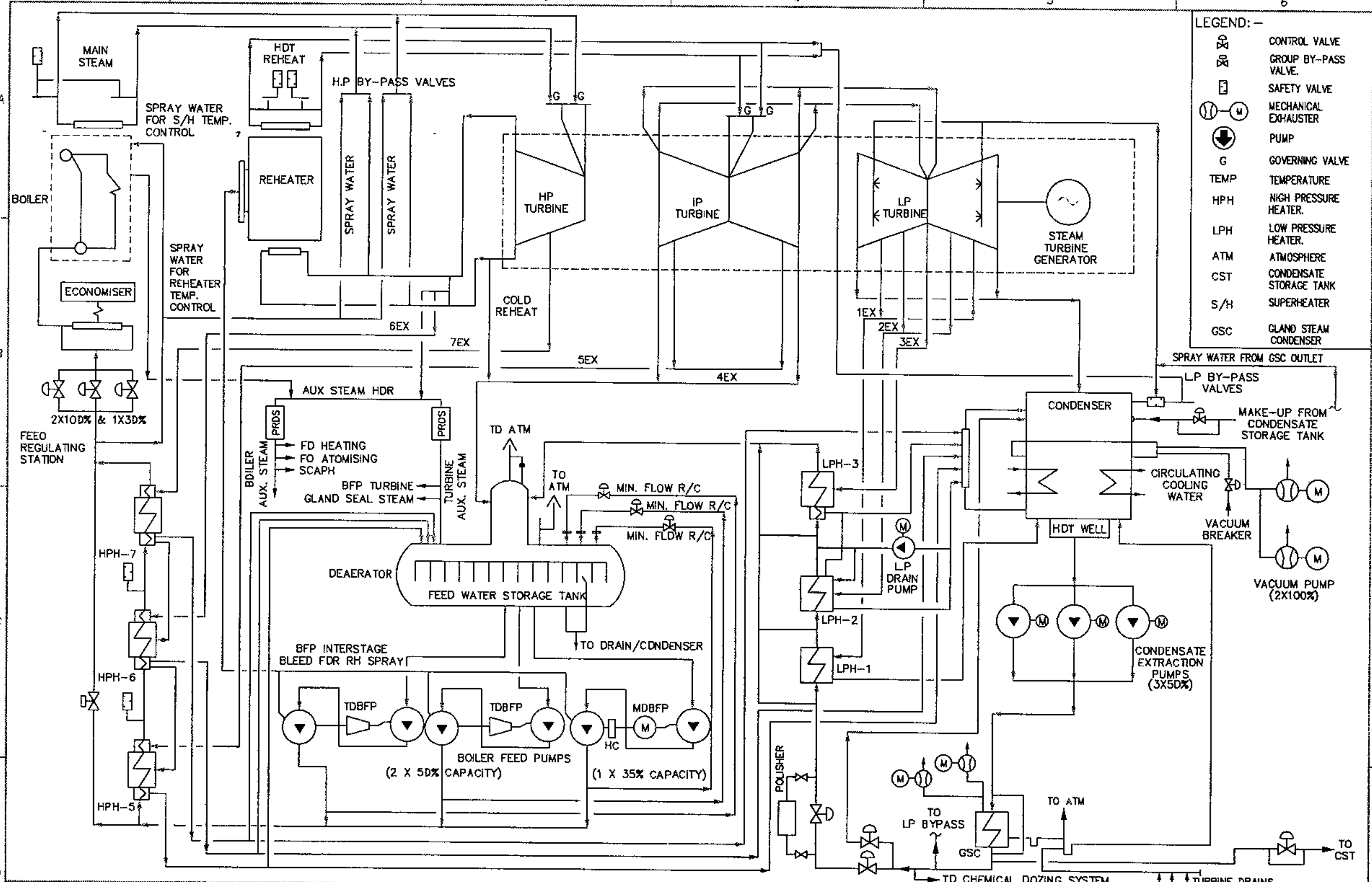


REVIEWED							
AG	KM	NB	AD	DPR	PRELIMINARY	D	15.09.09
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

SINGLE LINE DIAGRAM OF STEAM AND WATER SYSTEM

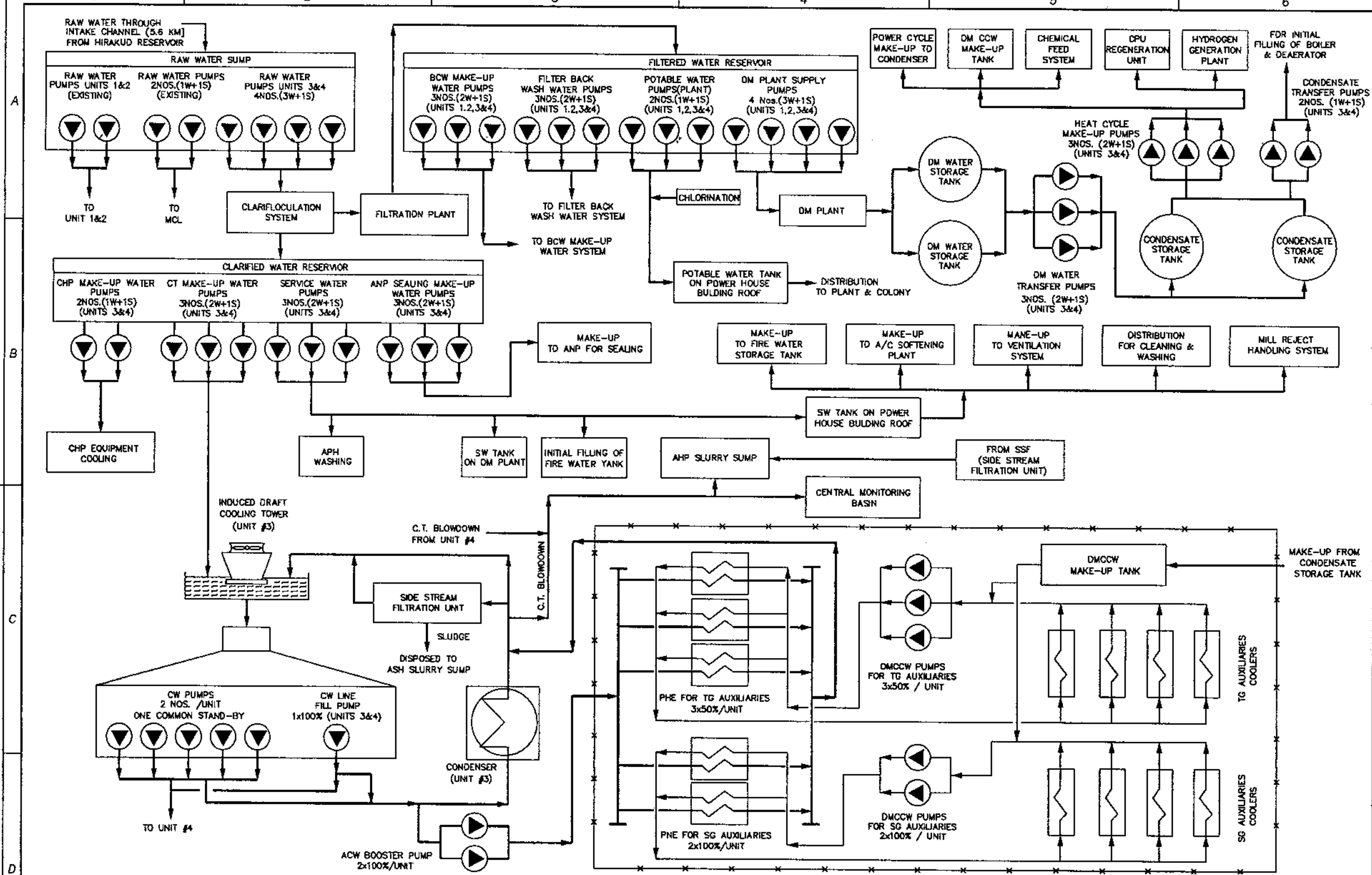
IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED

DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS

JOB NO.
SCALE :
DWG. NO. K8B09-005-DWG-DPR-002
REV. 0

K8B09-005-DWG-DPR-002-R0 15.09.09

A3 (9-96) [420x297]



REVIEWED								
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APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

SINGLE LINE DIAGRAM OF PLANT WATER SYSTEM

IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED

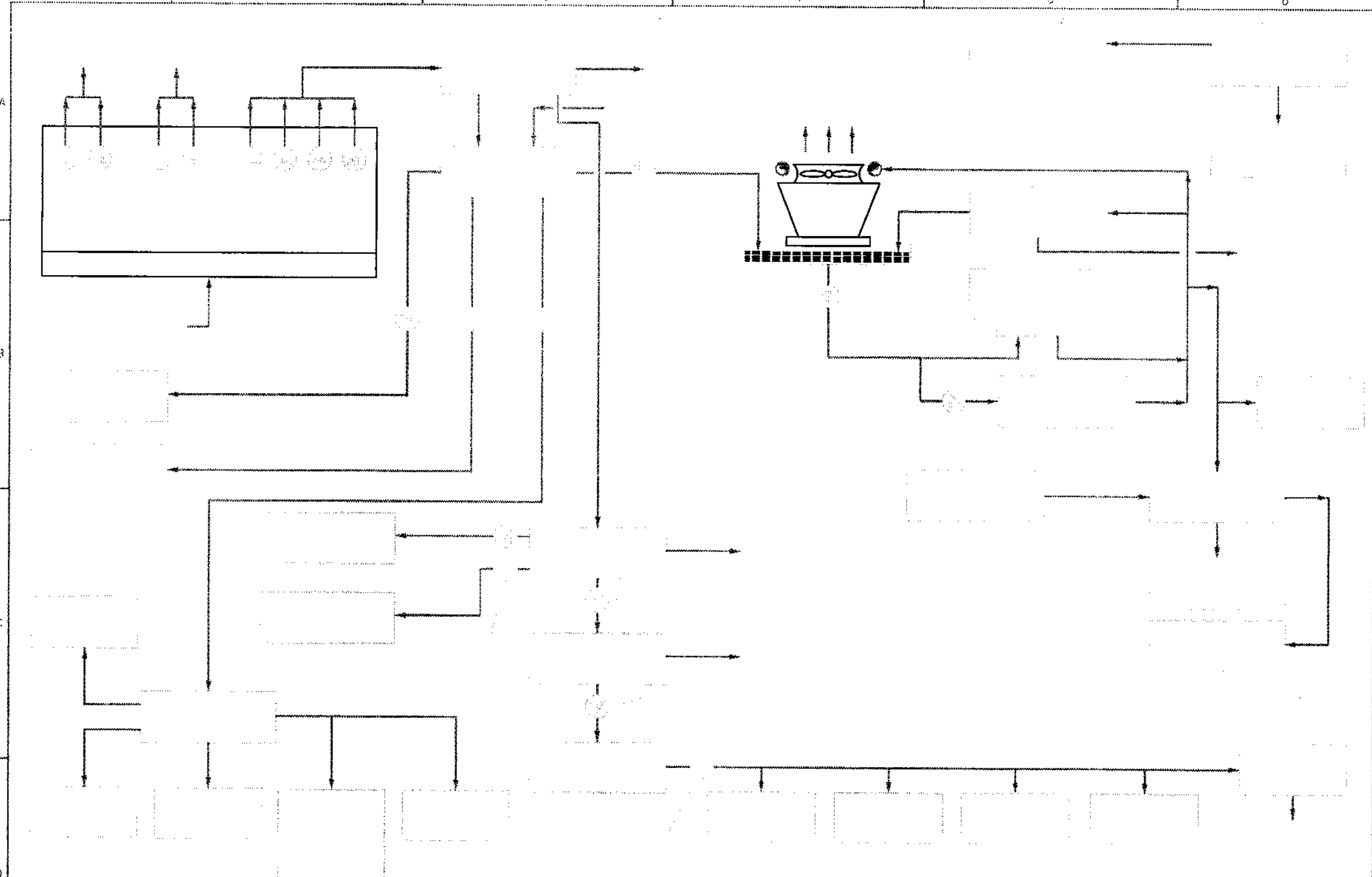
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS

JOB NO. DCPL- K8809 | SCALE : NIL

DWG. NO. K8809-006-DWG-DPR-001 | REV. 0

A3 (9-96) [420x297]

489



AG	KM	NB	PN	DPR	PRELIMINARY	0	02.09.09	
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE	REVIEWED

WATER BALANCE DIAGRAM

IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED

DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS

JOB NO.
SCALE :
DWG. NO. K8809-006-DWG-DPR-002
REV. 0

K8809-006-DWG-DPR-002-R0 02.09.09

A3 (9-98) [420x297]

490

ODISHA POWER GENERATION CORPORATION LTD. ★ BHUBANESWAR

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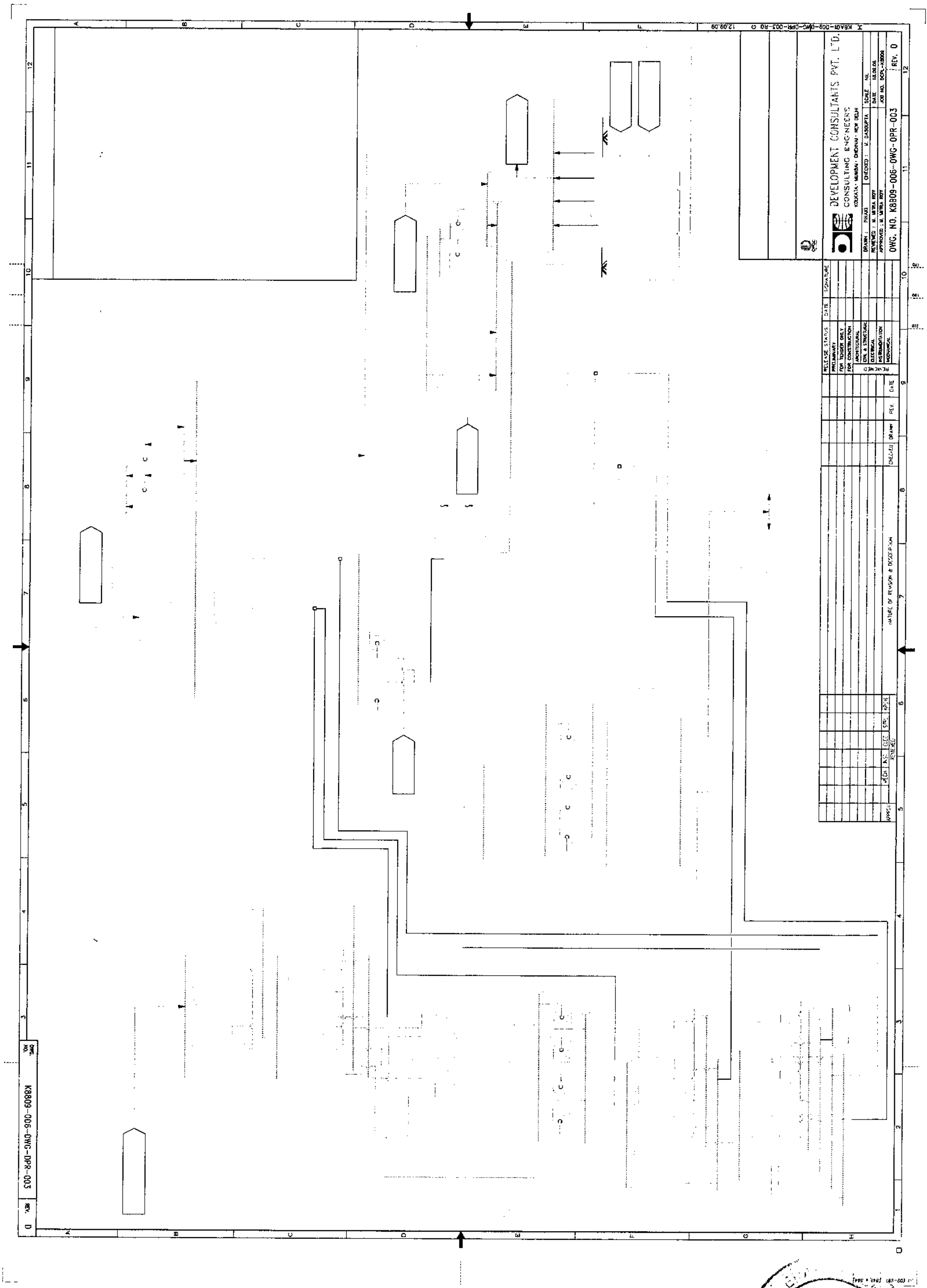
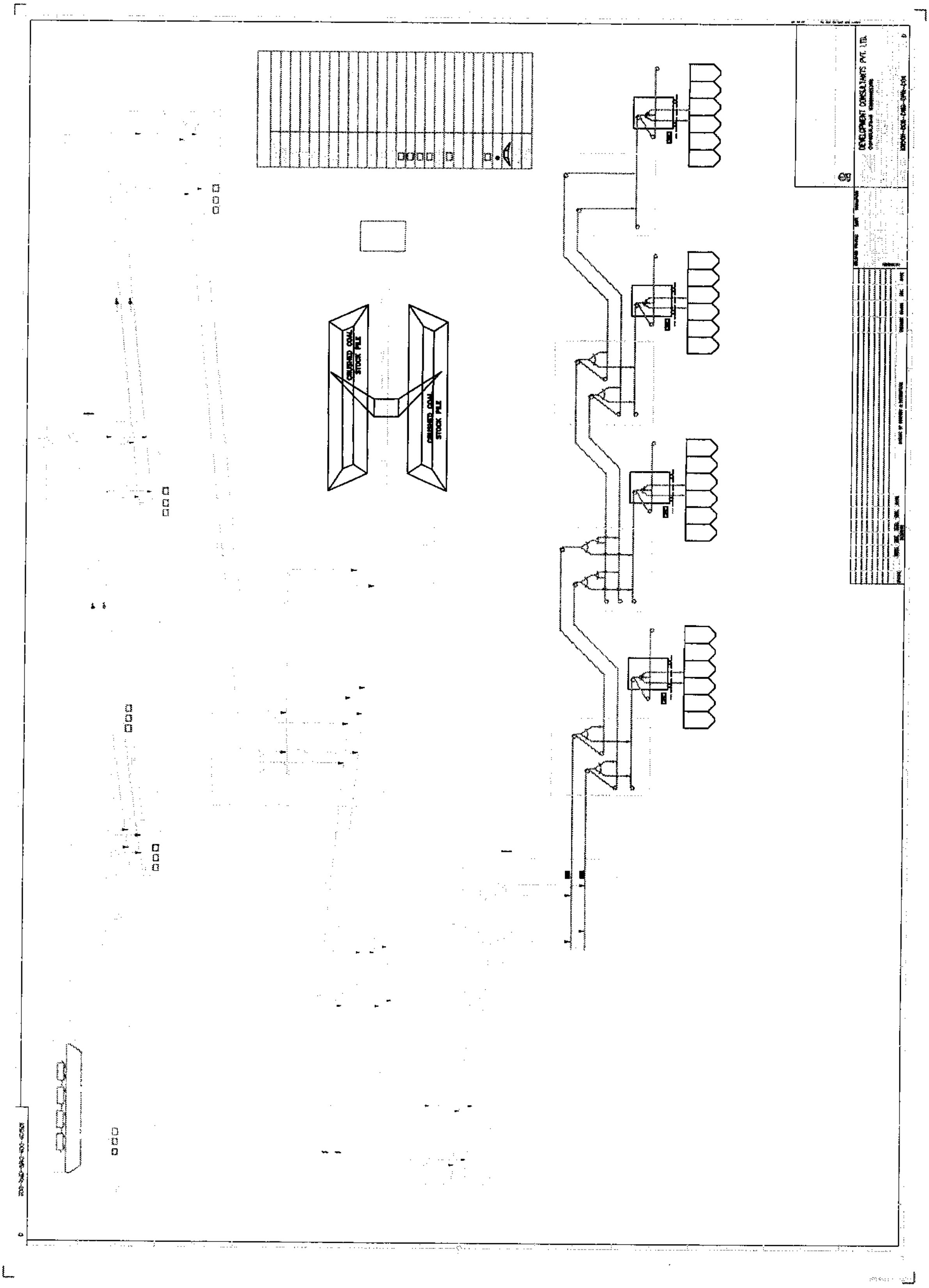
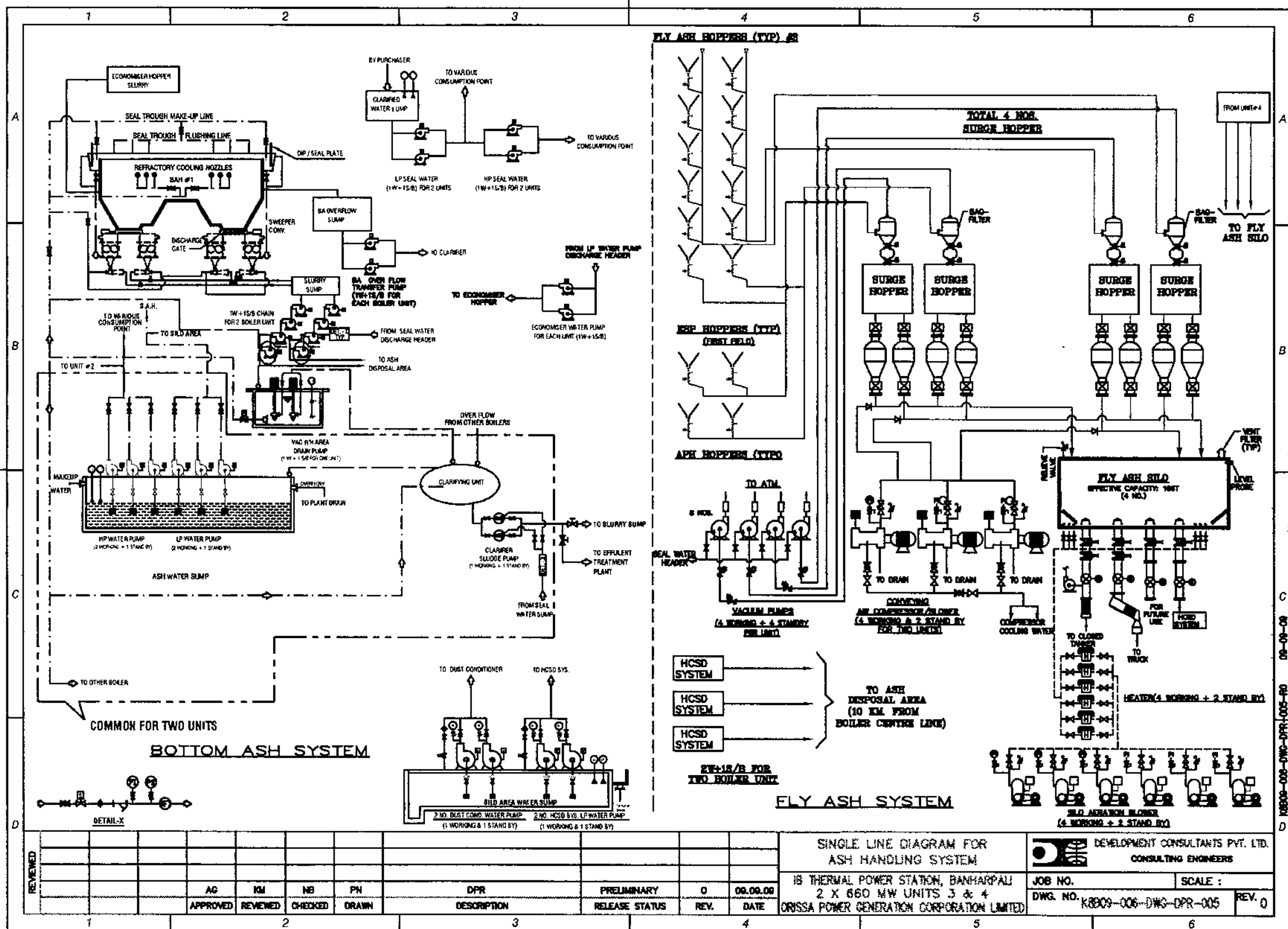
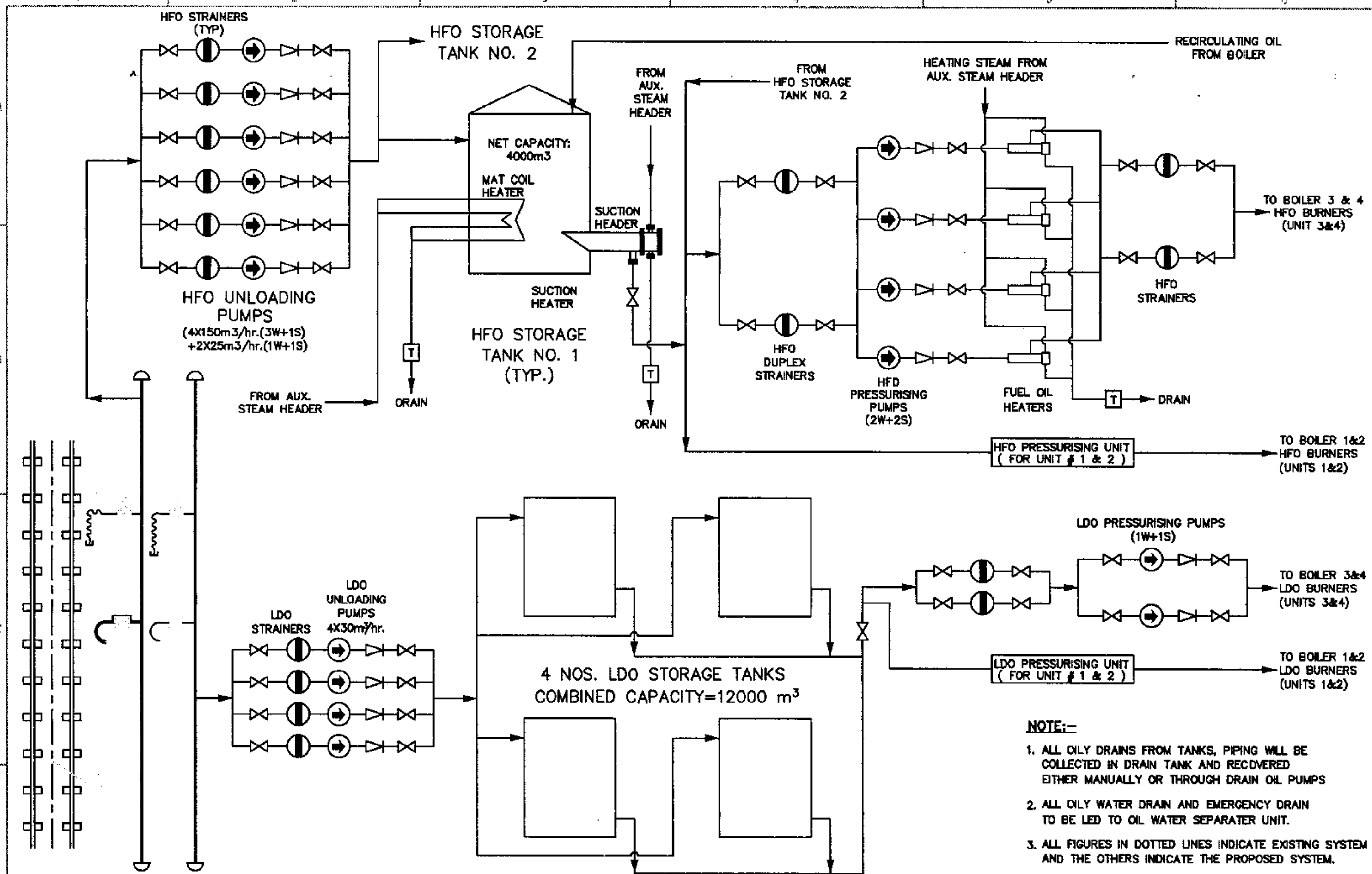

DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS
KOLKATA · MUMBAI · CHENNAI · NEW DELHI
DRAWN : PINAKI
CHECKED : M. DASGUPTA
SCALE NIL
REVIEWED : M. MITRA ROY
DATE 18.08.08
APPROVED : M. MITRA ROY
JOB NO. DCPL-K8809
DWG. NO. K8809-006-DWG-OPR-003
REV. 0
K8809-006-DWG-OPR-003
REV. 0

492


CRUSHED COAL STOCK PILE
CRUSHED COAL STOCK PILE
DEVELOPMENT CONSULTANTS PVT. LTD.


BOTTOM ASH SYSTEM
COMMON FOR TWO UNITS
ECONOMISER HOPPER SLURRY
SEAL TROUGH MAKE-UP LINE
SEAL TROUGH FLUSHING LINE
REFRACTORY COOLING NOZZLES
DIP / SEAL PLATE
SWEEPER CONV.
DISCHARGE GATE
BA OVERFLOW SUMP
TO CLARIFIER
SLURRY SUMP
LP SEAL WATER
HP SEAL WATER
TO VARIOUS CONSUMPTION POINT
TO ECONOMISER HOPPER
ECONOMISER WATER PUMP
FROM SEAL WATER DISCHARGE HEADER
TO ASH DISPOSAL AREA
TO SILO AREA
TO UNIT #2
OVER FLOW FROM OTHER BOILERS
CLARIFYING UNIT
CLARIFIER SLUDGE PUMP
TO SLURRY SUMP
TO EFFLUENT TREATMENT PLANT
FROM SEAL WATER SUMP
HP WATER PUMP
LP WATER PUMP
ASH WATER SUMP
TO PLANT DRAIN
TO OTHER BOILER
TO DUST CONDITIONER
TO HCSD SYS.
SILO AREA WATER SUMP
DETAIL-X
FLY ASH SYSTEM
FLY ASH HOPPERS (TYP) #8
ESP HOPPERS (TYP) (FIRST FIELD)
APH HOPPERS (TYP)
TOTAL 4 NOS. SURGE HOPPER
SURGE HOPPER
BAG-FILTER
FROM UNIT#4
TO FLY ASH SILO
VENT FILTER (TYP)
FLY ASH SILO
LEVEL PROBE
RELIEF VALVE
TO ATM.
SEAL WATER HEADER
VACUUM PUMPS (4 WORKING + 4 STANDBY PER UNIT)
CONVEYING AIR COMPRESSOR/BLOWER (4 WORKING & 2 STAND BY FOR TWO UNITS)
TO DRAIN
COMPRESSOR COOLING WATER
TO CLOSED TANKER
FOR FUTURE USE
HCSD SYSTEM
TO TRUCK
HEATER(4 WORKING + 2 STAND BY)
SILO AERATION BLOWER (4 WORKING + 2 STAND BY)
TO ASH DISPOSAL AREA (10 KM. FROM BOILER CENTRE LINE)
2W+1S/B FOR TWO BOILER UNIT
SINGLE LINE DIAGRAM FOR ASH HANDLING SYSTEM
IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS
JOB NO.
SCALE :
DWG. NO. K8809-006-DWG-DPR-005
REV. 0
AG
KM
NB
PN
APPROVED
REVIEWED
CHECKED
DRAWN
DPR
DESCRIPTION
PRELIMINARY
RELEASE STATUS
0
REV.
09.09.09
DATE
REVIEWED
A3 (8-96) [420x297]



NOTE:-

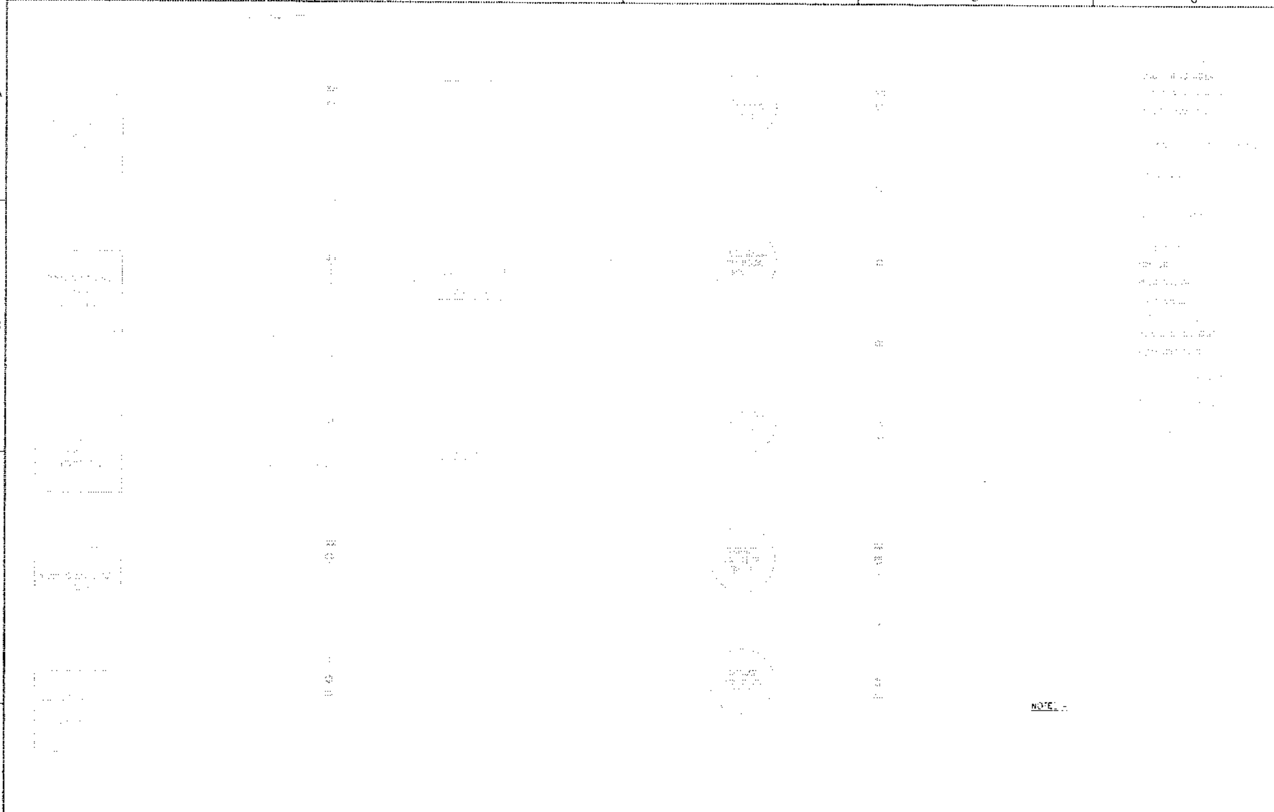
1. ALL OILY DRAINS FROM TANKS, PIPING WILL BE COLLECTED IN DRAIN TANK AND RECOVERED EITHER MANUALLY OR THROUGH DRAIN OIL PUMPS
2. ALL OILY WATER DRAIN AND EMERGENCY DRAIN TO BE LED TO OIL WATER SEPARATER UNIT.
3. ALL FIGURES IN DOTTED LINES INDICATE EXISTING SYSTEM AND THE OTHERS INDICATE THE PROPOSED SYSTEM.

REVIEWED	A.Ghosh	K.Mukherjee	M.Poddar	P.Nag	DPR	PRELIMINARY	0	09.09.09	SINGLE LINE DIAGRAM OF FUEL OIL SYSTEM IB THERMAL POWER STATION, BANHARPALI 2 X 660 MW UNITS 3 & 4 ORISSA POWER GENERATION CORPORATION LIMITED	DEVELOPMENT CONSULTANTS PVT. LTD. CONSULTING ENGINEERS JOB NO. SCALE : DWG. NO. K8B09-006-DWG-DPR-006 REV. 0
	APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE		

K8B09-006-DWG-DPR-006-R0 09.09.09

A3 (9-96) [420x297]

ODISHA POWER GENERATION CORPORATION BHUBANESWAR



A.Ghosh	K.Mukherjee	N.Biswas	P.Nag	DPR	PRELIMINARY	0	09.09.09	
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV	DATE	REVIEWED

SINGLE LINE DIAGRAM FOR COMPRESSED AIR SYSTEM (WITHIN COMPRESSOR HOUSE)

IB THERMAL POWER STATION, BANHARPALI
2 X 600 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED

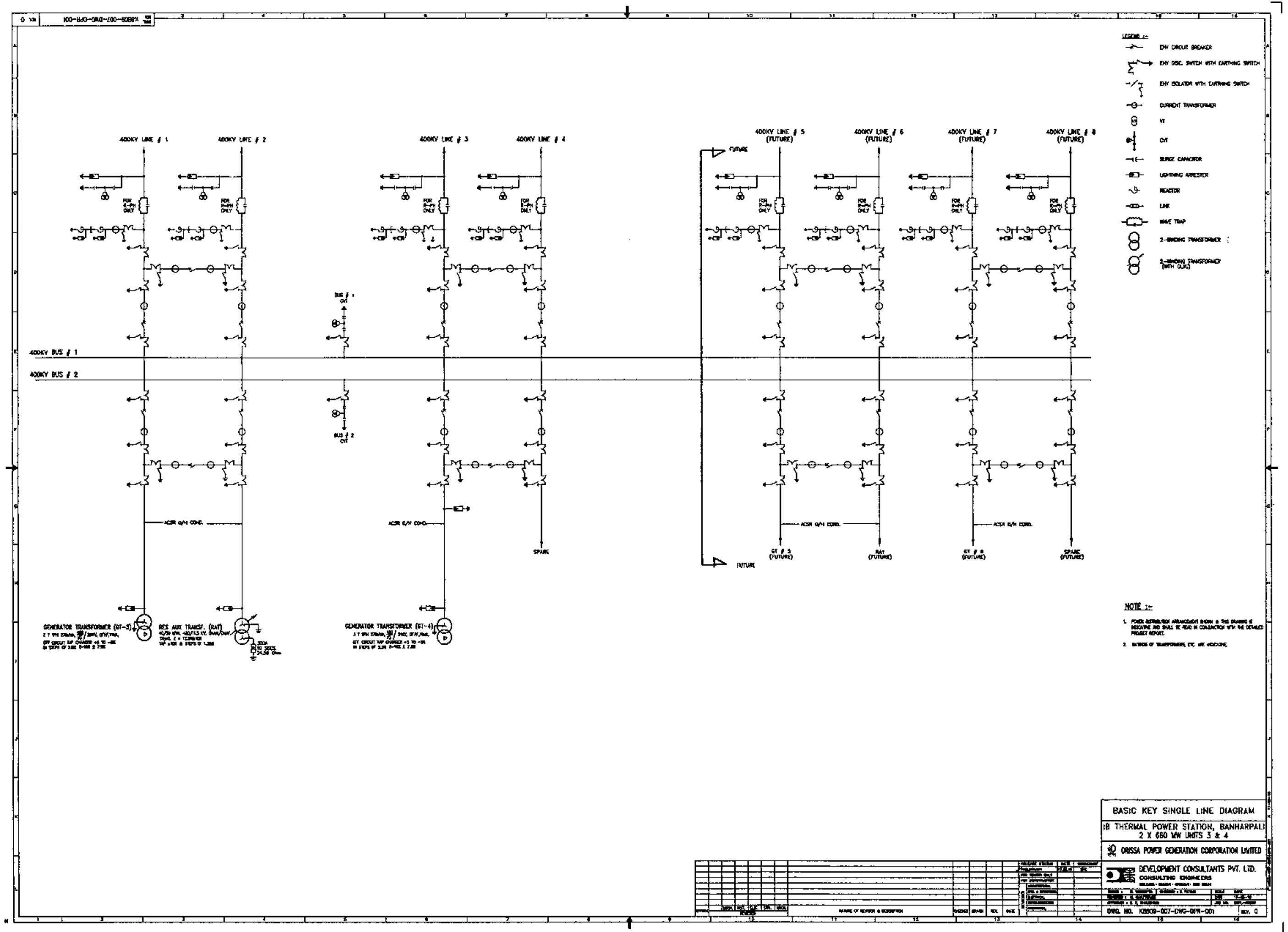
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS

JOB NO.
SCALE :
DWG. NO. K6B09-006-DWG-DPR-007
REV. 0

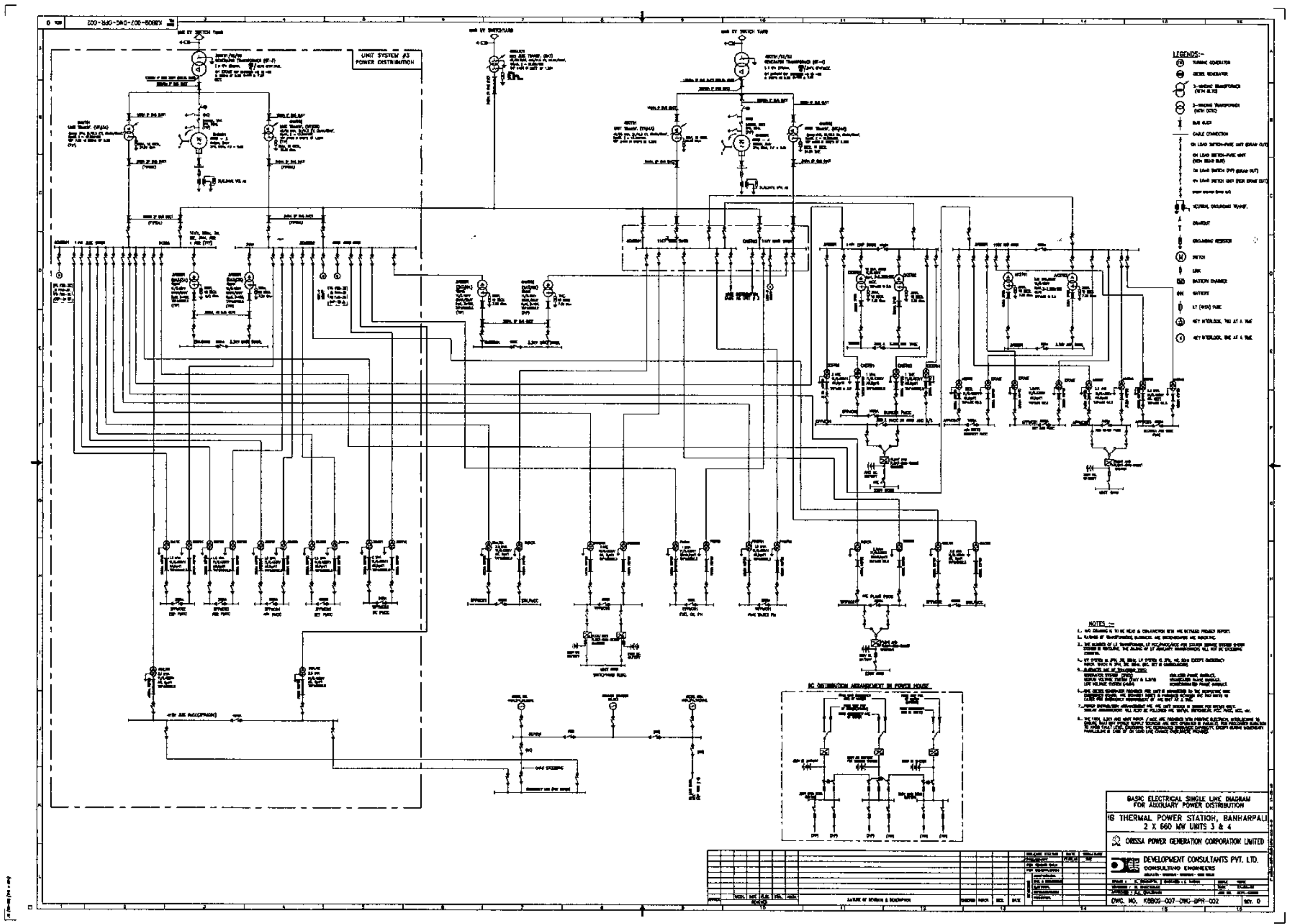
K6B09-006-DWG-DPR-007-R0 09.09.09

A3 (9-96) (420x297)

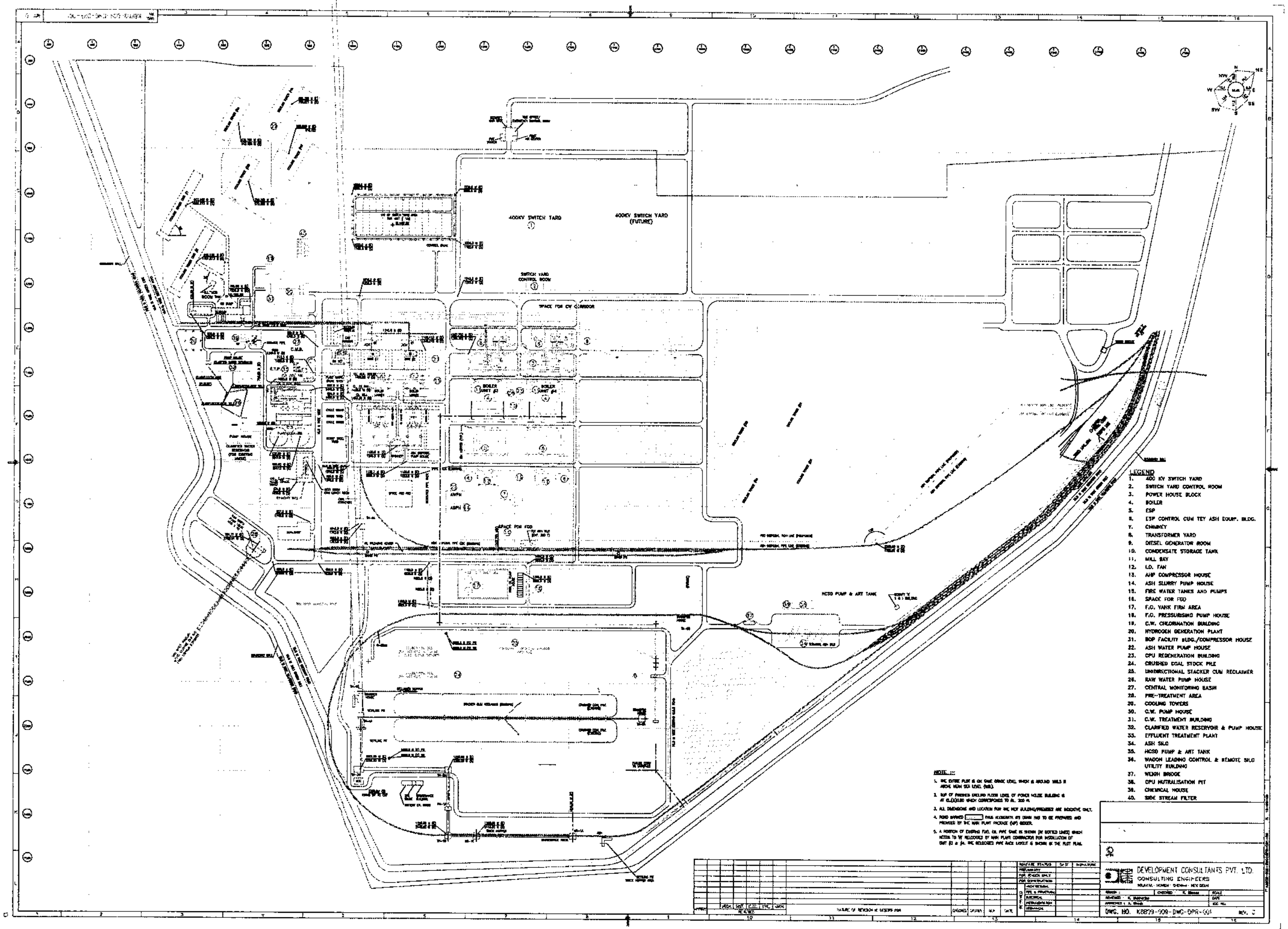
496



400KV LINE # 1
400KV LINE # 2
400KV LINE # 3
400KV LINE # 4
400KV LINE # 5 (FUTURE)
400KV LINE # 6 (FUTURE)
400KV LINE # 7 (FUTURE)
400KV LINE # 8 (FUTURE)
400KV BUS # 1
400KV BUS # 2
FUTURE
SPARE
LEGEND :-
EHV CIRCUIT BREAKER
EHV DISC. SWITCH WITH EARTHING SWITCH
EHV ISOLATOR WITH EARTHING SWITCH
CURRENT TRANSFORMER
VT
CVT
SURGE CAPACITOR
LIGHTNING ARRESTER
REACTOR
LINE
WAVE TRAP
2-WINDING TRANSFORMER
NOTE :-
BASIC KEY SINGLE LINE DIAGRAM
IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS
DWG. NO. K3909-007-DWG-OPN-001
REV. 0

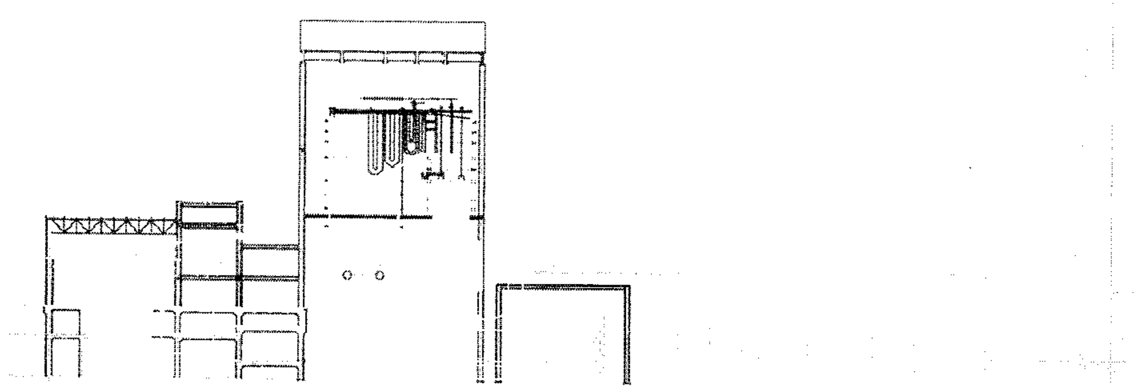

UNIT SYSTEM #3 POWER DISTRIBUTION
LEGENDS:-
NOTES :-
BASIC ELECTRICAL SINGLE LINE DIAGRAM
FOR AUXILIARY POWER DISTRIBUTION
IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED
DEVELOPMENT CONSULTANTS PVT. LTD.
CONSULTING ENGINEERS
DWG. NO. K6B09-007-DWG-BPR-002
REV. 0

4.97



498

GENERATION CORPORATION
BHUBANESWAR



REVIEWED									
	AG	KM	NB	AD	DPR	PRELIMINARY	0	15.09.09	
	APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE	

GENERAL CROS-SSECTION OF PLANT

IB THERMAL POWER STATION, BANHARPALI
2 X 660 MW UNITS 3 & 4
ORISSA POWER GENERATION CORPORATION LIMITED

DEVELOPMENT CONSULTANTS LTD
CONSULTING ENGINEERS

JOB NO.
SCALE :
DWG. NO. K8B09-009-DWG-DPR-002 REV. 0

K8B09-009-DWG-DPR-002-R0 15-09-09

A3 (9-96) [420x297]

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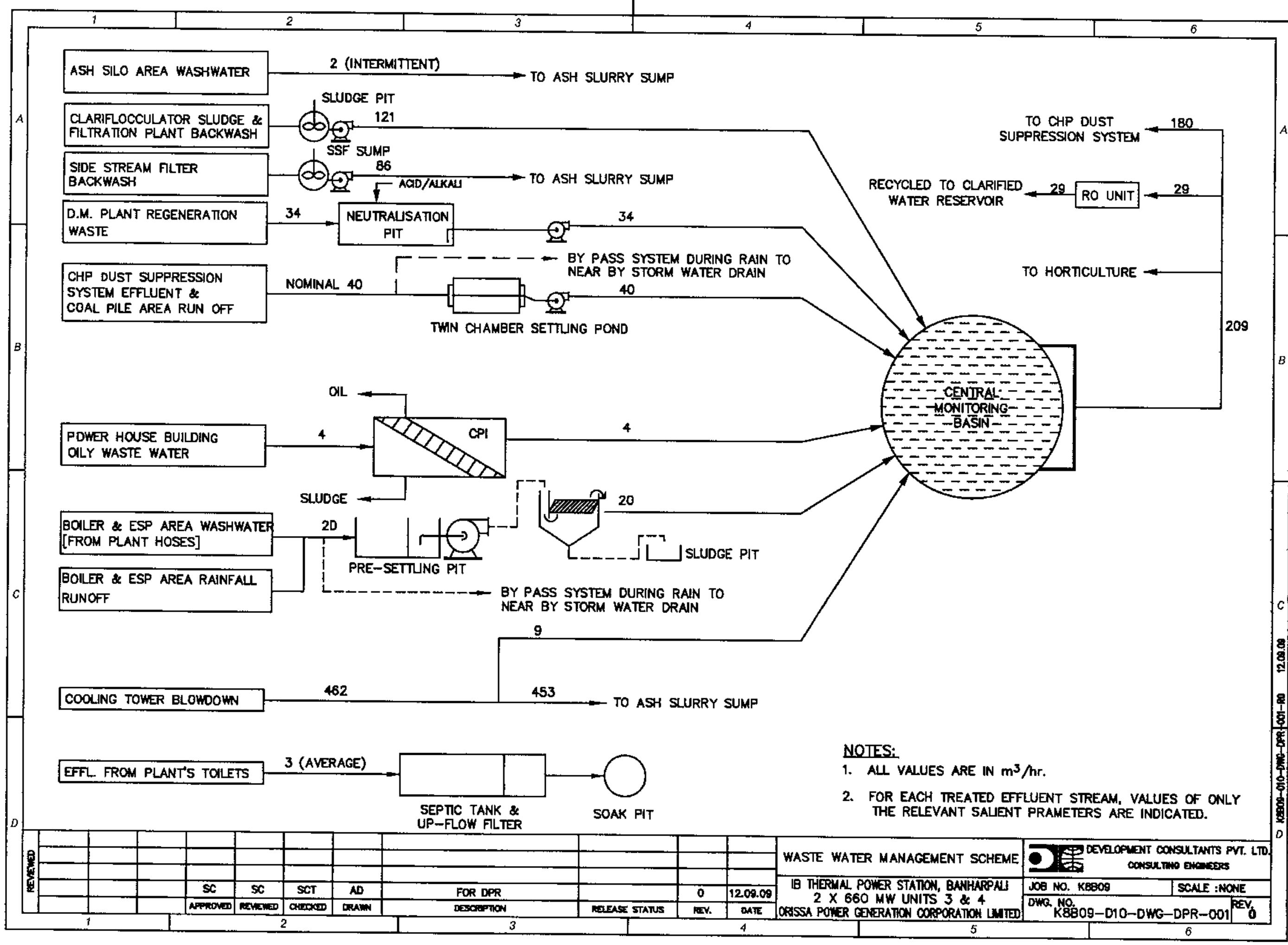
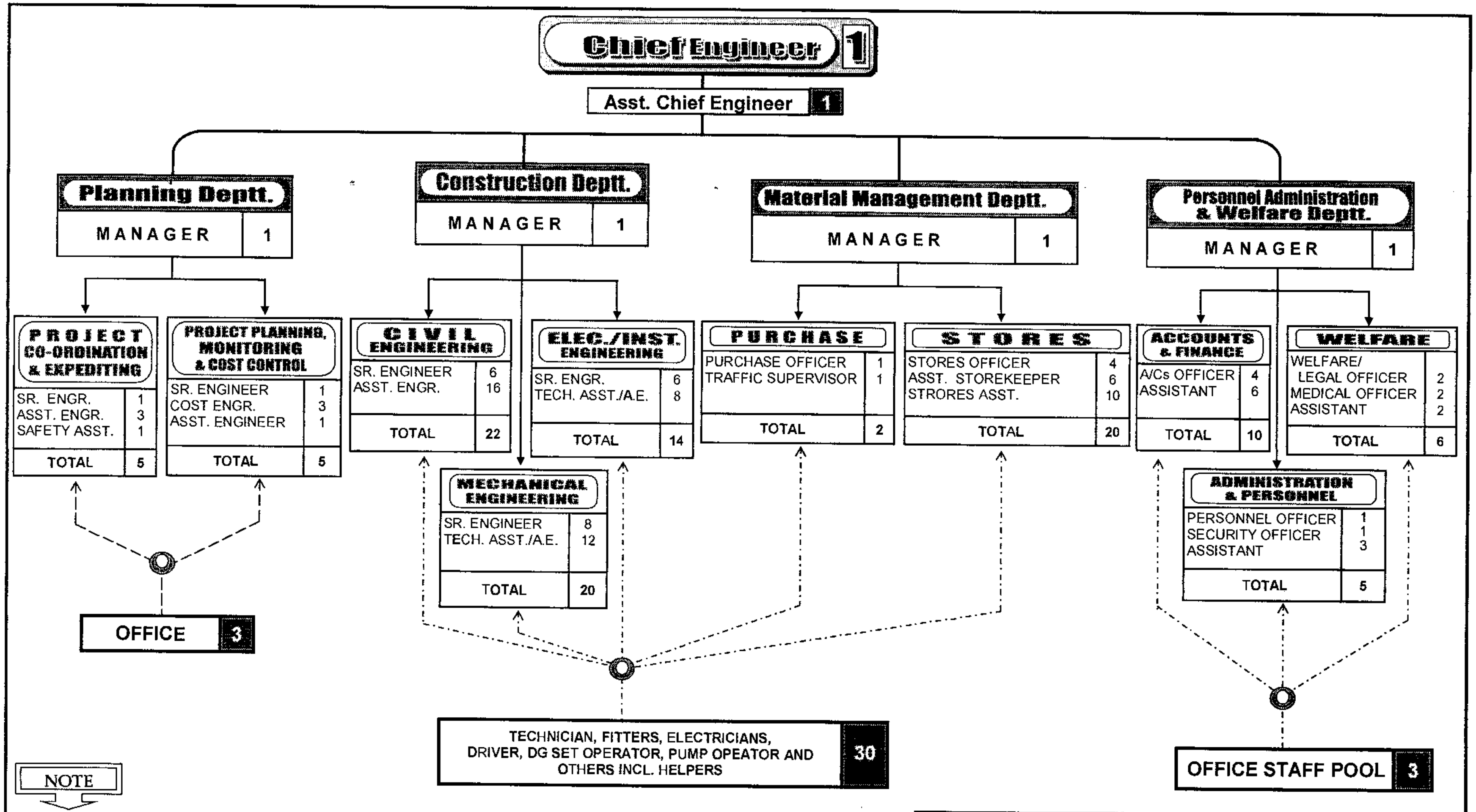


A3 (8-96) [420x297]



NOTE

1. Assuming project engineering and detailconstruction supervision to be done through Project Consultant.
2. Security, area cleaning, canteen, township maintenance, horticulture etc. would be contracted out.

REVISED	AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09
	APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

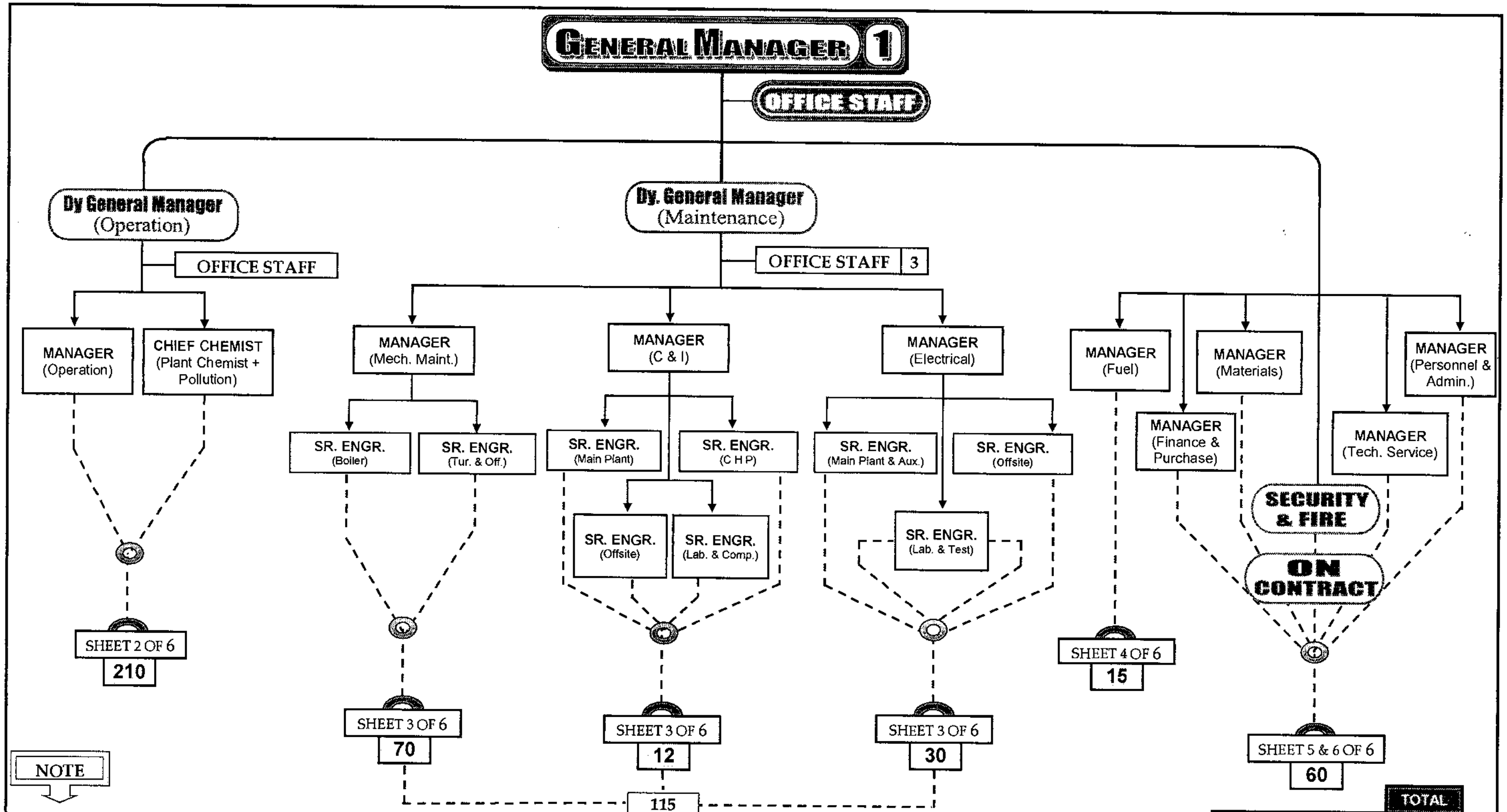
Organisation Chart
(Project Management Team)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LTD.

JOB NO.DCPL-K8B09 | SCALE : NIL

DWG. NO.K8B09-011-DWG-DPR-001 | REV. 0



NOTE

1. The additional staff requirement for overhauling, capital maintenance and special maintenance has not been considered. These are to be executed on contract basis.
2. Staff for Security & Fire Services are considered under contract.
3. The manpower under operation in the control room will be further reduced if modern state-of-the-art DCS based control and instrumentation is adopted.

REVISED	APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE
	AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09

Organisation Chart
(O & M)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LIMITED

JOB NO.DCPL-K8B09

SCALE : NIL

DWG. NO. K8B09-012-DWG-DPR-001
(Sheet 1 of 6)

REV. 0

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

502

OPERATION GROUP

DY. GENERAL MANAGER — No. 1

MANAGER (Operation) — No. 1

		No.
1.	Shirft Charge Engineer	7
2.	Unit/Controller/Control Room In-charge	16
3.	Desk Control Engineer incl. BOP Control Engineer	20
4.	Switchyard Control Engineer	12
5.	Switchyard Operator	12
6.	Boiler Local Operators	24
7.	Turbine Generator Local Operator	12
8.	Air Compressor, DG Set & A/C Plant Operators	12
9.	Fuel Oil Station Operators	7
10.	Ash Handling Plant & ESP Operators	20
11.	Ash Handling Plant & Boiler Area Helper/Khalasi	10
12.	Turbine Generator & other areas Helper/Khalasi	10
13.	Reserve Helper/Khalasi for mis. jobs	7
TOTAL		169

		No.
1.	Executive Assistant	1
2.	Computer Operator-cum-Steno Typist	1
3.	Peon	1
TOTAL		3

CHIEF CHEMIST (Lab + Pollution) — No. 1

		No.
1.	Chemist	1
2.	Asst. Chemist	3
3.	Laboratory Assistants	3
4.	Water Treatment Plant Operators	7
5.	Shift Chemist for Laboratory	7
6.	Shift Samplers	7
7.	Samplers	7
TOTAL		35

	TOTAL
OPERATION GROUP	210

NOTE

1. The additional staff requirement for overhauling, capital maintenance and special maintenance has not been considered. These are to be executed on contract basis.
2. Staff for Security & Fire Services are considered under contract.
3. The manpower under operation in the control room will be further reduced if modern state-of-the-art DCS based control and instrumentation is adopted.

REVISED							
AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

Organisation Chart (O & M)

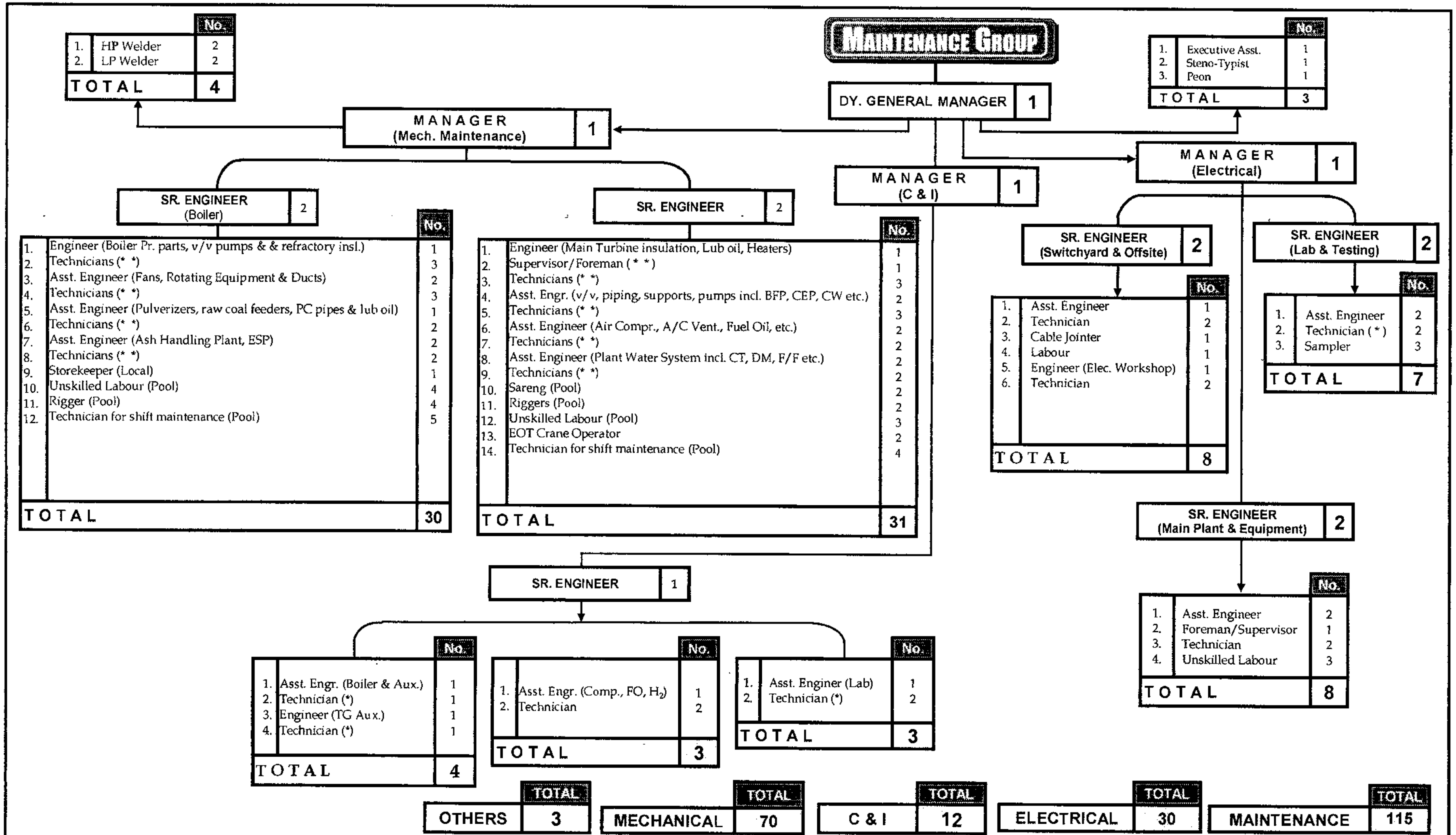
IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LIMITED

JOB NO.DCPL-K8B09 | SCALE : NIL

DWG. NO. K8B09-012-DWG-DPR-001 (Sheet 2 of 6) | REV. 0

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR



REVISED								
AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09	
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE	

Organisation Chart
(O & M)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LIMITED

JOB NO.DCPL-K8B09 | SCALE : NIL

DWG. NO. K8B09-012-DWG-DPR-001
(Sheet 3 of 6) | REV. 0

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

504

FUEL HANDLING GROUP

MANAGER (Fuel) — 1

		No.
1.	Fuel Movement Officer	2
2.	Asst. for Fuel Movement	2
TOTAL		4

SR. ENGINEER CHP (Operation & Maintenance) — 2

		No.
1.	Control Engineer/Desk Engineer	4
2.	Shift Technician	4
TOTAL		8

	TOTAL
CHP	15

AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

REVISED

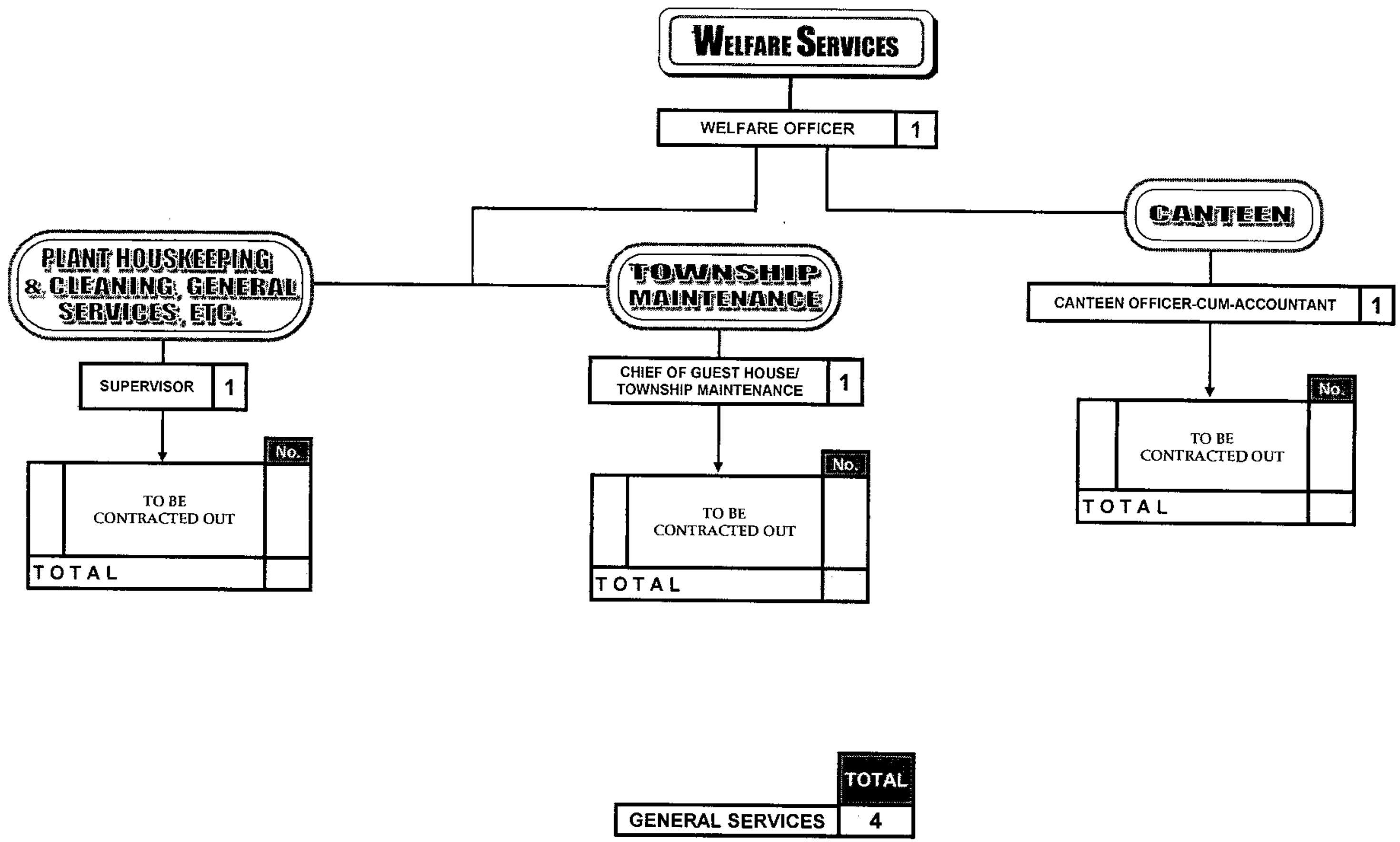
Organisation Chart
(O & M)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LIMITED

JOB NO.DCPL-K8B09	SCALE : NIL
DWG. NO. K8B09-012-DWG-DPR-001 (Sheet 4 of 6)	REV. 0

ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR



REVISED								
AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09	
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE	

Organisation Chart
(O & M)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LIMITED

JOB NO.DCPL-K8B09

SCALE : NIL

DWG. NO. K8B09-012-DWG-DPR-001
(Sheet 5 of 6)

REV. 0

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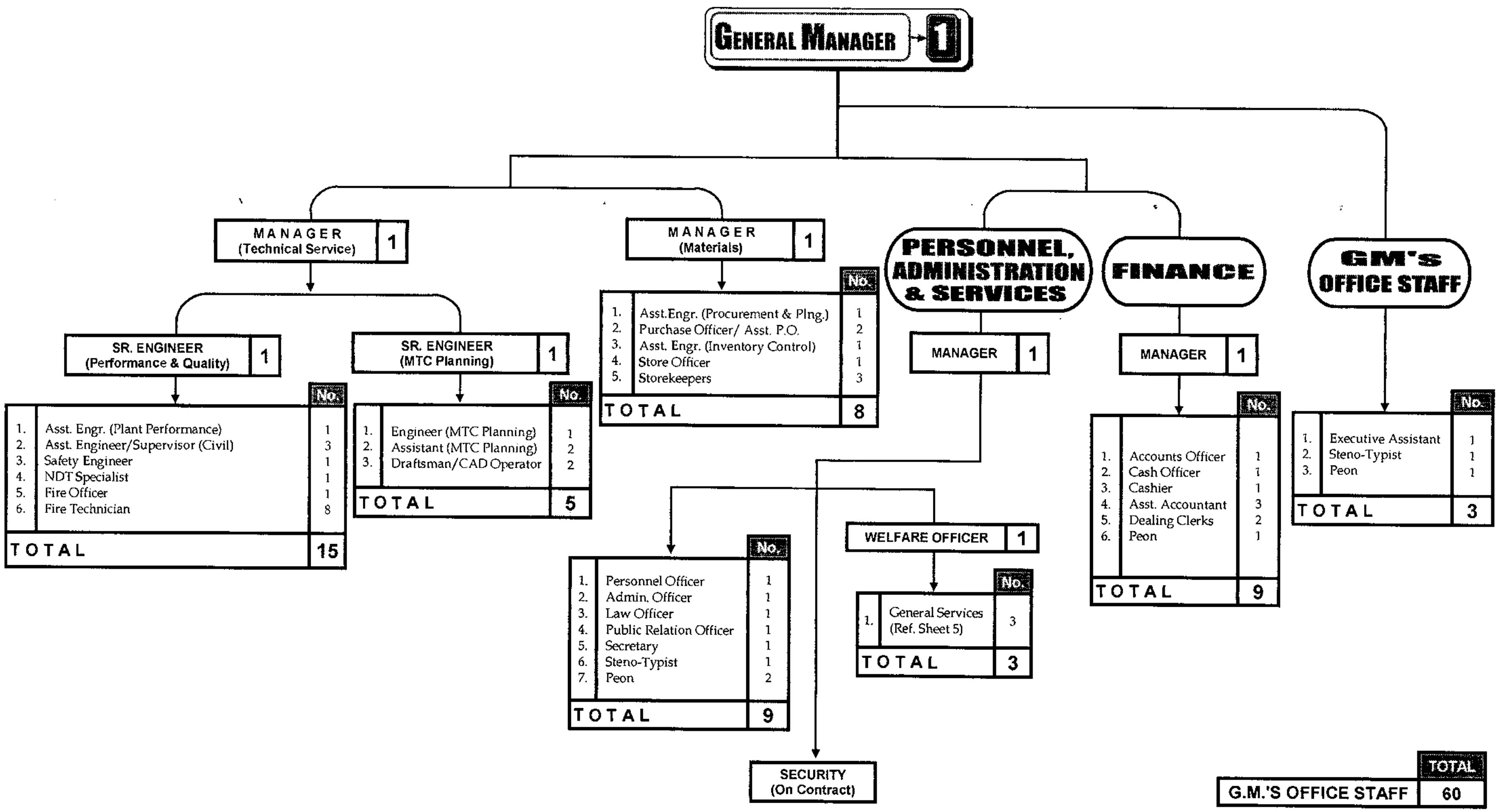


REVISED							
AG	KM	JS	JS	DPR	PRELIMINARY	0	21.07.09
APPROVED	REVIEWED	CHECKED	DRAWN	DESCRIPTION	RELEASE STATUS	REV.	DATE

Organisation Chart
(O & M)

IB THERMAL POWER STATION
2 x 660 MW UNIT 3 & 4
OPGC LIMITED

DEVELOPMENT CONSULTANTS PVT. LTD.

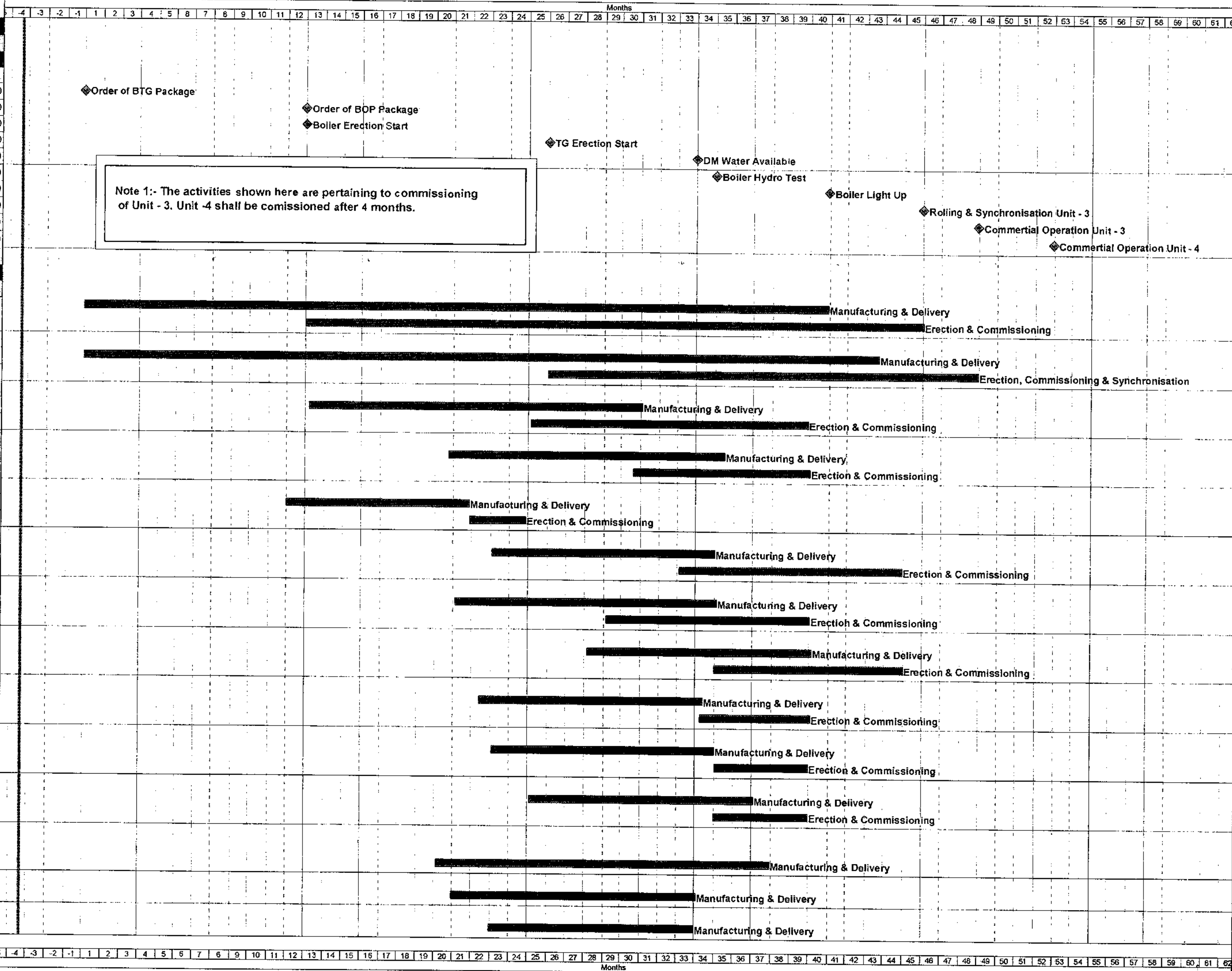
JOB NO.DCPL-K8B09

SCALE : NIL

DWG. NO. K8B09-012-DWG-DPR-001
(Sheet 6 of 6)

REV. 0

Activity ID	Activity Description	Orig Dur
IB TPS - 2X660 MW Units 3 & 4 - OPGCL		
MILESTONE		
MI110	Order of BTG Package	0
MI120	Order of BOP Package	0
MI130	Boiler Erection Start	0
MI140	TG Erection Start	0
MI145	DM Water Available	0
MI150	Boiler Hydro Test	0
MI160	Boiler Light Up	0
MI170	Rolling & Synchronisation Unit - 3	0
MI180	Commertial Operation Unit - 3	0
MI190	Commertial Operation Unit - 4	0
BTG PACKAGE		
Mechanical Work		
Boiler & Auxiliaries		
BO100	Manufacturing & Delivery	1,217
BO110	Erection & Commissioning	1,005
Turbine Generator & Auxiliaries		
TG100	Manufacturing & Delivery	1,300
TG110	Erection, Commissioning & Synchronisation	700
Electro Static Precipitator		
ESP100	Manufacturing & Delivery	545
ESP110	Erection & Commissioning	450
Fuel Oil System (HFO &LDO) for MP		
FOH100	Manufacturing & Delivery	450
FOH110	Erection & Commissioning	288
Power House EOT Cranes (2)		
EOT100	Manufacturing & Delivery	300
EOT110	Erection & Commissioning	92
Coal Preparation and Firing System		
CM100	Manufacturing & Delivery	365
CM110	Erection & Commissioning	363
AC & Ventilation System		
AC100	Manufacturing & Delivery	427
AC110	Erection & Commissioning	333
Mill Reject System		
MRS100	Manufacturing & Delivery	365
MRS110	Erection & Commissioning	307
Misc. Cranes & Hoist		
SP100	Manufacturing & Delivery	365
SP110	Erection & Commissioning	180
DG Set		
DG100	Manufacturing & Delivery	365
DG110	Erection & Commissioning	152
Compressed Air System		
CON120	Manufacturing & Delivery	365
CON130	Erection & Commissioning	154
Electrical Work		
Generator Transfarmer		
GT100	Manufacturing & Delivery	545
Station Transformer		
ST100	Manufacturing & Delivery	400
Reserve AuxiliaryTransformer		
UT100	Manufacturing & Delivery	335



Note 1:- The activities shown here are pertaining to commissioning of Unit - 3. Unit -4 shall be comissioned after 4 months.

Run Date 17FEB10 11:04 OP03

Sheet 1 of 3

PROJECT SCHEDULE

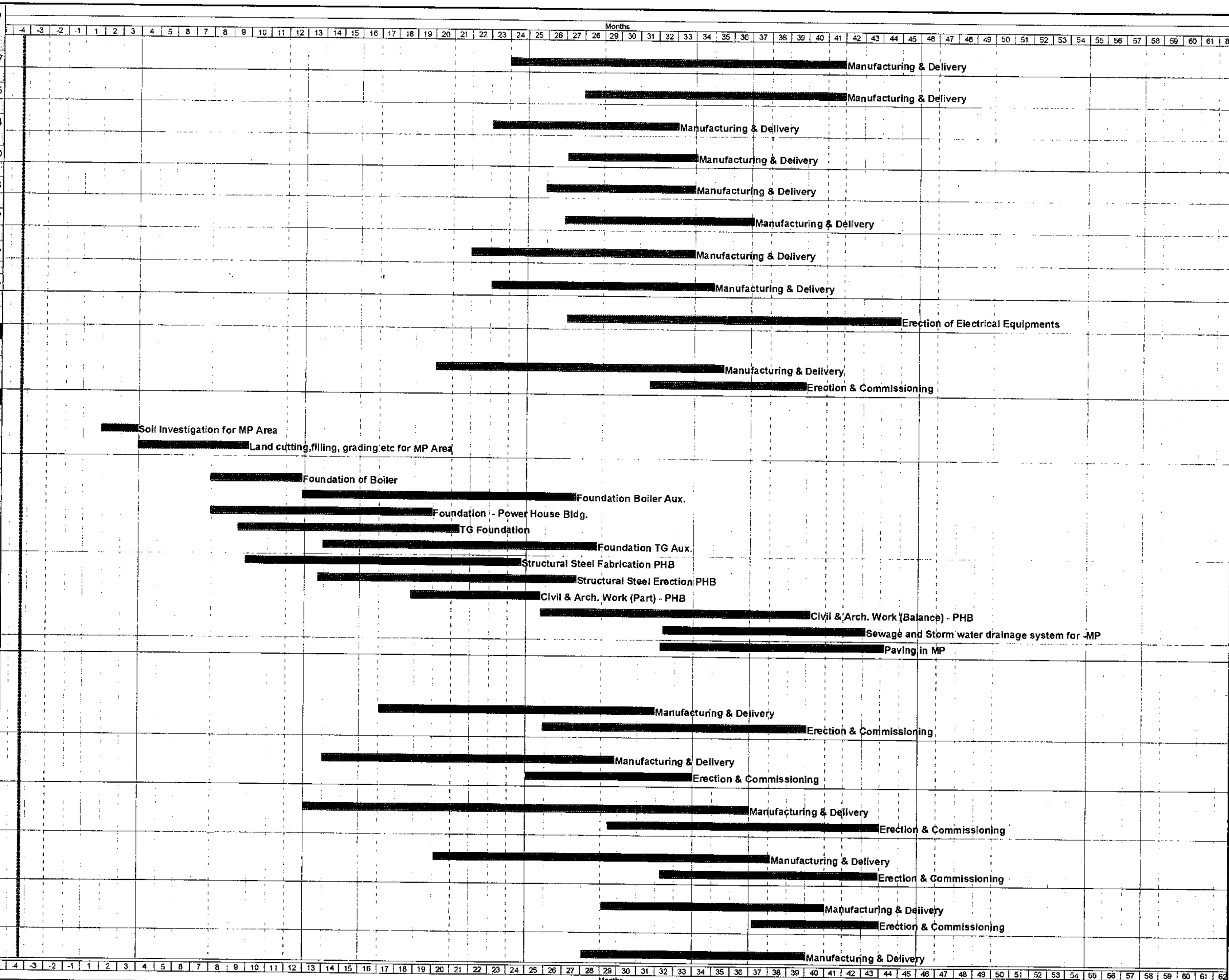
IB TPS- 2 x 660 MW Units 3 & 4 -OPGCL

DEVELOPMENT CONSULTANTS PVT. LTD.

DATE	REV. NO.	DESCRIPTION	JOB NO:	PRD.	CHKD.	APPVD.
17.02.10	0	PRELIMINARY	K8B09	AD	A Dey	RG
14.09.09	a	PRELIMINARY	K8B09	AD	A Dey	A Dey

ODISHA POWER GENERATION CORPORATION BHUBANESWAR

Activity ID	Activity Description	Drlg Dur
Generator Busduct & Accessories		
BD100	Manufacturing & Delivery	547
Neutral Grounding Resistor		
NGR100	Manufacturing & Delivery	425
Internal Distribution Switchgear		
SW100	Manufacturing & Delivery	304
Battery & Battery Charger		
BAT100	Manufacturing & Delivery	210
Local Control Board/Panel		
LCP100	Manufacturing & Delivery	243
OC Power Supply & UPS System		
UPS100	Manufacturing & Delivery	307
Cabling System		
CB100	Manufacturing & Delivery	365
Grounding & Lightning Protection System		
LPS100	Manufacturing & Delivery	365
Electrical Equipment Erection		
ER100	Erection of Electrical Equipments	544
Control & Instrumentation		
Control & Instrumentation : BTG Package		
C&I100	Manufacturing & Delivery	470
C&I110	Erection & Commissioning	255
Civil Work		
Preliminary Civil Works		
AG100	Soil Investigation for MP Area	60
AG120	Land cutting,filling, grading etc for MP Area	183
Major Civil Work		
PHB100	Foundation of Boiler	150
PHB110	Foundation Boiler Aux.	450
PHB120	Foundation - Power House Bldg.	365
PHB130	TG Foundation	365
PHB140	Foundation TG Aux.	450
PHB150	Structural Steel Fabrication PHB	455
PHB160	Structural Steel Erection PHB	425
PHB170	Civil & Arch. Work (Part) - PHB	213
PHB180	Civil & Arch. Work (Balance) - PHB	440
PHB185	Sewage and Storm water drainage system for	330
PHB190	Paving in MP	365
BOP PACKAGE		
Mechanical Work		
CW & ACW System		
CW100	Manufacturing & Delivery	450
CW110	Erection & Commissioning	430
Plant Water System		
PWS100	Manufacturing & Delivery	480
PWS110	Erection & Commissioning	272
Coal Handling System		
CHP100	Manufacturing & Delivery	730
CHP110	Erection & Commissioning	443
Ash Handling System		
AHP100	Manufacturing & Delivery	550
AHP110	Erection & Commissioning	355
Air Conditioning System		
AC200	Manufacturing & Delivery	364
AC210	Erection & Commissioning	208
Compressed Air System		
AU100	Manufacturing & Delivery	365



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Run Date 17FEB10 11:04 OP03

Sheet 2 of 3

PROJECT SCHEDULE

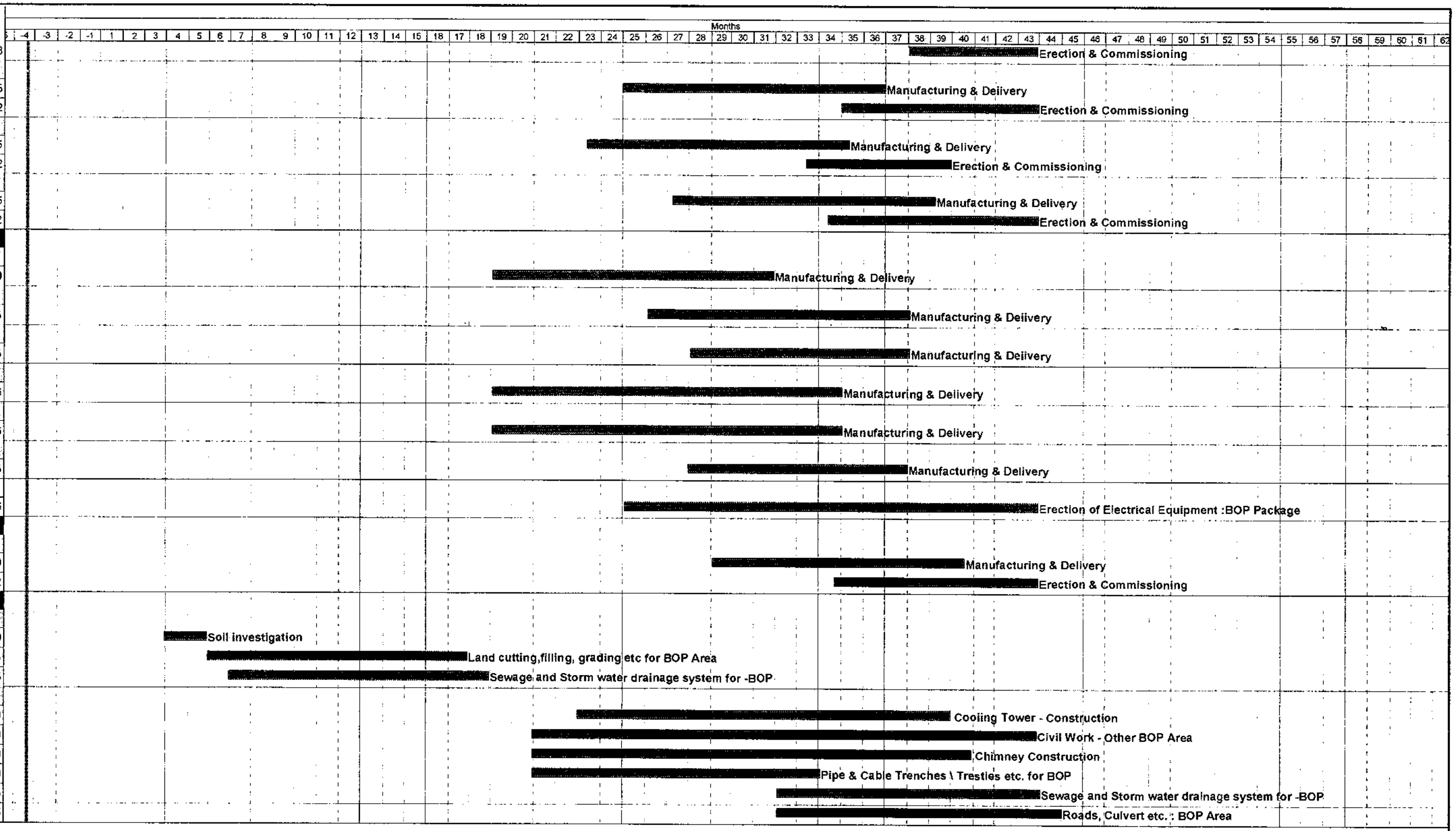
IB TPS- 2 x 660 MW Units 3 & 4 -OPGCL

DEVELOPMENT CONSULTANTS PVT. LTD.

DATE	REV. NO.	DESCRIPTION	JOB NO:	PRD.	CHKD.	APPVD.
17.02.10	[illegible]	PRELIMINARY	K9B09	AD	A Dey	RG
14.08.09	[illegible]	PRELIMINARY	K9B09	AD	A Dey	A Dey

ODISHA POWER GENERATION CORP. LTD. BHUBANESWAR

Activity ID	Activity Description	Orig Dur
AU110	Erection & Commissioning	178
Misc. Cranes & Hoist		
SP200	Manufacturing & Delivery	365
SP210	Erection & Commissioning	272
Fuel Oil Unloading System		
FOH200	Manufacturing & Delivery	365
FOH210	Erection & Commissioning	202
Fire Protection System		
FPS100	Manufacturing & Delivery	365
FPS110	Erection & Commissioning	292
Electrical Work		
Switchyard		
SW200	Manufacturing & Delivery	390
MCC, ACDB, DCDB, Fusa DB		
MCC200	Manufacturing & Delivery	365
Local Control Board/Panel		
LCP200	Manufacturing & Delivery	305
Other Misc. BOP Packages		
MSC100	Manufacturing & Delivery	486
Electrical System for Off site Packages		
SW210	Manufacturing & Delivery	486
Station Lighting System for BOP Area		
SW220	Manufacturing & Delivery	305
Electrical Equipment Erection		
ER200	Erection of Electrical Equipment :BOP	575
Control & Instrumentation		
Control & Instrumentation : BOP Package		
C&I200	Manufacturing & Delivery	350
C&I210	Erection & Commissioning	282
Civil Work		
Preliminary Civil Works		
CIVIL200	Soil Investigation	60
CIVIL205	Land cutting,filling, grading etc for BOP Area	365
CIVIL215	Sewage and Storm water drainage system for	365
Civil & Stractural Work : BOP Package		
CIVIL210	Cooling Tower - Construction	520
CIVIL240	Civil Work - Other BOP Area	700
CIVIL260	Chimney Construction	610
CIVIL270	Pipe & Cable Trenches \ Trestles etc. for BOP	400
CIVIL280	Sewage and Storm water drainage system for	365
CIVIL290	Roads, Culvert etc. : BOP Area	395



ODISHA POWER GENERATION CORPORATION LTD. BHUBANESWAR

Run Date 17FEB10 11:04 | OP03

PROJECT SCHEDULE

IB TPS- 2 x 660 MW Units 3 & 4 -OPGCL

Sheet 3 of 3

DEVELOPMENT CONSULTANTS PVT. LTD.

DATE	REV. NO.	DESCRIPTION	JOB NO:	PRD.	CHKD.	APPVD.
17.02.10	0	PRELIMINARY	K8B09	AD	A Dey	RG
14.06.09	A	PRELIMINARY	K8B09	AD	A Dey	A Dey