Detailed Project Report
for 2x1000 MW Imported Coal Based Thermal Power Project at Paguthan, Bharuch District, Gujarat

Detailed Project Report (June, 2015)
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(June 2015)
## Revision History

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<tr>
<td>FSSS</td>
<td>Furnace Safeguard and Supervisory System</td>
<td></td>
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<tr>
<td>GCV</td>
<td>Gross Calorific Value</td>
<td></td>
</tr>
<tr>
<td>GLC</td>
<td>Ground Level Concentration</td>
<td></td>
</tr>
<tr>
<td>GEPC</td>
<td>Gujarat Paguthan Energy Corporation</td>
<td></td>
</tr>
</tbody>
</table>
GOI : Government of India
Govt. : Government
GT : Generator Transformer Set
HBD : Heat Balance Diagram
HEI : Heat Exchanger Institute
HMBD : Heat & Mass Balance Diagram
HP : High Pressure
Hr / hr : Hour
HSR : Historical Storage & Retrieval
HT : High Tension
HVAC : Heating Ventilation & Air Conditioning
Hz : Hertz
IBR : Indian Boiler Regulation
ID : Induced Draft
IDC : Interest During Construction
IDCT : Induced Draft Cooling Tower
IEC : International Electro Technical Commission
IEEE : Institute Of Electrical Electronics Engineer
IEGC : Indian Electricity Grid Code
IP : Intermediate Pressure
INR/ Rs. : Indian Rupee
IS : Indian Standard
kA : kilo Ampere
Kcal : Kilo Calorie
Kg : Kilogram
KL : Kilo Liter
Km : kilo meter
kV : kilo Volt
kVA : kilo Volt Ampere
kW : kilo Watt
kWh/kWhr : Kilo Watt hour
LAN : Local Area Network
LCD : Liquid Crystal Display
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDO</td>
<td>Light Diesel Oil</td>
</tr>
<tr>
<td>LI</td>
<td>Lahmeyer International (India) Pvt. Ltd.</td>
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<tr>
<td>LP</td>
<td>Low Pressure</td>
</tr>
<tr>
<td>LP</td>
<td>Lighting Panel</td>
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<tr>
<td>Ltd.</td>
<td>Limited</td>
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<tr>
<td>LSHS</td>
<td>Low Sulphur Heavy Stock</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>LVS</td>
<td>Large Video Screens</td>
</tr>
<tr>
<td>M/m</td>
<td>Meter</td>
</tr>
<tr>
<td>m²</td>
<td>Square Meter</td>
</tr>
<tr>
<td>m³</td>
<td>cubic meter</td>
</tr>
<tr>
<td>MA</td>
<td>Milli Ampere</td>
</tr>
<tr>
<td>MAT</td>
<td>Minimum Alternative Tax</td>
</tr>
<tr>
<td>MCC</td>
<td>Motor Control Center</td>
</tr>
<tr>
<td>MCR</td>
<td>Maximum Continuous Rating</td>
</tr>
<tr>
<td>MIS</td>
<td>Management Information System</td>
</tr>
<tr>
<td>MLDB</td>
<td>Main Lighting Distribution Board</td>
</tr>
<tr>
<td>Mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>mg/l</td>
<td>Milligram per litre</td>
</tr>
<tr>
<td>Mm</td>
<td>Millimeter</td>
</tr>
<tr>
<td>MOEF</td>
<td>Ministry of Environment and Forests</td>
</tr>
<tr>
<td>MS</td>
<td>Main Steam</td>
</tr>
<tr>
<td>MSF</td>
<td>Media Sand Filters</td>
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<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
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<tr>
<td>MT</td>
<td>Metric Ton</td>
</tr>
<tr>
<td>MV</td>
<td>Medium Voltage</td>
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<tr>
<td>MVA</td>
<td>Mega Volt Ampere</td>
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<tr>
<td>MW</td>
<td>Mega Watt</td>
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<td>NB</td>
<td>Niobium</td>
</tr>
<tr>
<td>NDCT</td>
<td>Natural Draft Cooling Tower</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufactures Association</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
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<td>NGT</td>
<td>Neutral Grouting Transformer</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>NH</td>
<td>National Highway</td>
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<tr>
<td>NRI</td>
<td>Non Resident Indian</td>
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<tr>
<td>No./ Nos.</td>
<td>Number/ Numbers</td>
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<tr>
<td>NOx</td>
<td>Nitrous Oxides</td>
</tr>
<tr>
<td>NOC</td>
<td>No Objection Certificate</td>
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<tr>
<td>NM³</td>
<td>Normal Cubic Meter</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<td>NTP</td>
<td>Notice to Proceed</td>
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<tr>
<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
</tr>
<tr>
<td>OCTC</td>
<td>OFF Circuit Tap Changer</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OFAF</td>
<td>Oil Forced Air Forced</td>
</tr>
<tr>
<td>OFC</td>
<td>Optical Fiber Communication</td>
</tr>
<tr>
<td>OIU</td>
<td>Operator Interface Unit</td>
</tr>
<tr>
<td>ONAF</td>
<td>Oil Natural Air Forced</td>
</tr>
<tr>
<td>ONAN</td>
<td>Oil Natural Air Natural</td>
</tr>
<tr>
<td>OPC</td>
<td>Open Protocol Connectivity</td>
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<td>OPMS</td>
<td>Operation Performance Management System</td>
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<td>OLTC</td>
<td>On-load Tap Changer</td>
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<tr>
<td>OWT</td>
<td>Oxygenated Water Treatment</td>
</tr>
<tr>
<td>PA</td>
<td>Primary Air</td>
</tr>
<tr>
<td>PAS</td>
<td>Public Address System</td>
</tr>
<tr>
<td>PC</td>
<td>Pulverized Coal</td>
</tr>
<tr>
<td>PCB</td>
<td>Pollution Control Board</td>
</tr>
<tr>
<td>PDCL</td>
<td>Power Distribution Company Limited</td>
</tr>
<tr>
<td>PF</td>
<td>Power factor</td>
</tr>
<tr>
<td>PGCIL</td>
<td>Power Grid Corporation of India Limited</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>PLCC</td>
<td>Power Line Carrier Communication</td>
</tr>
<tr>
<td>PLF</td>
<td>Plant Load Factor</td>
</tr>
<tr>
<td>Ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>PPA</td>
<td>Power Purchase Agreement</td>
</tr>
<tr>
<td>PSS</td>
<td>Power System Stabilizer</td>
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</table>
### List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
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<tbody>
<tr>
<td>PT</td>
<td>Potential Transformer</td>
</tr>
<tr>
<td>PTC</td>
<td>Power Trading Corporation</td>
</tr>
<tr>
<td>PVC</td>
<td>Poly Vinyl Chloride</td>
</tr>
<tr>
<td>Pvt.</td>
<td>Private</td>
</tr>
<tr>
<td>RCC</td>
<td>Reinforced Cement Concrete</td>
</tr>
<tr>
<td>RFQ</td>
<td>Request For Quotation</td>
</tr>
<tr>
<td>RHS</td>
<td>Reheat Steam</td>
</tr>
<tr>
<td>Rpm</td>
<td>Rotations per minute</td>
</tr>
<tr>
<td>SADC</td>
<td>Secondary Air Damper Control system</td>
</tr>
<tr>
<td>SBC</td>
<td>Soot Blower Control system</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>SCR</td>
<td>South Central Railway</td>
</tr>
<tr>
<td>Sec</td>
<td>Second</td>
</tr>
<tr>
<td>SER</td>
<td>Sequence of Event Recorder</td>
</tr>
<tr>
<td>SG</td>
<td>Steam Generator</td>
</tr>
<tr>
<td>SOE</td>
<td>Sequence of Event</td>
</tr>
<tr>
<td>Sox</td>
<td>Sulphur Oxides</td>
</tr>
<tr>
<td>SPM</td>
<td>Suspended Particulate Matter</td>
</tr>
<tr>
<td>SPV</td>
<td>Special Purpose Vehicle</td>
</tr>
<tr>
<td>ST</td>
<td>Station Transformer</td>
</tr>
<tr>
<td>STG</td>
<td>Steam Turbine Generator</td>
</tr>
<tr>
<td>STMS</td>
<td>Smart Transmitter Maintenance Station</td>
</tr>
<tr>
<td>SWAS</td>
<td>Steam and Water Analysis System</td>
</tr>
<tr>
<td>TEFC</td>
<td>Totally enclosed Fan Cooled</td>
</tr>
<tr>
<td>TG</td>
<td>Turbine Generator</td>
</tr>
<tr>
<td>TMCR</td>
<td>Turbine Maximum Continuous Rating</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solid</td>
</tr>
<tr>
<td>TPD</td>
<td>Tons Per Day</td>
</tr>
<tr>
<td>TPH/ tph</td>
<td>Tons Per Hour</td>
</tr>
<tr>
<td>TPS</td>
<td>Turbine Protection System</td>
</tr>
<tr>
<td>TSE</td>
<td>Turbine Stress Evaluator</td>
</tr>
<tr>
<td>TSI</td>
<td>Turbo Supervisory Instrumentation</td>
</tr>
<tr>
<td>TSS</td>
<td>Turbo Supervisory System</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>UCD</td>
<td>Unit Control Desk</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterrupted Power Supply</td>
</tr>
<tr>
<td>US$ / USD</td>
<td>US Dollar</td>
</tr>
<tr>
<td>UT</td>
<td>Unit Transformer</td>
</tr>
<tr>
<td>UV</td>
<td>Ultra Violet</td>
</tr>
<tr>
<td>VDU</td>
<td>Video Display Unit</td>
</tr>
<tr>
<td>VWO</td>
<td>Valve Wide Open</td>
</tr>
<tr>
<td>XLPE</td>
<td>Cross Link Polyethylene</td>
</tr>
<tr>
<td>QB</td>
<td>Quartz Bulb</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
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</tbody>
</table>
1 EXECUTIVE SUMMARY

Founded in 1901 as China Light and Power Company Limited in Hong Kong, CLP Group is one of the leading power companies in the world. Through these years, CLP has grown to become a conglomerate of companies and retail businesses in different countries in the Asia Pacific Region.

CLP Holdings, which is listed on the Hong Stock Exchange, is one of the largest foreign investors in the Indian power sector with a total committed investment of over INR 14,500 Crores. This investment is spread across a diversified and environment-friendly generation portfolio that covers renewable energy, supercritical coal and gas fired power plants, amounting to over 3,000 MW.

CLP entered the Indian Power Sector in the year 2002 with the acquisition of a 655 MW gas fired power plant known as Paguthan Combined Cycle Power Plant (“PCCPP”) located in Bharuch District, Gujarat. This power plant was one of the first independent Power Projects (“IPP”) in India. CLP India’s assets complies with the highest level of internationally accepted standards in health, safety and environment management. Recently, PCCPP has been awarded with the President’s award for Occupational Health and Safety by the RoSPA (U.K) – which is the 15th Consecutive gold award from RoSPA (UK) for PCCPP.

CLP India also owns and operates a 1,320 MW (2 x 660MW) supercritical technology based coal-fired power plant in Jhajjar, Haryana which was awarded to CLP India under the Case II bidding in year 2008 by the State. It is among India's first few supercritical coal-fired power plants to be successfully developed and operated in the country. The plant got commissioned in record time – much ahead of tight Scheduled Commercial Operation Date.

CLP India is also one of the largest wind power developers in India with committed investment for wind projects of over 1,000 MW spread across six states. Wind has been an integral part of CLP’s business philosophy and making a vital contribution not only to CLP’s growth plans for India but also to meet its commitment to reduce its CO\textsubscript{2} emissions.

CLP India intends to expand their Paguthan Power Project by adding two coal fired units (high end supercritical or ultra supercritical technology based) of 800 to 1000MW units ("Paguthan Thermal Project"). The Project will be located within the existing premise of 655 MW PCCPP. The project and associated facilities shall be designed to accommodate the range of parameters for 800MW units to 1000MW. However, this report shall hereinafter consider two units of 1000 MW configuration for all calculations and analysis.

CLP India has appointed Lahmeyer International (I) Pvt. Ltd. (“LII”), as its Consultant/Engineer for the preparation of the Detailed Project Report (DPR) for Paguthan Thermal Project. The objective of the DPR is to establish the project details describing the site features, basic plant configuration, salient technical features, project execution plan and the financial analysis of the proposed thermal power project.

The Paguthan Thermal Project would be developed taking into account intrinsic features such as following:

(a) adequate land,
(b) transportation logistics of fuel
(c) nearby water source
(d) infrastructure facilities to evacuate generated power from the station
(e) supporting infrastructural facilities including road and rail connections.
Evacuation of power from Paguthan Thermal Project will be done at 400kV or 765 kV level (depending upon the transmission network availability in that region) through directly connecting transmission lines to nearby substation of PGCIL.

It is envisaged that the electrical energy generated from Paguthan Thermal Project will be sold to the distribution utilities and nodal agencies of States through Case-I tariff based bidding route. India continues to have electricity supply deficit in terms of peak demand. Considering the sustained increase in both energy and peak demand projected by CEA in its 18th EPS, India needs to keep adding generation capacity in coming decades to keep pace with the burgeoning demand of a growing economy. Further, after the realization of a synchronous national grid and anticipated increase in inter regional transmission capacity in coming years, the power generated from Paguthan Thermal Project can be utilised to meet the requirements of power deficit states of India.

The project site is located at a distance of 11km from Bharuch railway station and is accessible by the road connecting NH-8. The nearest airport is in Vadodara, which is 70 km from the site. Nearest seaport at Dahej is at a distance of 50 km from the site. Hence, transportation of materials to the project site will not be a major constraint.

The Paguthan Thermal Project will be built within the premises of existing PCCPP. Estimated consumptive water requirement for Paguthan Thermal Project is about 4450 m³/h wherein cooling water system will be designed to adopt re-circulating closed cooling water system with natural draft cooling tower.

The Paguthan Thermal Project is conceptualized to be operated by consuming imported coal having a GCV of around 5000 kCal/kg (ARB) measured on as received basis. Long and/or medium term fuel supply agreement (“FSAs”) will be executed with international fuel suppliers and coal-mining companies to ensure fuel supply to Project.

While the units shall primarily operate with 100% imported coal, the plant will also have the flexibility to receive/store and fire domestic coal @40% (by weight ) and rest 60% with imported coal. If required, domestic coal will be sourced through a coal linkage arrangement that GOI may grant or by participating in coal auction or entering into FSA with the commercial miners/counterparties.

Imported coal is proposed to be received through ships upto Dahej Port which is located 50 km away from project site. The unloaded coal at port will be transported to site through either of the following arrangement:

(a) Receiving coal from port to site through railway line: In this option coal rakes will directly reach to vicinity of power station site by taking a branch off line from the proposed bypass line (which are around 1km way from site) connecting Dahej-Samni-Bharuch and Mumbai - Delhi main line as conceptualized for implementation. While the unloading facility will be built with the siding, coal will be transported through boxed conveyor to site. Coal storage facility will be provided within the site boundary.

Alternatively,
(b) Coal will be transported to Nabipur terminal (around 6 kms away-owned by the Project) using existing Dahej- Bharuch line and Mumbai -New Delhi railway main line. Unloading and storing of coal will be done at Nabipur. The coal storage facility will be built adjacent to unloading facility and coal will be transported to power station site using boxed conveyors (to be laid from Nabipur to power station site).
The Annual Coal requirement for Paguthan Thermal Project at 85% PLF and imported coal GCV of 5000 kCal/kg (as received basis) will be 6.29 million tonnes per annum (MTPA).

Steam-water cycle consisting of steam cycle with regenerative feed heating arrangement operating at Ultra supercritical range has been proposed. The proposed plant shall adopt ultra supercritical steam parameters as necessary to achieve much higher efficiency and to lower generation cost and emissions levels. The plant will be designed to use re-circulating type cooling water system with natural draft cooling towers. Other plant auxiliaries and accessories would be designed as per the state-of-the-art technology and proven design to ensure safe and continuous operation of the unit with minimum unscheduled outage.

The generators would be 3-phase, 50 Hz, hydrogen and water cooled, 3,000 rpm machines with brush less/Static type excitation system and would generate power at 24 kV at 0.85 power factor (lagging). The electrical system proposed would be equipped with adequately sized equipment and with redundancy to ensure uninterrupted operation.

The proposed 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.

The proposed plant will be provided with necessary equipment and systems to meet all applicable environmental regulations. Low NOx burners have been envisaged to reduce the NOx generation and consequent emission. High efficiency electrostatic precipitators/ bag filters have been envisaged to limit the particulate emissions to less than 50 mg/Nm^3_. One number 275 M tall bi-flue chimney has been envisaged for the plant, in line with the MoEF guidelines, which will help dispersion of air borne emissions over larger area and thus minimizing the impact of the power plant on ground level concentrations. Closed cooling water system with natural draft cooling towers has been considered to significantly reduce water requirement for Plant. All effluent generated from the plant will be treated and wherever feasible suitably reused.

The plant layout has been developed keeping in view optimum use of land available within the identified land limit, land contour, wind rose pattern of the area, direction of supplies of input, direction of road access and railway entry, operational ease and initial investment requirement.

The first Unit of Paguthan Thermal Project will be scheduled to be commissioned in 42 months or earlier from “Zero date” and the 2nd unit 6 month thereafter. Date of Notice To Proceed (NTP) will be considered as the Zero Date. It is envisaged that NTP will be issued to the EPC Contractor to commence construction of the project immediately after Finance Closure.

Owing to vast experience that the promoter has in the area of power plant operation management, it is envisaged that PCCPP Project management team will carry out the Operation & Maintenance (“O&M”) of the power station. The Paguthan Thermal Project management will employ its own staffs and take support of the contractors to ensure the O&M management of Paguthan Thermal Project to the highest standards. The township facility available for existing PCCPP will be utilized to accommodate staffs required for Paguthan Thermal Project. If required, such facilities will be expanded further. All necessary statutory and non-statutory permits and clearances will be obtained during the course of development, construction and operationalization of Paguthan Thermal Project.
The project cost estimates are based on two units of 1000 MW each having ultra supercritical technology and associated auxiliaries. The fixed cost and variable cost of generation has been computed for the proposed project based on prevalent CERC tariff guidelines. The estimated Project Cost of Paguthan Thermal Project is working out to be Rs. 12,821 Crores including Custom Duty and other taxes & duties. The specific Project Cost works out to be Rs 6.41 Crores per MW. The first year tariff as per CERC tariff norm (2014-2019) works out to be Rs 4.61 /kWh. The levellized tariff works out to be Rs 4.79 /kwh.
## 2 INTRODUCTION AND BACKGROUND OF THE PROJECT

### 2.1 Introduction of the Project

CLP India Private Limited proposes to develop a Coal based thermal power project in Paguthan Village, Baruch District in the state of Gujarat. The Project will be located within the premises of the existing 655 MW PCCPP.

Project Company plans to install two units of either 800 MW or 1000 MW with total installed capacity of 1600 MW or 2000 MW respectively as “Paguthan Thermal Project”. However, hereinafter the report shall refer to two units of 1000 MW configuration.

### 2.1.1 Definitions

<table>
<thead>
<tr>
<th>Project Developer</th>
<th>CLP India Pvt Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Paguthan Thermal Project : 2 x 1000 MW</td>
</tr>
<tr>
<td>Selected Location</td>
<td>Paguthan in Baruch District of Gujarat, India.</td>
</tr>
<tr>
<td>Nearest Major Town</td>
<td>Bharuch at a distance 9 kms from site</td>
</tr>
<tr>
<td>Seismic Zone</td>
<td>Zone – III as per IS 1893-2002.</td>
</tr>
<tr>
<td>Access by Road</td>
<td>9 kms from NH 8</td>
</tr>
<tr>
<td>Access by Rail</td>
<td>Baruch station at 11 km.</td>
</tr>
<tr>
<td>Access by Sea</td>
<td>Nearest port is Dahej around 50 kms</td>
</tr>
<tr>
<td>Access by Air</td>
<td>Nearest Airport is Vadodara (70 Kms)</td>
</tr>
<tr>
<td>Distance from State capital</td>
<td>200 kms (Gandhi Nagar)</td>
</tr>
</tbody>
</table>

### 2.1.2 Preliminary Project Particulars

<table>
<thead>
<tr>
<th>Main Fuel</th>
<th>100 % Imported Coal, however the plant will have the flexibility to operate with 40% domestic coal, if required.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Transportation</td>
<td>Via sea to (Dahej) sea – port (India), and from port to site via Rail/road.</td>
</tr>
<tr>
<td>Water</td>
<td>Narmada River located at Angareshwar around 23 kms from site.</td>
</tr>
<tr>
<td>Land</td>
<td>Around 366 acres (this includes land occupied by existing PCCPP, other common facilities and land under possession)</td>
</tr>
<tr>
<td>Land Development</td>
<td>The entire power station will be laid at a uniform level.</td>
</tr>
<tr>
<td>Power Generating Unit</td>
<td>2 number of matching turbine generator sets fed by steam from pulverized coal fired boiler operating at high end super critical or Ultra super critical range.</td>
</tr>
<tr>
<td>Cooling System</td>
<td>Circulating condenser cooling system with 2 natural draft cooling towers - one for each unit.</td>
</tr>
<tr>
<td>Coal Handling System</td>
<td>Coal handling facility, comprising of Wagon Tippler/track hopper will be constructed at vicinity of site.</td>
</tr>
<tr>
<td>Ash Disposal System</td>
<td>The pressurized pneumatic system with silos will all be used to collect &amp; evacuate the fly ash, submerged chain conveyer system will be used for bottom ash. The provision in the design to install ash grinding units will be made</td>
</tr>
<tr>
<td>Power Evacuation</td>
<td>Power will be evacuated at 765kV or 400 kV level.</td>
</tr>
</tbody>
</table>
Environmental Aspects: Single 275m high twin flue stack as per MoEF guidelines and an adequately designed electrostatic precipitators/bag filters with more than 99.9% efficiency are envisaged.

Concept of Zero Liquid Discharge from Paguthan Thermal Project along with the associated facilities would be considered. Most of the waste water would be recycled back to the system after treatment for use in less priority areas.

Rehabilitation Requirement: Nil

2.1.3 Other Facilities

Township: Required nos. of dwelling units along with civic amenities shall be built by augmenting the existing facility.

2.1.4 Climate and Meteorological Data

<table>
<thead>
<tr>
<th>S. NO.</th>
<th>METEOROLOGICAL DATA</th>
<th>VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Min/ Max temp DBT/WBT basis)</td>
<td>Ambient Temp : 35°C (max)/ 21.1°C (min) annual</td>
</tr>
<tr>
<td>2.</td>
<td>Relative Humidity</td>
<td>Max : 89%, Mean :56.5%, Min: 21%</td>
</tr>
<tr>
<td>3.</td>
<td>Rainfall</td>
<td>Max: 1,022 mm (annual)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heaviest Monthly rainfall – 798.2 mm</td>
</tr>
<tr>
<td>4.</td>
<td>Wind directions/ wind rose/ wind speed</td>
<td>Wind speed : 20kmph (max)</td>
</tr>
<tr>
<td>5.</td>
<td>Seismic Zone</td>
<td>Zone – III</td>
</tr>
</tbody>
</table>

2.2 Justification of the Project

2.2.1 Introduction

Electricity is the prime mover for growth and is vital for the sustainance of a modern economy. While the projected GDP growth of the Indian economy @6% in the medium term, the long term growth rate of 8-10% is predicted. Such a growth would depends heavily on the availability of electricity to propel around industrial, agricultural and commercial activity.

India’s installed capacity has increased from 1,362 MW to over 258701 MW since independence and so far 563,238 villages have been electrified. However, the annual per capita consumption continue to be low at 917 kWh and this is amongst the lowest in the world. The end consumers of electricity viz. households, farmers, commercial establishments, and industries continue to grow subjected to frequent power cuts – both scheduled and unscheduled in many parts of the country.

The Electricity Act 2003 of India entrusts the Central Electricity Authority (CEA) under the Union Ministry of Power to prepare the National Electricity Plan for the next five years and the prospective plan for the next 10
years. The data and projections in this section are based on the latest published CEA surveys, studies & re-
ports.

2.2.2  All India Power Scenario

India has an installed capacity of 258701 MW as on 31.01.2015. Coal (including lignite) based thermal power
plants contribute about 60.37% of power generation in the country, followed by hydro of 15.79%, Wind &
other renewal energy/other sources 12.25%, Gas based 8.87% , Nuclear 2.23%, Liquid fuel based 0.46%. The
total thermal (coal, gas & diesel) is about 69.71%.

The State Sector contributes about 36.62%, the Central Sector about 27.31% and the Private Sector (IPPs)
about 36.05%. The sector wise break up of installed capacity in the country is indicated in the following table:

Table 2.1

<table>
<thead>
<tr>
<th>Sector</th>
<th>Hydro</th>
<th>THERMAL</th>
<th>Nuclear</th>
<th>RES</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coal</td>
<td>Gas</td>
<td>Diesel</td>
<td>Total</td>
</tr>
<tr>
<td>Central</td>
<td>10691</td>
<td>46775</td>
<td>7428</td>
<td>0</td>
<td>54203</td>
</tr>
<tr>
<td>State</td>
<td>27482</td>
<td>55890</td>
<td>6974</td>
<td>602</td>
<td>63467</td>
</tr>
<tr>
<td>Private</td>
<td>2694</td>
<td>53525</td>
<td>8568</td>
<td>597</td>
<td>62690</td>
</tr>
<tr>
<td>Total</td>
<td>40867</td>
<td>156190</td>
<td>22971</td>
<td>1199</td>
<td>180361</td>
</tr>
</tbody>
</table>

(Source: CEA, Monthly Report, January 2015)

The All – India, region wise, installed capacity is shown in the following table. Gujarat comes under the West-
ern Region and it has a total installed capacity of 28423 MW as on 31.01.2015. This is about 11 % of the total
installed capacity in the country.

Table 2.2

<table>
<thead>
<tr>
<th>Region</th>
<th>Thermal</th>
<th>Nuclear</th>
<th>Hydro</th>
<th>RES</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal</td>
<td>Gas</td>
<td>Diesel</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Northern</td>
<td>39431</td>
<td>5331</td>
<td>13</td>
<td>44775</td>
<td>1620</td>
</tr>
<tr>
<td>Western</td>
<td>61039</td>
<td>10915</td>
<td>17</td>
<td>71972</td>
<td>1840</td>
</tr>
<tr>
<td>Southern</td>
<td>28232</td>
<td>4962</td>
<td>939</td>
<td>34134</td>
<td>2320</td>
</tr>
<tr>
<td>Eastern</td>
<td>27427</td>
<td>190</td>
<td>17</td>
<td>27635</td>
<td>0</td>
</tr>
<tr>
<td>North-East</td>
<td>60</td>
<td>1571</td>
<td>142</td>
<td>1774</td>
<td>0</td>
</tr>
<tr>
<td>Islands</td>
<td>0</td>
<td>0</td>
<td>70</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>All India</td>
<td>156189</td>
<td>22969</td>
<td>1198</td>
<td>180360</td>
<td>5780</td>
</tr>
</tbody>
</table>

Source:- CEA Website

2.2.3  Energy Requirement & Peak Availability

Looking at the overall power supply position over the last 15 years, for the period 9th, 10th and 11th five year
plans till 2012, the average energy shortage is about 71,588 MU, climbing from 39,187MU in 9th plan end to
79,313 MU in 2011-12. In percentage terms, average energy shortage increased from 7.5% in 9th Plan end to 8.5% in 2011 – 12 (12th plan end). In 2012-13, energy shortage went up to 8.71%. However, it came down to 4.2% in 2013-14 due to a slowdown in the Indian economy. This is illustrated in the following tables:

Table 2.3
India: Power Supply Position, Million Units (MU)

<table>
<thead>
<tr>
<th>Period</th>
<th>Energy Requirement (MU)</th>
<th>Energy Availability (MU)</th>
<th>Energy Shortage (MU)</th>
<th>Energy Shortage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>9th Plan end</td>
<td>522,537</td>
<td>483,350</td>
<td>-39,187</td>
<td>-7.5</td>
</tr>
<tr>
<td>10th Plan end</td>
<td>690,587</td>
<td>624,495</td>
<td>-66,092</td>
<td>-9.6</td>
</tr>
<tr>
<td>2007-08</td>
<td>739,345</td>
<td>666,007</td>
<td>-73,338</td>
<td>-9.9</td>
</tr>
<tr>
<td>2008-09</td>
<td>777,039</td>
<td>691,038</td>
<td>-86,001</td>
<td>-11.1</td>
</tr>
<tr>
<td>2009-10</td>
<td>830,594</td>
<td>746,644</td>
<td>-83,950</td>
<td>-10.1</td>
</tr>
<tr>
<td>2010-11</td>
<td>861,591</td>
<td>788,355</td>
<td>-73,236</td>
<td>-8.5</td>
</tr>
<tr>
<td>2011-12</td>
<td>937,199</td>
<td>857,886</td>
<td>-79,313</td>
<td>-8.5</td>
</tr>
<tr>
<td>2012-13</td>
<td>998,114</td>
<td>911,209</td>
<td>-86,905</td>
<td>-8.71</td>
</tr>
<tr>
<td>2013-14</td>
<td>1,002,257</td>
<td>959,829</td>
<td>-42,428</td>
<td>-4.2</td>
</tr>
</tbody>
</table>

(Source: CEA)

The average shortfall/deficit during peak demand over the 3 five year plans is about 13,607 MW, rising from 9,252 MW in 9th Plan end to over 13,815 MW in 2011-12. In percentage terms, the average peak shortfall is about 12.45%. This is shown in the following Table 24 (a):

Table 2.4 (a)
Peak Demand (MW)
It is apparent that the pace and growth of electricity power generation in the country is simply unable to meet the demands of development and close – out the gap between supply and demand and India still remains a power deficit country.

The anticipated region-wise Annual Power Supply Position for the 2014 – 15 is given in the Table Below:

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Peak Demand (MW)</th>
<th>Peak Met (MW)</th>
<th>Peak Deficit/Surplus (MW)</th>
<th>Energy Requirement (MU)</th>
<th>Energy Availability (MU)</th>
<th>Energy Deficit/Surplus (MU)</th>
<th>Energy Deficit/Surplus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>47,570</td>
<td>46,899</td>
<td>-671</td>
<td>328,944</td>
<td>318,837</td>
<td>-10,107</td>
<td>-3.1</td>
</tr>
<tr>
<td>Western</td>
<td>45,980</td>
<td>52,652</td>
<td>6,672</td>
<td>288,062</td>
<td>289,029</td>
<td>967</td>
<td>0.3</td>
</tr>
<tr>
<td>Southern</td>
<td>41,677</td>
<td>32,423</td>
<td>-9,254</td>
<td>298,180</td>
<td>260,366</td>
<td>-37,814</td>
<td>-12.7</td>
</tr>
<tr>
<td>Eastern</td>
<td>17,608</td>
<td>17,782</td>
<td>174</td>
<td>118,663</td>
<td>114,677</td>
<td>-3,986</td>
<td>-3.4</td>
</tr>
<tr>
<td>North–Eastern</td>
<td>2,543</td>
<td>2,215</td>
<td>-327</td>
<td>14,823</td>
<td>12,248</td>
<td>-2,575</td>
<td>-17.4</td>
</tr>
<tr>
<td>ALL INDIA</td>
<td>147,815</td>
<td>144,788</td>
<td>-3,027</td>
<td>1,048,672</td>
<td>995,157</td>
<td>-53,515</td>
<td>-5.1</td>
</tr>
</tbody>
</table>

With the Govt. of India targeting a capacity addition of 88,537 MW during the XII Five Year Plan Period (2012 – 17) the annual capacity addition to achieve this ambitious target is 17,707MW.

The All India Region Wise Power (MW) and Energy requirement (MU) forecast of CEA for the end years of next four 5 year plans is shown in the Tables 2.4 (b) & 24(c) below:
Table 2.4 (b): Power Requirement (MW)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>37,265</td>
<td>60,934</td>
<td>86,461</td>
<td>121,979</td>
<td>164,236</td>
</tr>
<tr>
<td>Western</td>
<td>39,351</td>
<td>62,015</td>
<td>86,054</td>
<td>120,620</td>
<td>163,222</td>
</tr>
<tr>
<td>Southern</td>
<td>36,175</td>
<td>57,221</td>
<td>82,199</td>
<td>118,764</td>
<td>165,336</td>
</tr>
<tr>
<td>Eastern</td>
<td>15,122</td>
<td>24,303</td>
<td>35,928</td>
<td>53,053</td>
<td>72,874</td>
</tr>
<tr>
<td>North Eastern</td>
<td>2,021</td>
<td>2,966</td>
<td>4,056</td>
<td>6,169</td>
<td>8,450</td>
</tr>
<tr>
<td>ALL INDIA</td>
<td>124,995</td>
<td>199,540</td>
<td>283,470</td>
<td>400,705</td>
<td>541,823</td>
</tr>
</tbody>
</table>

Table 2.4 (c): Energy Requirement (MU)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>271,301</td>
<td>422,498</td>
<td>594,000</td>
<td>840,670</td>
<td>1,135,543</td>
</tr>
<tr>
<td>Western</td>
<td>271,453</td>
<td>394,188</td>
<td>539,310</td>
<td>757,318</td>
<td>1,028,974</td>
</tr>
<tr>
<td>Southern</td>
<td>243,912</td>
<td>357,826</td>
<td>510,786</td>
<td>7,279,913</td>
<td>1,017,526</td>
</tr>
<tr>
<td>Eastern</td>
<td>106,086</td>
<td>163,790</td>
<td>236,952</td>
<td>349,412</td>
<td>480,046</td>
</tr>
<tr>
<td>North Eastern</td>
<td>10,953</td>
<td>16,154</td>
<td>23,244</td>
<td>33,952</td>
<td>46,921</td>
</tr>
<tr>
<td>ALL INDIA</td>
<td>904,012</td>
<td>1,354,874</td>
<td>1,904,861</td>
<td>2,710,058</td>
<td>3,710,083</td>
</tr>
</tbody>
</table>

From the above demand forecasts, it is simply clear that there is ample scope for expansion of power generation assets in India.

2.2.4 Power Sector Scenario in Gujarat

The state of Gujarat has an installed capacity of 28423 MW, as on 31.01.2015. The sector wise break – up of power generation in Gujarat is given in Table 2.6 (a) below.

Table 2.5

<table>
<thead>
<tr>
<th>Sector</th>
<th>Hydro</th>
<th>Thermal</th>
<th>Nuclear</th>
<th>Wind/Rest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>772</td>
<td>6809</td>
<td>0</td>
<td>15</td>
<td>7596</td>
</tr>
<tr>
<td>Private</td>
<td>0</td>
<td>12780</td>
<td>0</td>
<td>4414</td>
<td>17194</td>
</tr>
<tr>
<td>Central</td>
<td>0</td>
<td>3072</td>
<td>559</td>
<td>0</td>
<td>3631</td>
</tr>
<tr>
<td>Total</td>
<td>772</td>
<td>22661</td>
<td>559</td>
<td>4430</td>
<td>28423</td>
</tr>
</tbody>
</table>

(Source: CEA website), Rounded of to whole number
Actual Power Supply Position in Gujarat up to October 2012 is given in Table 2.6 (b) below.

<table>
<thead>
<tr>
<th>Period</th>
<th>Peak Demand (MW)</th>
<th>Peak Met (MW)</th>
<th>Peak Deficit/ Surplus (MW)</th>
<th>Peak Deficit/ Surplus (%)</th>
<th>Energy Requirement (MU)</th>
<th>Energy Availability (MU)</th>
<th>Energy Deficit/ Surplus (MU)</th>
<th>Energy Deficit/ Surplus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9th plan end</td>
<td>8,005</td>
<td>6,700</td>
<td>-1,305</td>
<td>-16.3</td>
<td>53,693</td>
<td>47,530</td>
<td>-6,163</td>
<td>-11.5</td>
</tr>
<tr>
<td>10th Plan end</td>
<td>11,619</td>
<td>8,110</td>
<td>-3,509</td>
<td>-30.2</td>
<td>62,464</td>
<td>54,083</td>
<td>-8,381</td>
<td>-13.4</td>
</tr>
<tr>
<td>2007-08</td>
<td>12,119</td>
<td>8,885</td>
<td>-3,234</td>
<td>-26.7</td>
<td>68,747</td>
<td>57,614</td>
<td>-11,133</td>
<td>-16.2</td>
</tr>
<tr>
<td>2008-09</td>
<td>11,841</td>
<td>8,960</td>
<td>-2,881</td>
<td>-24.3</td>
<td>67,482</td>
<td>60,851</td>
<td>-6,631</td>
<td>-9.8</td>
</tr>
<tr>
<td>2009-10</td>
<td>10,406</td>
<td>9,515</td>
<td>-891</td>
<td>-8.6</td>
<td>70,369</td>
<td>67,220</td>
<td>-3,149</td>
<td>-4.5</td>
</tr>
<tr>
<td>2010-11</td>
<td>10,786</td>
<td>9,947</td>
<td>-839</td>
<td>-7.8</td>
<td>71,651</td>
<td>67,534</td>
<td>-4,117</td>
<td>-5.7</td>
</tr>
<tr>
<td>2011-12</td>
<td>10,951</td>
<td>10,759</td>
<td>-192</td>
<td>-1.8</td>
<td>74,696</td>
<td>74,429</td>
<td>-267</td>
<td>-0.4</td>
</tr>
<tr>
<td>APR-Oct, 2012</td>
<td>11,999</td>
<td>11,960</td>
<td>-39</td>
<td>-0.3</td>
<td>51,056</td>
<td>50,911</td>
<td>-145</td>
<td>-0.3</td>
</tr>
<tr>
<td>Oct, 2012</td>
<td>11,999</td>
<td>119,960</td>
<td>-39</td>
<td>-0.3</td>
<td>8,831</td>
<td>8,831</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(Source: Power Scenario at a Glance - Nov, 2012, CEA)

2.2.5 Indian Grids & Its Management

Ministry of Power had envisaged the establishment of an integrated National Power Grid in the country by the year 2012 with an inter – regional power transfer capacity of about 37,700 MW which was achieved on December, 2013.

All the five power regions of the country namely North – Eastern, Eastern, Western, Northern and Southern are now operating as one synchronous grid. This is facilitating free flow of power from surplus to deficit regions bringing much needed economy. The Southern Grid was recently synchronized to the Central Grid on 31st December, 2013 with the commissioning of 765 kV Raichur – Solapur Transmission Line thereby achieving “ONE NATION – ONE GRID – ONE FREQUENCY”.

While a significant progress has been achieved by connecting various regional grids, the Total Inter Regional Transmission Capacity of 35000 MW has been acheived and it is expected to be 75000 MW by the end of 12th Plan. The formation of National Power Grid will ease the transmission of power from surplus to deficit area as well as facilitate scheduled/ unscheduled exchange of power.

2.2.6 Conclusion Justifying the Project

India continues to have both energy and peak deficits. Considering the sustained increase in both energy and peak demand forecast projected by CEA in its 18th EPS, India needs to keep adding generation capacity in coming decades to keep pace with the burgeoning demand of a growing economy. Further, after the realization of a synchronous national grid and anticipated increase in inter regional transfer capacity in coming years, expansion of the Paguthan in the form of Paguthan Thermal Project is well justified.
2.3 Financial And Execution Capability

The project execution capability of a company mainly depends on its financial, technical and managerial strengths. Therefore, the financial and execution capabilities of the promoter companies including the management and the company profile have been dealt in this Section.

2.3.1 Company Profile

CLP founded as China Light and Power, in 1901, a Hong Kong based company in the field of power generation and distribution. Over the past two decades, CLP have expanded their footprints from Hong Kong into mainland China, Australia, India, Thailand and Taiwan. Presently, CLP Holdings Limited’s market capitalization is approximately HK$171billion.

CLP's involvement in the Indian power sector started in February 2002 when CLP acquired a majority stake in (655 MW gas based power project owned by) Gujarat Paguthan Energy Corporation Private Limited (GPEC) and assumed full ownership of the business in 2003. To date, CLP India is one of the largest foreign private power players and largest foreign investor in the wind power sector in India with projects in the State of Maharashtra, Gujarat, Karnataka, Tamil Nadu, Rajasthan totaling upto 1080 MW under different stages of commissioning.

In 2008, CLP has participated in competitive bidding conducted in the State of Haryana to develop coal based power project under standard bidding guidelines (case-2) issued by GOI. Consequently CLP has won the rights to build and operate a 1,320MW supercritical coal-fired power project. It has reinforced its position as one of the largest foreign investors in the Indian power sector. The project has since been implemented and put to commercial use.
3 PROJECT DESCRIPTION

The Paguthan Thermal Project being planned to be developed in single phase, will consist of two (2) units of 1000 MW based on imported coal with flexibility to operate with 40% domestic coal. The Project will be located adjacent to the existing 655 MW PCCPP in the Paguthan village of Bharuch District of Gujarat. The geographical location of the site lies at latitudes 21° 46’ 48.56” North and the longitudes 72° 58’ 41.74” East. The project site is located at a distance of about 11 km from Bharuch Railway Station on Mumbai - Ahmedabad broad gauge section and is accessible by the road connecting NH-8. The nearest Airport is Vadodara, which is about 70 km from the site. Nearest seaport Dahej is at a distance of about 50 km from the site. (Project Location has been placed under Exhibit-1.)

Techno-Economic feasibility has been considered as the prime criteria for site selection. This translates into locating adequate land with proximity to water source and feasible transport logistics for imported coal, which are the primary inputs for power generation. Besides, accessibility by rail and road, feasibility of power evacuation, sensitivity of the location (s) with respect to environmental, rehabilitation and resettlement aspects as well as aviation clearance have also been given due consideration in the selection process.

3.1 Land

The Paguthan Thermal Project will be built within the existing premise of aapproximately 366 acres of land which includes the existing plant and its auxiliary infrastructure. Certain infrastructure such as the access road to the plant, colony area, water reservoir, pumping station etc. are proposed to be shared with the new proposed Paguthan Thermal Project. The table – 3.1 provides an approximate break up of the land available and Table – 3.1A provides land usage details for existing and proposed project.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Items (All area includes green belt)</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant boundary area</td>
<td>250</td>
</tr>
<tr>
<td>2</td>
<td>Access road</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Colony</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-Total</strong></td>
<td><strong>336</strong></td>
</tr>
<tr>
<td>4</td>
<td>Nabipur Terminal</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Pumping Station area</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>366</strong></td>
</tr>
</tbody>
</table>

Table 3.1 A – Land usage details (Existing PCCPP plant & Proposed Paguthan Thermal Project)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land occupied by existing 655MW plant (Main plant, BOP, Naptha storage area)</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Common facilities</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Access road</td>
<td>9</td>
</tr>
<tr>
<td>b.</td>
<td>Water reservoir</td>
<td>9</td>
</tr>
<tr>
<td>c.</td>
<td>Colony &amp; Pumping station</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><strong>Total land for existing and common facilities</strong></td>
<td><strong>112</strong></td>
</tr>
</tbody>
</table>
Chapter 3: Project Description

3.1.1 Availability

The land area required for Paguthan Thermal project is already in possession of the Promoter. However, if any small parcel of land (15 acres) is required as per pt. 4 in aforesaid Table 3.1 (a), which shall be acquired to meet the requirement of project.

Primarily Paguthan Thermal Project shall be operating on 100% imported coal and therefore ~30 acres of land is earmarked within plant boundary for emergency storage of Ash for first 3 years of the project and the company proposes to construct an ash dyke.

If domestic coal supply scenario changes and situation arise wherein it is necessary for the plant to use domestic coal, then in such case additional land may be required for ash disposal. The land available at Nabipur Naptha Terminal (if vacant) along with some additional land may be required to be purchased for aforesaid case.

3.1.2 Advantages of Selected Site

The land is having very minor undulation and main Power Plant facilities are mostly located within the premises of the existing 655 MW PCCPP. No habitations are located in the identified plots of land. Therefore, there is no need for rehabilitation and resettlement. Plot plan (Dwg No. LII-GEOE14006-G-00110-001) is enclosed with this report.

3.2 Water

The proposed Project site is located at distance of about 23 km from the existing intake point for the existing 655 MW PCCPP located at Angareshwar on Narmada River. Paguthan Thermal project intends to use existing Raw Water Intake Pump House and Pipe Corridor by enhancing the capacity of Intake pumping and pipe line System. New pipeline will be laid to transfer additional water required for the Project. It is proposed to construct new raw water reservoir having 3 days of storage capacity to cater the Paguthan Thermal project consumptive and makeup water requirements when regular supply from river is not available. The Raw water from Narmada river shall be pumped to the plant raw water reservoirs and the water will then be pumped to the raw water clarifiers for treatment. Treated water will be stored in clarified water storage tank as shown in water balance diagram.

### Table 3.1 (a)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Proposed main plant area (Main plant, BOP, coal handling and storage facility)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Additional water reservoir</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Ash Dyke</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Total land for proposed plant &amp; facilities</td>
<td>126</td>
</tr>
<tr>
<td>3</td>
<td>Total Green belt (existing green area plus additional to be developed within available land )</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>366</strong></td>
</tr>
<tr>
<td>4</td>
<td>Coal unloading facility (Additional land required if the option of coal unloading near the plant vicinity is confirmed)</td>
<td>15</td>
</tr>
</tbody>
</table>
The capacities of existing DM water and potable water system will be further augmented to meet the requirement of the proposed Paguthan Thermal project. Some augmentation will include additional clarifiers, storage facility and additional demineralization facilities.

Estimated consumptive water requirement for Paguthan Thermal Project is about 4450 m³/hr. The above quantity of water includes makeup water for the cooling towers (to compensate for water loss on account of evaporation, drift and blow down) and other consumptive requirement.

Preliminary Water Balance Diagram for the Normal Plant Operation is shown in Dwg. No. LII-GEOE14006-M-00127-001 (Plant Water Balance Diagram)

The river water analysis data has been placed as Exhibit - 3.

### 3.3 Fuels

#### 3.3.1 Main Fuel Selection

The Paguthan thermal Project is conceptualized to be operated by firing imported coal having a design GCV of about 5000 kCal/kg on as received basis. FSA is planned to be put in place with international fuel suppliers and coal mining companies through medium to long term contracts. To have fuel flexibility, the units will be designed to receive, store and operate domestic coal also with 40% mix by weight. Coal shall be transported to Dahej Port by ship and then from Dahej Port to the coal unloading station to be located in the vicinity of the Plant. Take out point from the railway line that link Dahej port with Mumbai – Delhi Broad gauge line will be identified in consolation with railways and associated railway siding etc will be built. Either wagon tippler or track hopper system will be adopted with the approval of Indian railways.

A typical Coal Analysis of imported coal is placed in Exhibit - 4.

#### 3.3.2 Start-up & Flame Stabilization Fuel

Start-up, warm up and low load operation till flame stabilization shall be carried out with HSD. Boiler shall be so designed that oil firing for flame stabilization will not be required beyond 40% TMCR load.

### 3.4 Ash Handling System

To have flexibility in design, the Ash Handling System will be designed to receive, store and handle imported coal (60%) and domestic coal 40% mix by weight.

#### 3.4.1 Ash Quantity

Units are likely to generate two category of ash namely the Bottom Ash and Fly Ash. Bottom ash amounts to about 20% of the total ash generation and remaining will be the fly ash.

Estimated quantity of ash which will be generated from the plant firing imported coal having total ash content of 8%, is about 101 tonne per hour with two units at TMCR. The annual ash generation is worked out at around 0.79 million tonnes considering 85% PLF.
3.4.2 Bottom Ash System

Bottom ash from boiler furnace shall be collected in double “V” type water impounded hoppers. It will be removed through crusher and submerged chain conveyor and transferred to the bottom ash discharge Silos. From the silos, the bottom ash will be dumped in ash disposal area by using mobile trucks.

3.4.3 Fly Ash System

The fly ash handling system will be designed to remove fly ash from ESP hoppers, APH hoppers, duct hoppers, if any and economizer hoppers to convey the ash to ash silos through transfer piping system. The design consists of positive pneumatic dense phase fly ash handling system. Storage silos be installed and these will be of RCC construction having total 48 hrs storage capacities for two units while firing design coal at BMCR condition. Each fly ash silo shall be equipped with two dry type fly ash unloaders and one wet type fly ash unloader. The Silo system will be suitably designed to hand over all the fly ash collected to parties such as local brick manufacturers cement manufactures etc. who use fly ash as their input material as per the MOEF guidelines. To deal with the emergency, the system will be in place to transport fly ash from silo to the ash disposal area using closed tankers.

3.5 Ash Utilization and Disposal Options

As per the MoEF notification dated 13.10.2010, a new coal based power station should make plans for utilization 100% fly ash (in phased manner for first 3 years) from 4th year after Commercial Operation Date (COD). Hence, it is proposed to provide dry fly ash extraction and storage system to ensure that fly ash is utilized as per the MOEF guidelines. Ash Pond shall be provided for the proposed Project to accumulate unutilized ash during first 3 years of operation as stipulated in the above mentioned MoEF notification. Ash utilization will be thrust area of its activities within the environmental management. Supply of ash to cement plants in the region, for manufacture of cement, shall be taken up on priority.

3.6 Cycle Parameters Selection

In general, adoption of steam parameters with higher temperature and pressure will increase the cycle efficiency and in the process reduce the operating cost. However, higher steam pressure and temperature increases the design challenges. This will invariably push up the initial investment cost as well as cost of spares.

3.7 Cycle Parameters Selection Criteria

The objective for the cycle parameters optimization for the proposed power station is to achieve an efficient high performance power plant using proven technologies with equipment having history of high availability and high reliability.

The target design criteria established for the plant are based on the following points:

- Pulverized coal using imported coal.
- Unit Gross Electrical Output at 100% TMCR, 1000 MW
- Proven operating experience on the Last Stage Blade (LSB) length & material at 3,000 rpm
- Gross TG Cycle Heat Rate ≤1,850 Kcal/ kWh (CERC normative level).
- Sliding / Modified Sliding pressure operation
- Use plant emissions limits to establish backend equipment design
Detailed Project Report

2x1000 MW Coal Based TPP at Paguthan, Bharuch District, Gujarat (India)

• Circulating water temperature for Gross Unit Heat Rate; 33DegC
• Boiler efficiency set by air heater exit temperature of acid dew point plus 9DegC
• Equipment history of high availability and high reliability
• Commercially available with reasonable number of competitors

For doing the cycle parameters optimization, keeping the above points in mind, several issues have been looked into and the same are briefly as discussed below:

3.8 Steam Cycle Parameters

The proposed plant, consisting of two units each of 1000 MW capacity shall adopt Ultra Supercritical steam parameters to achieve higher efficiency and hence lower cost of generation. The review of parameters followed for units of comparable sizes indicates that typically steam parameters in the following range have been adopted:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Steam</td>
<td></td>
</tr>
<tr>
<td>• Pressure, bar</td>
<td>285 – 289</td>
</tr>
<tr>
<td>• Temperature, °C</td>
<td>600-610</td>
</tr>
<tr>
<td>Hot Reheat Steam</td>
<td></td>
</tr>
<tr>
<td>• Temperature, °C</td>
<td>615 -621</td>
</tr>
</tbody>
</table>

The primary factors which govern the steam cycle selection are; efficiency, equipment cost and the fuel price. With higher steam parameters, the investment cost goes up on account of increase in the cost of boiler and turbine equipment. However, on account of higher plant efficiency, the incremental investment cost is recovered within the initial years of operation.

The other major benefit of adopting higher steam cycle is reduction in emissions (SPM, CO₂, SO₂, NOx). Secondary benefits of higher steam cycle parameters are reduction in the capacities of auxiliary systems such as cooling water, coal and ash handling, thus some savings in the capital cost.

The advancement in metallurgical research coupled with rising fuel prices have contributed to the migration of manufacturers and project developers to higher steam parameters.

In India, presently there is no 1000 MW unit in operation. However there are few 800 MW supercritical thermal power plants in operation. Chief among them being:

• 5x800 MW Ultra Mega TPP, Coastal Gujarat Power Ltd, Mundra, of Tata Power

Also, there are upcoming similar capacity large powers projects are based on supercritical technology chief among them being:

• 2x800 MW Krishnapatnam Project of APGENCO
Detailed Project Report

2x1000 MW Coal Based TPP at Paguthan, Bharuch District, Gujarat (India)

- 2X800 MW NTPC Kudgi Thermal Power Project in Karnataka
- 2X800 MW NTPC Kudgi Thermal Power Project in Chhattisgarh
- 2X800 MW NTPC Gadarwara Thermal Power Project in Madhya Pradesh

Internationally some of large rating units (800-1200MW) have employed ultra supercritical technology (MS pressure 250-300 bar, MS temp 600°C and RH temp 600°C / 620°C). These parameters require higher grade materials and special welding technologies.

Steam Parameters in the Ultra Supercritical range is envisaged for the subject project in preparation of this report.

Based on the above analysis following Steam Parameters have been assumed in preparation of this detail Project Report:

Table – 3.3: Steam Parameter

<table>
<thead>
<tr>
<th>Cycle configuration</th>
<th>HPT Inlet Pressure (ata)</th>
<th>HPT Inlet Steam Temp (°C)</th>
<th>IPT Inlet Steam Temp (°C)</th>
<th>Feed Water Temp (°C)</th>
<th>Back Pressure (ata)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra Super-Critical Steam Condition</td>
<td>285.5</td>
<td>600</td>
<td>620</td>
<td>305</td>
<td>0.103</td>
</tr>
</tbody>
</table>

A tentative Heat & Mass Balance Diagram (Dwg. No. LII-GEOE14006-M-00126-001) is attached with this report.

3.9 Plant Building Design Criteria

In an effort to optimize the cost, following building concept has been looked into against the conventional designs. This will meet the necessary design criteria and other considerations including the O&M aspects.

Table – 3.4: Concept of Plant Buildings

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Bldg Description</th>
<th>Type of Structure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw water Pump house</td>
<td>RCC sump with roof shed and RCC/Steel support structure along with handling arrangement.</td>
<td>Control panel / MCC room and operator’s space with RCC roof and brick wall.</td>
</tr>
<tr>
<td>2.</td>
<td>Raw Water storage reservoir / sump</td>
<td>Earthen, lined Type Uncovered.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Clarified water storage</td>
<td>RCC Type Covered.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Clarified water &amp; Fire water pump house</td>
<td>RCC sump with covered RCC support structure along with handling arrangement.</td>
<td>Control panel / MCC Room with RCC roof and brick wall.</td>
</tr>
<tr>
<td>5.</td>
<td>DM Plant - vessel &amp; regeneration area Chemical Laboratory</td>
<td>RCC Type Covered.</td>
<td>Existing</td>
</tr>
<tr>
<td>6.</td>
<td>Fire Water tanks</td>
<td>RCC Type Uncovered.</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Bldg Description</td>
<td>Type of Structure</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7.</td>
<td>Chemical House.</td>
<td>Multi storied with RCC Roof and brick wall.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>CW Pump House Sodium hypochlorite dosing Plant.</td>
<td>RCC sump roof shed and RCC/Steel support structure along with brick cladding &amp; handling arrangement.</td>
<td>Control room MCC room, safety equipment room with RCC roof and brick wall. False ceiling in control room area.</td>
</tr>
<tr>
<td>9.</td>
<td>Gas Chlorination Building</td>
<td>RCC/ steel support structure along with brick cladding &amp; handling arrangement.</td>
<td>Control room, MCC room, safety equipment room, with RCC roof &amp; brick wall. False ceiling in control room area.</td>
</tr>
<tr>
<td>10.</td>
<td>CW treatment building</td>
<td>Steel structure with shed</td>
<td>Control panels</td>
</tr>
<tr>
<td>11.</td>
<td>Fuel Oil Pump house</td>
<td>Fabricated support structure with brick cladding, preferably.</td>
<td>Control panel / MCC Room with RCC roof and brick wall</td>
</tr>
<tr>
<td>12.</td>
<td>Fuel Oil tank farm area</td>
<td>Uncovered</td>
<td>Existing</td>
</tr>
<tr>
<td>13.</td>
<td>Effluent Treatment Pump house</td>
<td>RCC Type Covered.</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Central Monitoring Basin</td>
<td>Uncovered</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>RO building</td>
<td>RCC Type Covered.</td>
<td>Control room with RCC roof &amp; brick wall, false ceiling in control room area.</td>
</tr>
<tr>
<td>16.</td>
<td>Control &amp; Instrumentation Lab.</td>
<td>RCC Roof and brick wall</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>DG Room / Compressor House</td>
<td>RCC Type Covered.</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>ESP Control Building.</td>
<td>RCC Type Covered with brick cladding wall False ceiling in control room area</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Permanent Store</td>
<td>Steel structure, covered roof and sides. Enclosed building</td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Workshop</td>
<td>Fabricated structure, covered roof shed and sides. with EOT crane</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Administrative Bldg.</td>
<td>RCC type covered with Provision of False ceiling</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Service Bldg.</td>
<td>RCC Type Covered.</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Security Bldg.</td>
<td>RCC Type Covered with large glass window</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Canteen</td>
<td>RCC Type Covered.</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Time Office, Medical Centre &amp; Rest Rooms</td>
<td>RCC Type Covered.</td>
<td>Medical Centre – False</td>
</tr>
</tbody>
</table>
### Chapter 3: Project Description

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Bldg Description</th>
<th>Type of Structure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.</td>
<td>Fire Tender parking</td>
<td>RCC Type.</td>
<td>Open on all sides</td>
</tr>
<tr>
<td>27.</td>
<td>Fire station building</td>
<td>RCC Roof with covered side with brick</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>Cycle &amp; scooter stand.</td>
<td>Open with roof shed and fabricated support structure.</td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>Weigh Bridge control room</td>
<td>Fabricated structure, covered roof and sides.</td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td>Not used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>Centrifuge building</td>
<td>RCC roof, double storey, covered sides for chemical area, open sides for centrifuge area.</td>
<td>Control room, Chemical storage &amp; neutralizing pit.</td>
</tr>
<tr>
<td>33.</td>
<td>CPU regeneration building</td>
<td>RCC roof covered sides with brick for control room. Roof shed &amp; fabricated support structure for regeneration area.</td>
<td>Control room, Chemical storage &amp; neutralizing pit.</td>
</tr>
</tbody>
</table>

The concept of the above buildings will meet their respective functional requirements. However, the concept will offer reduced cost and reduced completion schedule.

#### 3.10 Equipment Sourcing

Steam Generator and Turbo Generator with the proposed ultra super critical steam parameters and other BOP equipment shall be sourced from international reputed suppliers. Depending on Project techno economics and regulatory requirements, equipment may be sourced from domestic supplier as well.

#### 3.11 Transportation Logistics

Considering that Project has to undergo a construction phase, the plant and machinery need to be brought to the project site by various means of transportation. Further, coal needs to be transported to site on a continuous basis for entire life of the plant.

The project site is located at a distance of 11 km. from Bharuch Railway Station and is accessible by the road connecting NH-8. The nearest Airport is Vadodara, which is 70 km from the site. Nearest seaport Dahej is at a distance of 50 km from the site. Hence, transportation of materials to the project site will not be a major constraint. However, detailed transport logistic study shall be reviewed at the plant of project execution phase.

Hence, transportation of materials to the project site will not be a major constraint.
3.12 Electrical Systems

Assumptions

Following assumptions and basis have been considered for the Project.

- Power will be generated at 24 kV or any other voltage as per generator manufacturer’s standard design within the range of 20 to 27 kV.
- Power will be evacuated at 400 kV or 765kV.
- 1x30% Motor Driven and 2x50% Turbine Driven Boiler Feed Water Pump will be provided for each unit.
- Failure of any auxiliary transformer or supply feeders will not affect the full load operation or start up/shut down of any unit.
- Simultaneous failure of two transformer/feeders in a particular system is not considered, as design with such option to be uneconomical and oversized

Auxiliary Power Distribution & Evacuation System:

Power generated by each of the 1000 MW units will be stepped up to evacuation voltage of 400 kV or 765kV through dedicated Generator Step up Transformer [GSUT]. Generator will be connected with GSUT through Isolated Phase Bus Duct (IPBD). The total auxiliary load of the power plant i.e. Unit loads as well as station loads will be catered by three winding Unit Auxiliary Transformer (UAT’s) which will step-down the generation voltage to 11 KV. It will be further stepped down to 415 V for supply of auxiliary power to smaller motors and miscellaneous LT auxiliaries. (Refer Main SLD drawing no. Lii-GEOE14006-E-00140-001).

Each 1000MW unit will be provided with one (1) number of 100% rated 24 (within range of 20 to 27 kV)/11.5/11.5 KV three winding UAT. These transformers will feed the respective 11 kV Unit Switchgear Buses.

A 765/11.5/11.5 KV or 400/11.5/11.5 KV, three winding Startup/Standby transformer is proposed for the 2X1000MW (nominal) units. This transformer will suitably connect to the 11 kV Unit Buses. Start-up power for the unit as well as station auxiliaries will be supplied through this Startup/Standby Transformer.

In case of failure of Unit Auxiliary Transformer, this arrangement will provide redundancy in power supply to the unit and station auxiliaries of the proposed power plant.

Automatic Fast Bus Change Over scheme shall be provided at 11 kV. Slow bus changeover scheme shall be provided at 415 V. This arrangement will provide dual redundant power supply to the auxiliaries during start-up shut down as well as during plant operation.

Power Distribution system will be designed considering the following aspects.

Generator Step-up Transformer (GSUT)

As described above, each generator shall be connected to the 765kV or 400kV switchyard via one (1) number dedicated Generator Step-up transformer (GSUT). As three phase transformer of this capacity will be difficult to transport, three single-phase banks for each generating units are considered. One single-phase bank will be provided as common standby for two generating units. The transformer will be outdoor, oil immersed, ONAN/ ONAF/ OFAF or ODAF cooling and will have Off-Circuit Tap Changer (OCTC) on HV side with tap range, ±2 X
2.5% with a vector group of YNd11. The HV side terminals will be connected to 765kV or 400 kV grid through overhead conductor. HV side will be solidly earthed.

The MVA rating of the GSUTs shall be sufficient to evacuate power generated by the respective steam turbine generator under VWO (valve wide open) condition.

The GSUTs will be so sized as to be able to evacuate power from the STG under all conditions of ambient temperature, frequency variations and voltage variations as specified in Design Ambient.

**Unit Auxiliary Transformer (UAT) & Startup/Standby Transformer**

Two (2) nos. 120/60/60 MVA, 24/11.5/11.5 kV, three-phase, three-winding, oil immersed, outdoor type, Unit Auxiliary Transformer (UAT) have been envisaged to cater total auxiliary loads for 2x1000 MW (nominal) units.

One (1) nos. 120/60/60 MVA, 765/11.5/11.5 kV or 400/11.5/11.5 kV, Startup/Standby three winding transformer is proposed for the 2X1000MW (nominal) units. Start-up power for the unit as well as station auxiliaries will be supplied through this Startup/Standby Transformer. This transformer will also act as standby for the Unit auxiliary transformer.

**EHV Switchyard Configuration**

A 765kV or 400 kV Gas Insulated Switchyard with Double Bus scheme is proposed to be constructed adjacent to the power plant to evacuate the power from the power plant.

The switchyard will be provided with the following 765kV or 400kV Bays:
1) Generator Step-up Transformer #1 Feeder
2) Generator Step-up Transformer #2 Feeder
3) Start up/ Standby Transformer Feeder
4) Outgoing line Feeders #1
5) Outgoing line Feeders #2
6) Future bay
7) Tie between existing and new 400kV switchyard main Bus #1 (this tie connection will be applicable only if the power is evacuated at 400kV lines).
8) Tie between existing and new 400kV switchyard main Bus #2. (this tie connection will be applicable only if the power is evacuated at 400kV lines).
9) Bus Reactor #1 Feeder (if required)

**3.13 Power Evacuation**

Evacuation of power from the proposed power plant will be done at 765kV or 400 kV level. The generation voltage is envisaged as 24 kV or will be as per the standard design of manufacturer. For evacuation of power, three (3) nos. single phase 415 MVA, 24 / 800/V3 kV or 24 / 420/V3 kV generator transformers are envisaged for each unit.

One 765kV or 400 kV switchyard will be constructed in the proposed power plant. For this purpose, two nos. Dedicated 765kV or 400kV high capacity line is proposed for power evacuation.
4  SITE ANALYSIS

4.1  Site Selection criteria

The main factors considered for the selection of a suitable site is (a) fairly close to sources of water and (b) coal. Land required for accommodating the in-plant facilities of the project is already in the possession of the company within the premises of existing power plant. The other factors considered while selecting the power plant site are:

a) Availability of adequate industrial land for power plant, ash disposal, township and other facilities.
b) Minimal rehabilitation requirement
c) Availability of required quantity of water throughout the year,
d) Ease of transportation of coal,
e) Market for power,
f) Environmental compatibility,
g) Transportation of Over Dimensional Consignment (ODC).
h) Area doesn’t fall in any restricted area.

4.2  Description of Selected Site

1)  Location and Approach

The Proposed Project proposed to be developed will consume the imported coal. The Project will be located adjacent to the existing Power Plant. The geographical location of the site lies at latitudes 21° 46' 48.56" North and the longitudes 72° 58' 41.74" East. The project site is located at a distance of about 11 km from Bharuch Railway Station on Mumbai - Ahmedabad broad gauge section and is accessible by the road connecting NH-8. The nearest Airport is Vadodara, which is about 70 km from the site. Nearest seaport Dahej is at a distance of about 50 km from the site.

2)  Land

The land area required for the expansion is already in the possession of the Project Company. Primarily plant shall be running on 100% imported coal and Project Company proposes to construct an ash dyke within plant boundary.

Some additional land may be required for ash disposal in case the Project Company runs the plant on blended coal having 60% imported and 40% domestic coal. The land available near Nabipur Railway Station along with some additional land may be required to be acquired.

3)  Water

The proposed Project site is located at distance of about 23 km from the existing intake point for the existing 655 MW PCCPP located at Angareshwar on Narmada River. Project company intends to use existing Raw Water Intake Pump House and Pipe Corridor with suitable augmentation to meet the requirement of expansion. It has been proposed to construct a new raw water reservoir having 3 days of storage capacity to cater the plant consumptive and makeup water requirements for both the units when regular supply from river is not available. The Raw water from Narmada river shall be pumped to the in-plant raw water reservoir and then water will be pumped to the raw water clarifiers from treatment. The treated water will be stored in clarified water storage tank as shown in water balance diagram.

Additional DM water tanks /Potable water tanks will be provided with proposed power plant. Water analysis report for Narmada river is enclosed at Exhibit-3.
4) Fuel Source and Transportation Logistics:

The plant has been conceptualised as an imported coal fired Thermal Power Plant with flexibility to fire domestic coal @40% by weight. The fuel sourcing arrangement will be finalized by entering into contract with international suppliers and domestic suppliers.

(a) Coal requirement for 2x1000 MW project, when units are operating on 100% imported coal is estimated as 6.29 million tonnes /annum considering GCV of 5000 kcal/kg at 85 % PLF.

(b) Blended Coal requirement when units operate @ 40% weight domestic coal (Design GCV of 3200 Kcal/kg) and balance 60% on imported coal (GCV of 5000 Kcal/kg) will be (i) imported coal - 4.41 MTPA (ii) Domestic Coal - 2.94 MTPA

Imported coal will be transported by sea and is planned to be unloaded at Dahej Port. However Domestic coal will be transported using Road/Rail/Sea transportation arrangement (as applicable) to Dahej Port.

Subsequently coal from Dahej port will be transported by railway wagons to site by constructing railway siding on the rail line proposed to be laid for connecting Dahej port with Mumbai – Delhi Broad gauge line.

HSD will be used for startup and low load stabilization.

The indicative coal and liquid fuel analysis is enclosed at Exhibit-4.

5) Construction Water

The construction water for the power plant will be sourced from Existing PCCPP.

6) Construction Power

Construction power can be sourced from existing gas based plant with a permission of state Discoms.

7) Climate and Meteorological Data

The Meteorological and Ambient conditions Data for the Project site is given in Exhibit - 2.
5 PROPOSED INFRASTRUCTURE

Ultra super critical steam parameters have been envisaged for the proposed units.

It is proposed to use clarified water for condenser cooling. Plant consumptive water requirements will be met by treating the raw water from Narmada River. The water shall also be pre-treated before storing into clarified water storage tank to meet the designated specification requirement of clarified water suitable for the plant.

The bottom ash will be collected in wet form in double “V” type water impounded hoppers and fly ash will be collected in dry form in Fly Ash Silos. Suitable avenues for Bottom ash utilization (such as road construction, back filling low lying areas, etc.), will be looked. Un-utilized bottom ash will be disposed to the ash pond using mobile trucks from Bottom Ash discharge bin. Unutilized fly ash will be disposed off to the ash pond using mobile trucks or closed tanker.

Switchyard will be located near the power block as indicated in the Plot Plan (Dwg No. UI-GEOE14006-G-00110-001). Evacuation of power from the proposed power plant will be done at 765kV / 400 kV level. The plant will be designed in compliance with applicable National and International Codes and Standards such as ASME, ASTM, DIN, BS, IEC, IEEE, IS, etc. The plant will comply with all local statutory regulations and requirements, such as Indian Boiler Regulations (IBR), CCoE, Indian Factories Act, Indian Electricity Act, Environmental Regulations, etc.

5.1 Mechanical Systems

5.1.1 Plant Performance Parameters

The steam parameters envisaged for the plant from each unit shall be as follows.

- Main Steam pressure at HP Turbine Inlet : 285.5 ata
- Main Steam temperature at HP Turbine Inlet : 600 °C
- Hot Reheat Steam pressure at HP Turbine Inlet : 56.89 ata
- Hot Reheat Steam temperature at IP Turbine Inlet : 620°C
- Turbine Max Continuous Rating capacity (TMCR) : 2870TPH

The final steam conditions will be as per Ultra Super-Critical technology and guaranteed parameters, as agreed by original equipment manufacturer (OEM) during finalization of EPC Contract at the implementation stage of the Project.

To get the advantage of standard proven design at competitive cost, the steam parameters have been selected considering the parameters offered by different manufacturers for equipment of similar type and rating. The plant with the above steam parameters, operating with imported coal is found to be the optimum option with respect to plant efficiency and economic and reliable fuel supply.

5.1.2 Steam Generator & Auxiliaries

The proposed steam generator will be of the latest design concept. The design shall also be supported by successful operational history. The Steam Generator will have following characteristic features:
• Once-through boiler
• Simple water / steam system
• Grinding and firing system with roller mills and low NOx burners
• Two line air and flue gas system

The above features result in the following benefits:

• The furnace platen design and the bundle design being less sensitive to fouling.
• Steam generation and steam temperature unaffected by varying coal quality and fouling of the heating surfaces
• High efficiency
• High availability
• Low auxiliary power consumption
• Low emissions
• Short start-up times
• Quick load following capability

The steam generator shall be designed to operate satisfactorily with any of the fuels in the specified range and on the basis of the steam generator manufacturer’s overall knowledge of fuels from these areas.

To have flexibility in design, the Boilers shall be designed to operate satisfactorily for blend of imported coal (60%) and domestic coal (40% mix by weight)

The steam generator performance and efficiency guarantees shall be based on the ‘performance / design coal’ as specified.

A. General Arrangement

The overall arrangement for the steam generator will incorporate the following key aspects:

• The steam generator will be designed for outdoor operation arranged in the form of a self-contained construction with integrated boiler house roof.
• At the rear of the boiler two sets of regenerative air pre-heaters will be arranged with vertical flue gas ducts so as not to allow fly ash accumulation. Electrostatic Precipitators/ bag filters will be located downstream.
• The mills and bunker bay shall only be arranged on the front side of the boiler.
• Air and flue gas systems will be arranged in two-line design.
• Simple air system arrangement with single secondary air collecting duct and symmetrically arranged air ducts to the burners.
• The boiler soot-blowers will be arranged on both sides and will be placed on platforms, which will be suspended from the boiler structure.

B. Design

The steam generator shall be once-through type designed for Ultra Supercritical steam conditions, for flexible cycling operation and for sliding/modified sliding pressure operation.

The steam generator will be designed to generate about 2870 TPH of main steam at TMCR for 1000MW respectively. The steam parameters envisaged for the plant at the steam turbine inlet to generate 1000MW from each unit shall be as follows.
Main steam pressure at Superheater outlet : About 289.8 ata
Main steam temperature at Superheater outlet : About 602 °C
Hot Reheat steam temperature at Reheater outlet : About 621.4°C
Turbine Max Continuous Rating capacity (TMCR) : About 2870 TPH

The final steam conditions will depend on the equipment vendors selected.

VWO capacity shall have 5% margin over TMCR Capacity and BMCR capacity shall be 2% over and above Turbine VWO (Valve wide open condition) at 3% make up condition.

Main parts of the boiler plant will be designed for 30 years life. The pressure parts of the boiler will be designed for 200,000 operating hours.

C. Load Range and Operating Requirements

The steam generator and firing equipment shall be suitable for operation at all loads, from start-up to the maximum continuous rating (MCR) of the unit. In the range from self-sustaining load to MCR Load the unit shall be capable of stable firing without the use of fuel oil igniters or warm-up guns to stabilize the coal flame.

The unit shall be designed for safe and reliable operation under the following conditions:

- Daily load swings from self-sustaining load of MCR
- Operation at MCR for extended periods.
- Operation at self-sustaining load (minimum) of MCR for extended periods (which should be not more than 40% of BMCR while firing performance coal or worst coal).
- Sliding pressure operation at partial loads from design pressure at approximately 90% of MCR.
- Operation at all heaters out of operation condition.

D. Pressure Parts, Tubes & Headers

All pressure parts shall be designed in accordance with the most stringent conditions of ASME, Section IX and Indian Boiler regulations, IBR. Design, manufacture, testing and erection of the boiler shall be in accordance with IBR requirement.

The steam generator shall be provided with an adequately dimensioned collecting vessel, separators and a circulating pump, to ensure stable operation under low load conditions.

The separators will be designed to separate the water/steam mixture during operation below the minimum supercritical once through boiler load of 40% BMCR. The final minimum once through load of the boiler will depend on the equipment vendor selected. The entrained steam can escape upwards through the connecting pipe work to the first stage superheater. The saturated water flows downwards and then to the collecting vessel via the connecting pipe work. A certain water level will be maintained in the vessel during low load operation and the surplus will be recirculated to the economizer inlet by means of a circulation pump.

All tubes and headers shall be seamless type, truly circular, free from blisters, scale, and mechanical defects and shall meet the requirements of ASTM. Tubes and headers shall be of the material and thickness required for the service in accordance with the ASME code and approved by IBR.

Headers shall be of seamless material. Headers shall be fabricated with shop welded stub tubes for headers requiring field welded tube connections. Headers shall be provided with necessary inspection nipples.
The furnace, the superheater and the reheater surrounding walls will be water-cooled gas-tight evaporator membrane walls. In the cold flue gas section (economiser) the surrounding walls will be water cooled.

The hopper and the furnace will consist of spirally wound membrane walls. Downstream and intermediate header the convection part surrounding walls should consist of vertical evaporator membrane walls with spacing as per the standard proven design of the boiler manufacturers.

The burners will be arranged in the front and rear wall or four corners of the furnace. The location and elevation of burners will be arranged in such a way that the heat flux in the firing zone is within the permissible levels.

The Ultra supercritical once through boiler will be designed to ensure that the furnace spiral and vertical membrane walls have adequate flow stability and distribution is maintained under all operation regimes.

E. Superheater and Reheater

The superheater and reheater shall be of the radiant or convection type, or combination convection and radiant type. The superheater and reheater tubes shall be of seamless material.

Transverse spacing of panels, platens, and convection surfaces in the furnace area shall be designed to minimize ash accumulation.

Superheater and reheater headers shall be provided with shop welded stub tubes for field weld connection of thermo-couple for metal tube temperature measurement.

The superheater steam temperature control system shall utilize water spray desuperheating. The primary reheat steam temperature control system shall utilize either tilting burners or gas proportioning dampers. Excess air shall not be permitted as a control method. If gas-proportioning dampers are envisaged to overcome high maintenance requirements associated with the use of proportioning dampers with erosive coals shall be provided.

Secondary reheat steam temperature control system utilizing water spray desuperheating shall be provided. Due to the unit heat rate degradation associated with its use, the secondary system shall be used only as a backup or an emergency system, to maintain the reheating temperature during transients or abnormal operating conditions.

The steam generator shall be designed and constructed to include the equipment required for the capability of matching superheat and reheat steam temperatures to turbine metal temperatures during a turbine cold start, warm start, and hot start. Main steam and reheat steam headers and piping shall be arranged to facilitate installation of attemperators or valves required for the metal temperature matching.

All superheater and reheater heating surfaces will be of in-line arrangement and will be designed in such a way that they are fully drained and vented.

F. Economizer

The economizer shall be of the continuous bare tube non-steaming type, arranged for counter-flow of combustion gases and feed water. The economizer tubes shall be in-line and fully drainable along with headers. Extended surface shall not be considered. The economizer headers shall be located outside the gas path.
Erosion shields shall be provided to protect tubes in areas of expected ash concentrations. Tube spacing shall be such that standard soot blowing equipment may be employed for cleaning. The economizer shall be arranged in banks to allow for effective soot blowing.

G. Air and Gas System

The steam generator shall be of balanced draft type with 2x 60% capacity axial Forced Draught (FD) Fans and 2x 60% capacity axial Induced Draught (ID) Fans with a proven type with variable blade pitch control offering high efficiency. ID fans of radial type with variable frequency drive may also be considered based on the proven standard design of the supplier. The FD fans / ID fans will be designed based on the coal with the highest air requirement and flue gas volume respectively. In addition, for the design of the ID fan, the expected air leakage of the air heater during operational cycle (approximately 50% higher than design value) will be considered. Two sets of Regenerative rotary type tri-sector Air Pre-Heaters (RAPH) shall be provided for primary air and secondary air system.

(i) Air System

The air flow path designed in two parallel lines. The air ducts will be designed to limit air velocity below 16 m/sec. The ducts will be structurally rigid and leak tight. Dampers and expansion joints will be provided as per system design and layout requirements.

Combustion air will be supplied by means of the FD fans, following which the air is preheated in regenerative air pre-heaters. The primary air will be supplied by 2x60% capacity Primary Air (PA) Fans from where the primary air shall pass through regenerative air pre-heaters. For the secondary air one steam coil air pre-heater will be arranged upstream of each RAPH.

(ii) Air Heaters

Combustion air and primary air will be preheated in two sets of RAPHs. Additionally, one steam-heated air pre-heater will be installed upstream of the secondary regenerative air pre-heater.

- Steam Coil Air Pre-heater (SCAPH)

To prevent the flue gas from cooling down to its dew point, when the ambient air temperature is very low and during fuel oil firing at start-up and low load operation, one stage steam heated air heater will be provided on the discharge side of the forced draught fans. For optimized temperature control during different load conditions, the steam coil air heater will be designed as a two stage heat exchanger. The heat exchanger will be furnished with galvanized finned carbon steel tubes. The capacity and surface of the steam heated air pre-heater will be designed so that when operating under full load conditions and at lowest ambient air temperature the flue gas temperature at regenerative air pre-heater outlet can be maintained at least 10 °C above the flue gas dew point.

- Regenerative Air Pre-heater (RAPH)

The steam generator will be equipped with two sets of vertically rotating regenerative air pre-heater, one set each for primary air and secondary air. The RAPH will be provided with AC motor drive for normal operation and air motor drive for cooling during shut down in emergency. Air pre-heater will be provided with rotor stand still sensors and fire sensing and protection system for the safety of the equipment. Soot blowers will be provided for on-load cleaning of air pre-heaters during start-up (oil firing). The RAPH will be arranged so that the flue gas and air will flow through them in counter flow directions. To minimize the air leakage at the air and flue gas sides of the pre-heater, all seals will be designed so that they can be adjusted during operation.
(iii) Flue Gas System

The flue and gas ductwork system will be designed in two-line design. Flue gas ducts will be designed to ensure that the velocity of flue gas in the ducts does not exceed 13 m/sec. The ducts will be structurally rigid and leak tight. Dampers and expansion joints will be provided as per system design and layout requirements.

Electrostatic precipitator/bag filter will be located downstream of RAPH, where the flue gases will be freed of most of their dust burden before being routed through the ID Fans to the stack.

It is proposed to install high efficiency (~99.9%) ESP/Bag filter having an efficiency that limits the outlet emission below 50 mg/Nm$^3$, at BMCR operation with worst coal firing. ESP/Bag filter will be provided with microprocessor based programmable type control system for transformer rectifier sets, rappers and ESP/Bag filter management system to ensure the safe and optimum operations.

Wet limestone type flue gas desulphurization system (FGD) will be provided to minimize emission of SOx. Space is provided in the plant layout for storing, handling & feeding limestone.

One bi-flue chimney is envisaged for the two units of the plant. The chimney height will be 275 m as per environmental norms.

H. Coal Pulverisers

For meeting the coal requirement of the unit, with specified margins and spare capacities, the following criteria shall be adopted to select the number of mills for accomplishing the pulverizing task.

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of standby mills</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 100% of BMCR with worst coal firing</td>
<td>0 (Zero)</td>
</tr>
<tr>
<td>At 100% of BMCR with design coal firing</td>
<td>1 (One)</td>
</tr>
</tbody>
</table>

The type, number (n) and capacities of the mills will be selected so that the criterion specified above shall be fulfilled with 90 % loading on working mills and required fineness.

Considering the grinding fineness required, it is suggested to equip the mills with rotating classifiers. The classifier rotating speed adjustment allows control of the grinding fineness for the coal fired.

The mills shall have a pulverised coal storage capacity, which can be activated by increasing the primary airflow and/or decreasing the classifier rotating speed. The storage capacity is a function of the grindability and moisture content of the coal.

2 x 100 % capacity seal air fans common for all mills of one unit will be provided along with associated piping and valves / dampers.

Mill rejects will be handled manually. Each pulverizer shall be equipped with Mill reject hopper and the disposal of mill rejects shall be handled by using forklift truck.

I. Fuel Firing System

The grinding and firing system as well as the design of the furnace will be suitable for the use of the envisaged coal(s). With the (n-1) mills, the maximum boiler output (BMCR) should be obtained when firing the design fuel. With (n) mills, BMCR shall be obtained while firing worst coal. With only two adjacent mills in operation, the minimum stable load without fuel oil support firing the design coal will be 40 % of BMCR.
The design of the unit must also take into account the required measures so that the unit will be capable of operating with wide range of fuel characteristic.

The arrangement of the low- NOx burners, at different levels, tangential type or front/ rear wall side will be as appropriate for the type of the coal and as per the manufacturer’s proven standard practice for the units of similar type and rating, to achieve uniform furnace heating with any combination of mills in operation.

Operation of the pulverised coal firing system will be in accordance with NFPA safety regulations. Interlocks and precautionary measures implemented in the burner control system ensure safe operation required by the safety regulations.

J. Fuel Oil Firing System
The High Speed Diesel Oil (HSD) will be used for start-up and for low load support firing only. The fuel oil supply system for ignition and support of the coal firing of the boiler will consist of storage tanks, fuel oil pumping stations and a suitable number of ignition and support burners for the boiler. Project Company proposes to utilize existing 2 Nos. of HSD storage tanks and associated unloading facility within the existing plant premises for the proposed or 1000MW units.

Start-up, warm up and low load (up to 40% BMCR) operation will be carried out with HSD. Steam generator will be so designed that oil firing for flame stabilization will not be required beyond 40% BMCR.

K. Raw Coal Bunkers
The raw coal bunker shall be sized for 8 hours of worst coal for BMCR operation. The material used generally in the upper parts of the bunker shall be carbon steel plate; and the area from where cone formation is taken, carbon steel plate protected with stainless steel liners shall be used. The corners of rectangular bunkers shall be lined with curved formed stainless steel plates to avoid clogging of wet coal. The minimum valley angle shall be 65\(^\circ\) so as to ensure that there is no choking. Each of the bunkers shall be provided with radio-frequency type or equal level probes to indicate high, low, low-low levels in the control rooms and all local panels. The bunkers shall be provided with air blasters at strategic locations and the system shall be complete with air supply pipe work valves, blasters, panel etc. Motor operated rack & pinion gates shall be provided at bunker outlets. Coal chutes shall be provided with poke holes and emptying bunker chute to be suitable for loading trucks at ground floor.

L. Ash Removal
The ash removal equipment shall consist of a furnace bottom ash extractor, directly connected to the boiler bottom ash hopper outlet by an intermediate transition chute, refractory lined internally and having a water seal trough, allowing for steam generator expansion. The bottom ash will be transported to the dewatering bins through crusher (if required) with the help of submerged chain conveyer. From dewatering bins, the ash will be sent offsite for utilization. Fly ash will be extracted in dry from & stored in silos for utilization. Un-utilized bottom & fly ash will be disposed to ash pond.

5.1.3 Steam Turbine and Accessories
The steam turbine generator (STG) shall be rated for 1000MW at the TMCR condition. Steam turbine shall be provided with reheat system and regenerative feed heating system to achieve the best possible steam cycle efficiency.
Main Turbine

The steam turbine shall be multi-cylinder, tandem compound, single reheat, regenerative, condensing design with separate HP, IP and LP casing(s) directly coupled with the generator; and suitable for indoor installation. The plant would be designed to operate as a base load station. However, continuous operation under two shift and cyclic modes during certain periods of the year is also envisaged. The turbine design will cover adequate provision for quick start-up and loading of the units to full load at a fast rate. Apart from constant pressure operation, the turbine will also have the facility for sliding pressure operation. The turbine will be provided with suitable margins for VWO flow to generate at least 105% TMCR load corresponding to VWO flow.

The steam turbine is envisaged to be of three cylinders; one single flow high pressure (HP) turbine, one single flow intermediate pressure (IP) turbine and one double flow low pressure (LP) turbines. However, final configuration of the Turbine will be decided at the implementation stage during finalization of EPC Contract, considering optimum Turbine Cycle efficiency.

The rotors of the whole shaft line will be provided with integral expansion sleeve couplings and rigidly interconnected.

This steam turbine shall be of well-proven design. The shaft line support between the turbines will be designed such that well-defined loading of the bearings which leads to a well running behaviour of the machine, without problems of vibration excitation due to uneven charged adjacent bearings and misalignment problems due to differential expansion. All bearing pedestals will be mounted directly onto the foundation except the thrust bearing pedestal, which is to be designed to slide on the foundation to equalize the absolute expansion of the turbine casings. This bearing pedestal shall represent the axial fixed point of the entire shaft line.

Lubricating Oil System

The turbine generator shall be provided with a complete self contained Lubrication Oil System. The system will cater to the lubrication requirements of the bearings, turbine turning gear (if hydraulic drive is envisaged) during start up and shut down and jacking during turning gear operation. In addition, it will also supply oil to the generator seals under emergency condition. Adequate redundancy will be provided in the system to ensure safe and un-interrupted operation and safe shutdown of the turbine generator. The complete lubricating oil system shall be self-draining to a tank from where the oil can be purified, cooled & pumped back to the system.

The main lubricating oil pump will be a gear type and will be driven either by the turbine shaft or by a separate AC motor, as per the manufacturer’s standard design. The pump shall be self-priming.

During a normal operation / shutdown of the turbine generator, the oil pressure from the main lubricating oil pump will decrease to a point at which the AC motor driven auxiliary lubricating oil pump will be automatically started. A further decrease of the oil pressure will initiate the start of the DC motor driven emergency lubricating oil pump.

Turning Gear

A turning gear system shall be provided to engage and turn/roll the turbine generator shaft system prior to starting / restarting the turbine or during a trip / showdown as it is essential to ensure that there are no temporary bows in the rotor. The turning gear shall be used continuously for any period that the turbine is out of service. If at any time after a shutdown the rotor eccentricity is higher than usual, the turbine should be left on turning gear until the eccentricity indication has reached and maintained its normal minimum value for at
least one hour. Rolling the turbine shaft with a higher than normal eccentricity can lead to excessive vibration and radial rub damage, with the possibility of permanently bowing the rotor.

Turning gear motor shall be either electric motor driven or hydraulic as per the standard proven design of the Supplier.

Turning gear will be automatically started at turbine (rotor speed of less than 50 to 100 rpm) and will stop automatically when the speed rises above 50 to 100 rpm.

- **Governing System**

  The turbine shall be provided have throttle or nozzle controlled type governing. The steam turbine generator unit shall be equipped with an electro-hydraulic governing system. The governing system shall be highly reliable and operationally safe and capable of controlling, with stability, the speed of the turbine at all power outputs between zero and the specified maximum power output when the unit is operating isolated or the energy input to the steam turbine when the unit is operating in parallel with the other units. For the governing and control system of the turbine a complete self-contained control fluid system shall be provided. Adequate redundancy will be provided in the system to ensure safe and un-interrupted operation and safe shut down of the turbine generator. The working fluid for governing system shall be fireproof type synthetic oil.

- **Condensate System**

  (i) **Surface Condenser**

  Two numbers condenser shall be provided one for each LP turbine. The surface condensers shall be a single pass or double pass design heat exchanger with divided water boxes that will facilitate operation of one half, while the other half is under maintenance. The bottom of the condenser shall serve as a hot well for condensate storage. The thermal design of surface condenser shall be based on HEI standards.

  Condenser shall be sized considering 10% plugging margin in its tubes. Further condenser shall be sized such that the backpressure shall be limited within the acceptable level while parallel operation of the unit with HP/LP bypasses system. The condenser tube material shall be SS (suitable for River water use as cooling medium).

  The condenser shall be designed to accept the steam from LP bypass system as well as other steam & water drains from casing & heaters. The lowest pressure feed water heater may be installed in the condenser upper shell steam dome as per supplier’s design. The supports for the heater shall be furnished with the condenser.

  The condenser shall be provided with integral air-cooling section from where air and non-condensable gases shall be drawn out with the help of vacuum pumps. The condenser shall also be equipped with suitable steam impingement protection arrangement.

  The hot well shall be of about three minute’s condensate flow at VWO condition and shall contain an adequately sized drain connection to allow complete draining of the condenser hot well for maintenance.

  (ii) **Condensate Extraction Pump (CEP)**

  The condensate extraction pumps shall be 3x50% capacity, motor driven and of the vertical, multistage, wet pit suction, "can" type with double suction first-stage impellers.

  The CEP shall provide the head and capacity required for operation at the turbine valves wide open (VWO), 3% Make-up and 5% overpressure operating condition plus a minimum 10% design margin on both head and ca-
pacity. Each pump shall be sized in such a way that any two pumps will able to supply 110% of the flow requirements at VWO operation with 3% makeup for each unit. Shut-off head shall be at 130% of design head. The CEP shall be provided with online vibration monitoring system.

The condensate pump impellers, shafts, and shaft sleeves shall be constructed of stainless steel or materials, which have equal or exceed the strength, corrosion-erosion qualities of stainless steel.

The motors shall be vertical, solid shaft, drip-proof, and of squirrel-cage induction design. The motors shall be designed with an oil lubricated thrust bearing capable of carrying the condensate pump thrust loads under all conditions of operation.

(iii) Vacuum Pumps

Vacuum pumps of 2 x 100% capacity shall be provided. The vacuum pumps shall be of liquid ring type with both the stages (in case of 2-stage pump) mounted on a common shaft. The unit shall require no internal lubrication; and shall be free from damage by water vapour, entrained droplets or slugs of water. Pumps shall be designed for hogging as well as holding operation. Capacity of each pump shall be sufficient to maintain continuously the condenser vacuum corresponding to the saturation pressure of the condensate in hot well at design cooling water inlet temperature, when the condenser is working at its design capacity of steam, condensate and heat input (VWO steam flow, heater drains diverted to condenser etc).

The pump capacity shall be such that during turbine start-up, it is possible to create sufficient vacuum in the Condenser within 25 minutes, with both pumps working in parallel, suitable for raising the steam turbine to its rated speed.

The design capacity of each pump shall be selected to meet the above requirements with a margin of 10%. The pump TDH shall take into account the pressure drop, in suction pipeline between pumps and condenser and in the pump discharge side including air vent pipe stack outside Turbine building, as estimated for the design capacity. The operation of each pump shall be fully automatic in both holding as well as hogging operation modes.

The pumps shall be single stage / double stage, as necessary to meet the design conditions. The pumps shall not cavitate under all operating conditions. Suitable compression ratio shall be selected so that the pumps operate effectively at all conditions of operation with the specified cooling water temperature. The pumps shall be designed for indoor installation and for continuous duty to handle mixture of air, steam and non-condensable gases.

(iv) Regenerative Feed Heaters

Regenerative feed heating system shall be envisaged for the turbine cycle to improve the efficiency. While, exact number of heaters may be based on the optimization to be carried out by the EPC contractor at the implementation stage, typical feed heating system with five numbers of LP heaters, one number direct contact type deaerating heater and double train HP Heaters, each train having three HP heaters are foreseen for this type of unit, as discussed below.

HP and LP feed heaters shall be tube and shell type in horizontal arrangement. LP feed heaters will be of horizontal and U-tube type with integral drain cooler. Shell of rolled steel as per ASTM A-516 Gr. 70, Water box channel of carbon steel as per ASTM A-516 Gr. 70 and welded to tube sheet. Tubes shall be of solid drawn SS 304.
Horizontal, direct contact spray or spray cum tray type Deaerator with a horizontal feed water storage tank of about 5-10 minutes storage capacity at BMCR shall be provided. The Deaerator storage tank capacity will be selected to receive drains from boiler start-up system, if applicable. The Deaerator shall be capable of deaerating all the incoming condensate and HP heater drains. It will effectively remove the dissolved oxygen in condensate and completely remove the traces of carbon dioxide. The Deaerator will be designed such that the dissolved oxygen content is not greater than 0.005 ppm at the deaerator feed water outlet, under all operating conditions. All pressure parts such as shell, heads and nozzles shall be of carbon steel as per ASTM A-515 Gr. 70. Shell shall be of welded construction. Hardened 400 series stainless steel impingement plates for flashed drain inlet from HP heaters, BFP recirculation, boiler startup drains etc.

HP heaters will be horizontal and U-tube type with integral desuperheating, condensing and drain cooling sections. Shell will be of carbon steel as per ASTM-516 Gr. 70 and water box channel as per ASTM A-266 class-II, which shall be welded to tube sheet. Tubes to be welded to tube sheets and then roller expanded. Tube shall be of solid drawn SS 304.

All feed water heaters shall be arranged for satisfactory ‘shell pull’ during dismantling. Piping connections shall be located so that the shell can be removed with minimal piping disconnection.

(v) Condensate Polishing Unit (CPU)

For maintaining the feed water purity condensate polishing plant will be provided in the feed water cycle downstream of condensate extraction pumps. The function of the CPU will be to purify the condensate effluent from the condenser by removing solids and dissolved salts with the intent of reducing corrosion and depositions in the steam-water cycle.

The condensate polishing plant will be full flow, 4 x33.3 % capacity mixed bed trains, consisting of full capacity service vessels for each unit. The resins to be used would be strong acid cation and strong basic anion type appropriate for the influent condensate quality. The resins will be separated and regenerated externally by transferring to a dedicated regeneration station. A common external regeneration facility will be provided for both units.

The CPU will be provided with associated chemical regeneration system for preparing, measuring and dosing the required chemicals.

• Boiler Feed System

It is proposed to have 2 x 50% turbine driven feed pumps (TDBFP) and 1x50% motor driven boiler feed pump (for startup purpose) for the unit with the booster pumps mounted on a common shaft. Each pump will be designed with parameters to suit the steam generator requirements such that two feed pumps will be capable of meeting the full requirements of the boiler turbine unit with the third pump as a standby. Each pump shall be sized in such a way that two TDBFP will able to supply 110 % of the flow requirements at VWO operation with 3% makeup for each unit. A minimum 10% design margin on both head and capacity is envisaged on each pump over the above stated criteria. Shut-off head shall be at 130% of design head. The BFP shall be provided with online vibration monitoring system.

The feed flow will be controlled by controlling the speed of the drive turbine by throttling the control valve in case of turbine driven pumps, whereas hydraulic coupling will be utilized to achieve speed control of motor driven pumps. Provisions will be made for warm-up arrangement of standby pump, if required.
5.1.4 Balance of Plant

1. Coal Unloading, Transportation and Feeding System

Imported coal will be received at Dahej port by ship from overseas coal sources. The coal from port will be transported by rail to dedicated Railway siding of the project. Wagon tipplers or track hoppers (as the case may be) will be used to unload the coal at dedicated railway siding. Unloaded coal will be transported to site for storage/consumption though boxed conveyors. Coal storage dome capacity has been considered for 30 days, to take care of any contingencies in receipt of coal.

To have flexibility in design, the Coal Handling Plant shall be designed to receive, store and handle imported coal (60%) and domestic coal 40% mix by weight.

Crushers will be provided to bring down the size of coal to that suitable for the pulverisers. Capacity of the crushers and associated screens and feeders shall be decided during bid assessment stage. From crusher house after crushing the crushed coal will either be stored in coal Dome of 30 days capacity or may be sent coalbunkers in the power house for stacking. The coal dome will also have stacking and reclaiming arrangement to transfer crushed coal-to-coal bunker within power house. One number stacker cum reclaimer of 1600 TPH shall be provided.

The operation of coal handling system will be 14 hours in a day – which will be adequate to handle 24 hours of coal requirement for 1000MW (nominal) units.

2x100% capacity belt conveyors, each of capacity 1600 TPH will be provided. For each unit, the bunkers shall have a storage capacity of 8 hours of worst coal for BMCR operation. From the bunkers, the Coal will be fed to mills by raw coal feeders.

The coal handling plant will be provided with the facility for recording the quantity and analysis of the raw coal received in the station and fed to the bunkers. In-line magnetic separators, bunker level indicators, flap gates in bifurcating chutes, chute vibrators, sump pumps (for underground areas) will be provided, where-ever necessary, to make the system efficient and trouble free.

Scheme for proposed Coal handling system is shown in the attached drawing No LII-GEOE14006-M-40121-001.

Suitable pollution control measures like dust extraction and dust suppression systems shall be provided at different transfer points and crusher houses and ventilation system to supply fresh air in underground tunnels will be provided. In addition, roof extraction fans will be provided in essential areas like crusher house and boiler bunker floors. Air conditioning for control room and pressurized ventilation with unitary air filter unit for MCC buildings of coal handling plant will be provided.

Plant effluent is used in ash handling system for equipment sealing and cooling and the same will be reused for coal dust suppression system. Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc. will be provided for distributing water at all transfer points, crusher house, control rooms etc.

A centralized control room with microprocessor based control system (PLC) has been envisaged for operation of the coal handling plant. Except locally controlled equipment like travelling tripper, dust extraction/dust suppression/ventilation equipment, sump pumps, water distribution system etc., all other in-line equipment will be controlled from the centralized coal handling control room but will have provision for local control as
well. All necessary interlocks, control panels, MCC’s, mimic diagrams etc. will be provided for safe and reliable operation of the coal handling plant.

Please refer **Table 5.3** for major technical parameters.

### 2. Fuel Oil Handling System

Start-up, warm-up and low load operation (up to 40%) will be carried out by HSD for which existing storage tanks (2x600 m³) and unloading facilities will be utilized for the proposed plant. HSD is being brought to the plant by road and unloaded to the storage tanks by means of 3 nos. (2 working + 1 standby) unloading pumps.

Five (5) nos. (4 working + 1 standby) pressurizing pumps (for 2 units) will be installed to supply oil from storage tanks to boilers.

The unloading pumps are located in a pump house near the tanker-unloading header.

The pressuring pumps will be located adjacent to oil tanks. Recirculation will be provided at the outlet of pumping unit and near the burner front in the boiler, to ensure availability of fuel oil at the required pressure and temperature. Necessary piping, valves and strainers provided in the system.

Scheme for proposed HSD Fuel oil handling system is shown in the attached *Dwg No LII-GEOE14006-M-40221-002*.

Please refer **Table 5.3** for major technical parameters.

### 3. Ash Handling System

For each unit, Bottom ash will be collected in wet form; while fly ash will be collected in dry form to facilitate utilization. The un-utilized fly ash & the bottom ash will be disposed to the ash pond using mobile trucks. Ash extraction system is unitized basis and ash disposal systems will be common for all units.

To have flexibility in design, the Ash Handling Plant shall be designed to receive, store and handle imported coal (60%) and domestic coal 40% mix by weight.

Scheme for proposed Bottom Ash handling system is shown in the attached *Drawing No LII-GEOE14006-M-40421-001* and Fly Ash handling system is shown in the attached *Drawing No LII-GEOE14006-M-40421-002*.

For the design of the Ash Handling System, the following data has been considered for each Unit.

<table>
<thead>
<tr>
<th>Parameter (each Unit)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly coal firing rate at TMCR condition based on 85% PLF</td>
<td>839 TPH</td>
</tr>
<tr>
<td>- Blended coal (4280 kCal/kg)</td>
<td></td>
</tr>
<tr>
<td>Total ash content considered for</td>
<td></td>
</tr>
<tr>
<td>(a) Blended Coal</td>
<td>14 %</td>
</tr>
<tr>
<td>Bottom ash (BA)</td>
<td>20 %</td>
</tr>
<tr>
<td>Fly ash (FA + APH + DH Ash + Eco Ash)</td>
<td>90 %</td>
</tr>
</tbody>
</table>
5.1.5 Bottom Ash system

It is envisaged that the bottom ash will be collected in wet form and disposed to the ash pond. Ash extraction system is unitized basis and ash disposal will be common for two units.

Bottom ash from boiler furnace shall be collected in double “V” type water impounded hoppers. The bottom ash handling system will be provided to remove bottom ash from bottom of the boiler through submerged chain conveyor and to transport the bottom ash to the bottom ash discharge bin by submerged chain conveyor. From discharge bin, the ash will be dumped into ash disposal area by using mobile truck.

5.1.6 Fly Ash system

The fly ash handling system will be provided to remove fly ash from ESP hoppers, APH hoppers, bag filter hoppers economizer hoppers to transport fly ash to fly ash silo via ash transfer piping system which utilizes positive pneumatic dense phase fly ash handling system and further to transport fly ash from fly ash silo to the ash disposal area by using mobile truck and closed tanker. The conveying system will be sized such that ash collected in 8 hours will be evacuated in 6 hours.

For dry ash conveying to storage silos, (4W+2S) compressors will be provided for two units. The conveying system will be sized for continuous evacuation of ash from hoppers. To facilitate easy flow of dry ash, (3W+1S) fluidizing blowers will be provided for three (3) silos. Dry ash will be transported to 3 nos. main storage silos of RCC construction having 16 hrs storage capacity each, for 2 units. Each fly ash silo shall be equipped with two dry type fly ash unloaders and one wet type fly ash unloader, to unload into truck to facilitate utilization. Silo area will be provided with fencing, office block, gate complex and passage for entry/exit of vehicles. The user industries will take the dry fly ash from these silos in closed tankers.

In the event of any unutilized ash available in the silos, the same shall be transported to the ash pond through mobile trucks.

Please refer Table 5.3 for major technical parameters.

5.1.7 Ash Pond

All efforts will be made to promote utilization of fly ash to the fullest extent. In the event not enough utilization is found, fly ash shall be disposed to the ash pond (by mobile trucks). The ash pond will have a water cover always to prevent ash being carried by wind.

In view of the stringent restrictions form environmental authorities with respect to allocation of land for ash pond, the ash pond with green belt is envisaged including ash pond (storage), dyke wall, ash water lagoon and green belt purpose. The ash pond envisaged could be developed in stages.

5.1.8 Water System and Others

It is proposed to install a closed recirculating cooling water system using natural draft cooling towers, with 10°C temperature rise across the condenser. It is envisaged to design the system for Cycles of Concentration (COC) of 5.5. Clarified water shall be used in closed recirculating cooling water system.

Estimated clarified water requirement for cooling water circulation is about 98750 m³/h for each unit including auxiliary cooling water requirement of about 5925 m³/h approximately. Considering evaporation, drift loss and blow down and selected COC, the make-up water requirement will be about 4300 m³/h for two units. Accordingly, estimated raw water make-up water requirement for the cooling water system and other consumptive needs is 4450 m³/h (max.). The clarified water 466 m³/h, potable water (21 m³/h) & DM water (77 m³/h) available from existing plant have been accounted.
Scheme for proposed Water Balance Diagram is shown in the attached **drawing No LII-GEOE11006-M-00127-001**.

Please refer *Table 5.3* for major technical parameters.

### 5.1.9 Raw water Intake System

The plant raw water requirement will be met partly by existing river water Intake pump house for existing PCCPP and balance by augmentation of the raw water pumping system at the river pump house. The Intake water pump house for existing PCCPP is located at Narmada river. It is proposed to construct a separate in-plant raw water reservoir having storage of 30 days to cater the water requirements for the proposed plant. Provision for interconnection with existing in-plant raw water reservoirs shall also be made. A separate clarified water make up pump house shall be constructed to make up the clarified water to clarifiers of proposed plant.

To supply the clarified make-up water, three (3) nos. makeup water pumps (2 working and 1 standby) shall be installed at the water reservoir inside the plant.

Please refer *Table 5.3* for major technical parameters.

### 5.1.10 Circulating and Auxiliary Cooling Water System

The plant CW system will include the CW and auxiliary CW pumping system, and Natural draft cooling tower.

It is proposed to provide one common circulating water pumping station for two units in the plant. The pumping station will have Four (4) numbers of circulating water pumps, two (2) for each unit. The all four pumps shall be working. For supplying circulating water from CW pump house to TG area and from TG area to cooling tower, steel pipe will be provided. For interconnecting CW duct with CW pump, condenser and cooling towers, steel pipes would be used.

2W+1S auxiliary cooling water booster pumps will be provided for supply of auxiliary cooling water to 3x50% heat exchangers for each unit, which shall be used for cooling the closed cycle cooling water. The cooling water supply for the ACW system shall be tee off from the main cooling water pipes in the Turbine hall. The auxiliary cooling water booster pumps will be located within the TG building.

The cold water after cooling tower will be led to the CW pump house through the cold-water channel by gravity. CW system blow-down would be drawn from the discharge of the condenser. The cooling tower blow down shall be discharged in the CMB and shall be used in ash handling, dust suppression, horticulture etc. Balance liquid effluent (From CMB) will be treated in reverse osmosis. The permeate of RO will be fed so condenser cooling system & the reject will be used in the FGD system/dust suppressions etc.

Please refer *Table 5.3* for major technical parameters.

### 5.1.11 Closed Cycle Cooling Water System

Closed circuit cooling water system would be adopted for steam generator and turbine generator and common auxiliaries. DM water would be used in the primary circuit, which in turn will be cooled by circulating water in plate type heat exchangers. Make up to the primary side closed loop would be from unit DM make up system. For the secondary side, (auxiliary) cooling water would be tapped from CW inlet to condenser and discharged into the discharge duct down stream of the condenser.

Please refer *Table 5.3* for major technical parameters
5.1.12 Water Treatment System
The water treatment system comprises of Water Pre-treatment Plant, Chlorination Plant, Condensate Polishing Plant, CW Treatment Plant as described below.

DM water will be supplied from existing CCPP. DM water will be stored in 2x4,000 m³ of DM water storage tank. DM water make up requirement during normal operation is insignificant for power cycle system. The major requirement will be during commissioning & unit start up. Three nos. DM water Transfer pumps (3 X 50%) will be provided to transfer the DM Water from the DM storage tank to reserve feed water (condensate) tanks each of capacity 800 m³ for further heat cycle make up system.

The DM Water cycle make-up system will consist of 2x100% (1w+1s) cycle make up pumps for feeding to condensate hot well as well as reserve feed water storage (condensate) tank. Besides, there will be 2 x 100% SG fill pumps for plant for direct filling of SG with Demineralised Water. These pumps will be located near DM Water Tanks.

Please refer Table 5.3 for major technical parameters.

5.1.13 Condensate Polishing Plant (CPU)
For maintaining the feed water purity, condensate-polishing plant will be provided in the feed water cycle at the downstream of condensate extraction pumps. The function of the CPU will be to purify the condensate effluent from the condenser by removing solids and dissolved salts with the intent of reducing corrosion and depositions in the steam-water cycle circuits.

Each Condensate Polishing unit shall consist of Four (4) service vessels (three working & one standby vessel) of 33.33% capacity for each TG Unit /

The condensate polishing plant will be 4 X 33.33%. capacity mixed bed trains, for each unit. The resins to be used would be strong acid cation and strong basic anion type appropriate for the influent condensate quality. The resins will be separated and regenerated externally by transferring to a dedicated regeneration station. Common external regeneration facility will be provided for two (2) units.

The CPU will be provided with associated chemical regeneration system for preparing, measuring and dosing the required chemicals.

5.1.14 Chlorination plant
Chlorination shall be used for dosing into the CW system and raw water pre-treatment plant.

Continuous dosing in (a) CW pump chambers (b) Raw water intake channel to Clariflocculators to maintain a residual Chlorine @0.2 ppm will be carried out. Provisions will be made to carryout shock dosing (in CW pump chambers) at a rate of maximum 5 ppm, for 30 minutes every shift of 8 hours.

5.1.15 Service Water & Potable Water System
Drinking water requirement for the plant will be met from the existing PCCPP. There will be 2x100% drinking water pumps for colony supply and 2x100% pumps for plant supply.

Plant service water requirement will be met by a set of pumps selected as per the system parameters.
5.1.16 Effluent Treatment Plant

The Plant is designed for zero liquid discharge. Water treatment will be provided for oil contained water effluent and for RO reject. Sewage will be treated separately and reserved for horticulture. Cooling Tower blow down will be used for ash handling, dust suppression, FGD system, horticulture etc. after necessary treatment. The following are the different type of effluent to be treated before reuse.

1. The water from cooling tower blow down.
2. Effluent from clarifiers has high turbidity. It will be treated in the thickness & centrifuge. Supervalent will be recycled and solid effluent will be disposed at site.
3. All chemical area drains and CPU regeneration wastes are directed to the neutralization basin. Once the pH of the wastewater has been adjusted to acceptable limit, the neutralization basin effluent will be transferred to CMB.
4. Effluent from Boiler, Turbine and other areas, which may contain oil traces, will be pumped to oil/water separator. The oil will be pumped out periodically and trucked out for offsite disposal. Treated water will be directed to CMB.
5. The wastewater in transformer area may contain oil. Disposal of wastewater from transformer yard will be directed to Oil/water separator. Then the water will be directed to common effluent treatment plant.
6. Effluent generation is dependent, to some extent, on the operating practices in the plant. Residual effluent will be reused, to the extent possible, for dust suppression (for coal handling plant and open areas) and green belt.
7. The boiler chemical cleaning effluent is considered with the vendor since it is once a while requirement.

5.1.17 Rain Water

The rain water will be collected in the rain water harvesting pits from the storm water drain running all around the project. Rain water harvesting pits are connected at regular interval to the storm water drain. Thus the rain water will recharge the ground water.

Excess rain water will flow to common collection pit from where water can be pumped for reuse in the plant.

The plant sanitary waste will be treated in the sewage treatment plant.
Table – 5.2
Details of Effluents (At MCR operation)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Source of Effluent</th>
<th>Quantity (m³/h)</th>
<th>Quality</th>
<th>Disposed to</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooling Tower Blow Down</td>
<td>827</td>
<td>NA</td>
<td>CMB</td>
<td>Used for cycle make up, AHP make up, FGD CHP, Gardening etc.</td>
</tr>
<tr>
<td>2</td>
<td>Boiler blow down</td>
<td>Nil</td>
<td>NA</td>
<td>CMB</td>
<td>Nil for once-through boiler</td>
</tr>
<tr>
<td>3</td>
<td>DM Plant N Pit</td>
<td>Nil</td>
<td>NA</td>
<td>NA</td>
<td>DM water supply from existing PCCPP</td>
</tr>
<tr>
<td>4</td>
<td>PTP sludge and filter back wash</td>
<td>14 approx.</td>
<td>Thickner centrifuge</td>
<td>Solid waste disposed at site.</td>
<td></td>
</tr>
</tbody>
</table>

Please refer enclosed Plant water balance diagram.

5.1.18 Fire Detection and Protection System

A comprehensive fire detection and protection system is envisaged for the complete power station. This system will generally conform to the recommendations of TAC guidelines and NFPA – 850.

Scheme for proposed Fire fighting & protection system is shown in the attached Drawing No LII-GEOE14006-M-41521-001.

The following fire detection and protection systems are envisaged.

Hydrant system for complete power plant covering the entire power station including all the auxiliaries, buildings in the plant area. The system will be complete with piping, hydrants, valves, instrumentation, hoses, nozzles, hose boxes/stations etc.

Automatic high velocity water spray system for all oil filled transformers located in transformer yard and those of rating 10 MVA and above located within the boundary limits of plant, main and unit turbine oil tanks and purifier, lube oil piping (zoned) in turbine area, generator seal oil system, lube oil system for SG feed pumps, consisting of detectors, deluge valves, projectors, valves, piping, instrumentation etc.

Automatic medium velocity water spray system for cable vaults and cable galleries of the main plant, switchyard control room, CHP control room and ESP control room consisting of smoke detectors, linear heat sensing cable detectors, deluge valves, isolation valves, piping, instrumentation, etc.

Automatic medium velocity water spray system for conveyors, galleries, transfer points and crusher house consisting of quartz bulb (QB) detectors, linear heat sensing cables, deluge valves, nozzles, piping, instrumentation, etc.

Automatic medium velocity water spray system for un-insulated fuel oil tanks storing fuel oil having flash point 65 deg C and below consisting of QB detectors, deluge valves, nozzles, piping, instrumentation, etc.

Automatic sprinkler or water spray system shall be provided for store.
Foam injection system for fuel oil storage tanks consisting of foam concentrate tanks, foam pumps, in-line inductors, valves, piping & instrumentation etc.

For protection of control room, equipment room, computer room and other electrical and electronic equipment rooms, suitable “Halon substitutes” such as “INERGEN” or “AGRONITE” system would be provided.

Fire detection and Alarm system – A computerized analogue, addressable type early warning system will be provided to cover the complete power plant with compatible detection systems.

Portable and mobile extinguishers, such as pressurized water type, carbon-dioxide type, foam type, dry chemical powder type, will be located at strategic locations throughout the plant.

1 no. fire tender of water type, dry chemical powder (DCP) / foam type, trailer pump with fire jeep etc. shall be provided in the fire station.

An over ground fire water pump house will be constructed near these firewater storage tanks.

The Fire water supply system shall consist of the following major equipments:

- Two (2x100%) main electric motor driven hydrant pump
- One (1x100%) Diesel engine driven hydrant pump
- One (1x100%) electric motor driven spray water pump
- One (1x100%) Diesel engine driven spray water pump
- Two (2x100%) electric motor driven pressure maintenance pump

Firewater pumps will be installed in the pump house for hydrant and spray system and the same will be driven by electric motor and diesel engines as per TAC guidelines. The water for foam system will be tapped off from the hydrant system pumps.

For the above firewater pumping station, automatic pressurization system consisting of pressure maintenance pumps and pneumatic tanks will be provided. The Fire Protection Water supply system shall be maintained at a static pressure of 8 bar by the pressure maintenance pump which shall start automatically when the pressure falls below a preset level.

Depending on the requirement in detail design – if required booster pumping stations should also be provided.

All necessary instrumentation & controls for the entire fire detection, alarm and protection system will be provided for safe operation of the system.

Please refer Table 5.3 for major technical parameters.

5.1.19 Service Air & Instrument Air System

For service air and instrument air requirement of main plant and auxiliaries, total five nos. (4W+1S) air compressors each having a capacity of 35 Nm3/ min (approx) and a discharge pressure of 8.5 kg/cm2 (g) shall be provided. These compressors will be oil-free screw type provided with all accessories such as suction filters, inter-coolers, after coolers etc.
Both instrument air and service air shall take air from its own common discharge manifold from the oil free screw type compressor. The two manifolds are interconnected with a non-return valve fitted in between to allow one way flow from services air to instrument air side as emergency back-up.

Desiccant type air dryers with sufficient standby capacity and capability of achieving a dew point of – 40 deg. C will be provided on the instrument air system.

The air drying plant shall be given a tap off from the common manifold to dry out the air. Individual air receiver will be provided near each air compressor and further unit air receivers will be provided near main plant of each unit.

Detail Scheme for the proposed Compressed Air system is shown in the attached Drawing No LII-GEOE14006-M-41621-001.

Please refer Table 5.3 for major technical parameters.

### 5.1.20 Air Conditioning System

Inside design conditions of 25±1°C dry bulb temperature and relative humidity not exceeding 50% ± 5% is proposed to be maintained in all air-conditioned areas.

Air Conditioning system will be provided for all those areas, which require close control of environment conditions and will cover the following areas:

Central Control Room consisting of Control Rooms, Control Equipment rooms, Telecommunication Rooms, Microprocessor, Computer and Programmers Rooms, Data Storage Rooms, UPS Rooms, Instrumentation Laboratory and Steam & Water Analysis Rooms, Conference Room, Shift Charge Engineer’s Room (if applicable), Relay Rooms.

The Chilled water Plant for main plant, shall consist of two numbers (2 x 100% capacity) "Vapour Compression" type chilling units employing electrically driven screw/centrifugal type compressors for plant capacity 100 TR and above and reciprocating type compressors up to 100TR. This system also consists of 2 x 100% capacity chilled water pumps. Area wise 50% standby AHUs shall be provided i.e. areas can be air conditioned using a set of AHUs with a redundancy of 50% for main plant. Fresh air units shall be 1 x 100 % capacity.

The following areas will be provided with the above Air Conditioning system:

- ESP Control Room.
- Coal Handling Plant Control Room.
- Switchyard Control Room including Computer Rooms, Telemetry Room, PLCC & Telex Room.
- Required areas in Service/Facilities Building/Administration Building.
- Demineralization plant Control Rooms, Water and Fuel Analysis Room, Instruments Room.
- Any other area, which contains control and instrumentation equipment requiring Space Conditioning or otherwise requires being air conditioned.

For other areas, either package type air-conditioning unit will be provided as per requirement.

### 5.1.21 Ventilation system

Ventilation system will be designed to supply fresh outdoor air and will be selected for maintaining inside conditions for those areas where close control of temperature is not required, but nevertheless have a stipulated maximum temperature.
The exhaust of hot air out of the station building will be achieved by provision of roof extractors and wall mounted exhaust fans. With this system the dry bulb temperature (DBT) within the turbine building will be maintained at a temperature not exceeding outside ambient by 5°C at all times of the year.

The following areas will be provided with forced ventilation system with filtered supply air and exhaust fans / roof exhausters:

- All rooms of turbine building which are not air-conditioned.
- Switchgear rooms and cable galleries of main plant
- Non air conditioned area of ESP control room
- Any other areas where equipment heat load is high.

Battery rooms, Chemical stores and toilets will be provided with exhaust ventilation with minimum 12 air changes. All other buildings / areas will be ventilated by mechanical ventilation process using combination of filtered supply air fans and roof exhausters or wall mounted exhaust fans.

5.1.22 Piping System

Piping, valves, fittings, supports, for steam, condensate, water, oil, air and others etc. will be provided as per the requirement of the systems. Pipelines running outside the powerhouse will be routed on pipe trestles to the extent possible. However large diameter raw water and cooling water pipes will be buried. Proper protection, by wrapping coating and/ or other necessary corrosion protection devices, will be taken. For high temperature steam line ASTM A-106 Gr. B, ASTM A-335, P22, P91, P92 shall be used.

5.1.23 Chemical Feed System

Although high purity water will be used as heat cycle make-up, careful chemical conditioning of the feed steam condensate cycle is essential as a safeguard against corrosion and possible scale formation due to ingress of contaminants in the make-up system.

Normally All Volatile Treatment (AVT) chemistry is adopted for Once through supercritical boiler. AVT is the traditional water treatment method where Hydrazine and ammonia or amine is injected upstream of Low Pressure heaters of the condensate system or down-stream of condensate Polishing plant. As high purity of feed water is required and no additional conditioning chemicals can be fed to the boiler, the use of condensate polishing is required with once through units.

Now another system which is known as Oxygenated water treatment (OWT) has been applied by few manufacturer to overcome the problem faced in AVT.

In OWT system, ammonia and oxygen will be injected upstream of Low Pressure heaters of the condensate system. Also oxygen can be injected in the Boiler Feed pump suction.

The following chemical dosing system to be provided;

Ammonia + hydrazine dosing for start up and Ammonia + oxygen dosing for normal operation.

The Chemical Feed System shall consist of two independent systems of Low Pressure (L.P) Dosing Systems for AVT system. The LP dosing system shall be designed on unit system i.e. each power generation unit shall have its own chemical dosing system and thus shall be independent of other units in the station. The chemical feed systems shall be self contained and complete.
5.1.24 Condenser On-load Tube Cleaning System

Each condenser half will be provided with Condenser On Load Tube Cleaning System complete with ball recirculation Units complete with pumps, drive motors, ball collectors, etc. and appurtenances matching the requirements of the Condenser.

5.1.25 Hydrogen Gas System

Hydrogen gas with a purity of 99.9% (by volume) is required for cooling of the generators. It would be required for the initial filling and continuous make-up during normal operation for maintaining the required purity in the generator. The normal Hydrogen gas requirement for one unit is about 12 N cu.m / day. This requirement will be met by procuring the Hydrogen gas cylinders from the external sources.

5.1.26 Thermal Insulation

All equipment / pipes / ducts whose surface temperature is higher than 60°C, will be provided with thermal insulation for personnel protection and heat conservation. The insulation material will be chemically inert, non-combustible and will be harmless. Outer surface of the insulation will be covered with aluminium cladding of 22 BWG. Materials and thickness of insulation will be selected so as to limit the surface temperature to 60°C.

5.1.27 Cranes & Hoists

Two (2) no. of EOT cranes each are envisaged in the turbine hall for erection and maintenance of turbo-generators and their auxiliaries except generator stator. The main/aux hook capacity of each crane will be 10% over and above the heaviest component / equipment (including lifting beam and slings etc.) to be handled in TG hall.

CW Pump house, Workshop and other Facilities requiring frequent handling of heavy loads will also be provided with EOT cranes of suitable capacity. For handling other heavy equipment weighing more than 3000 kg or lifting height of more than 10 m or travel of more than 15 m shall be electrical hoist. Manual hoist with / without trolleys for loads more than 40 kg for the safe and efficient operation of the plant, unless specified otherwise. Manual cranes and hoists of appropriate type and rating will be provided.

Gantry crane of suitable capacity has been envisaged for the gates / screens of CW pumping stations, raw water pumping station etc.

The hoisting equipment capacities will be finalized during detail engineering after finalization of building sizes, layout and equipment details.

5.1.28 Chimney

A 275 M high RCC chimney is envisaged to comply with environmental regulations. The chimney will be provided with lightning arrestors and aviation warning lights. System design will include on-line Opacity / Suspended Particulate matter monitoring system, SOx and NOx monitoring system, CO monitoring and Flue Gas Oxygen analysers etc. The Chimney will be provided with rack & pin-ion type elevator to facilitate maintenance.

5.1.29 Elevators

One (1) goods-cum-passenger elevator of about 3000 kg carrying capacity will be provided for each of the steam generating units. One (common for both units) passenger elevator will be provided for bunker bay /
tripper floor. One (1) goods-cum-passenger elevator of 1000 kg at the power house building. One (1) no. for Service building.

One (1) – 1000 kg passenger cum goods elevators to be provided for TP near coal bunkers and one (1) – 1000 kg passenger cum goods elevators to be provided for Crusher House of Coal handling plant.

Please refer Table 5.3 for major technical parameters.

5.1.30 Painting & Corrosion Protection

All mechanical and electrical equipment including piping system and structures will be painted with international standards / IS standard colour code for ease of identification. All steel structures will be painted with epoxy resin based paints. Galvanised structures will have minimum 610 mg/m² zinc coating. Suitable allowance on thickness will be provided for the surfaces, which cannot be protected by application of painting. All buried piping will be provided with bitumen paint based coating and wrapping.

5.1.31 Workshop & Laboratory

The power plant will be equipped with a work shop capable of catering to the routine maintenance requirements of the plant. A central chemical laboratory adjacent to the DM plant buildings is envisaged for the station. This will have necessary equipment and facilities to test and analyze steam, water, oil, coal etc. required to ensure satisfactory operation and maintenance of the station.

5.1.32 Major Technical Parameters

Please refer Table 5.3 for major technical parameters.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>Technology Features of Equipment/ System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Steam Generator</td>
<td>2</td>
<td>Circulation: Assisted Forced Circulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Furnace bottom: Dry/Wet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Draft: Balance/Forced</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum continuous rating</td>
</tr>
<tr>
<td></td>
<td>BMCR</td>
<td>T/hr</td>
<td>~ 3070</td>
</tr>
<tr>
<td></td>
<td>Nominal (TMCR)</td>
<td>T/hr</td>
<td>~ 2870</td>
</tr>
<tr>
<td></td>
<td>Pressure at super heater outlet</td>
<td>Ata</td>
<td>289.8</td>
</tr>
<tr>
<td></td>
<td>Temperature:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At Super heater outlet</td>
<td>°C</td>
<td>602</td>
</tr>
<tr>
<td></td>
<td>At Re-heater outlet</td>
<td>°C</td>
<td>621</td>
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<td>Air Pre-Heaters</td>
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<td>Regenerative (bi-sector) (Ljungstrom)</td>
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<td>Type</td>
<td>Unit</td>
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<tr>
<td></td>
<td>Nos.</td>
<td>2 Nos/unit</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Milling Plant per unit</td>
<td></td>
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<tr>
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<td>Mill</td>
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<tr>
<td></td>
<td>Type: Bowl/Tube/Ball &amp; Race</td>
<td>Bowl</td>
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<td></td>
<td>Nos: Working /Standby</td>
<td>n / 0 (BMCR with worst coal)</td>
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<td></td>
<td>Capacity/Mill</td>
<td>T/hr</td>
<td>About 90</td>
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<td>PA Fans</td>
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<tr>
<td></td>
<td>Nos.</td>
<td>2x60% for each unit</td>
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</tr>
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<td>1.3</td>
<td>Draft Plant per unit</td>
<td></td>
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<td>ID Fans</td>
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<tr>
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<td>Type: Radial/Axial</td>
<td>Axial or Radial</td>
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<tr>
<td></td>
<td>Nos: Working/Standby</td>
<td>2x60% for each unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drive: Fixed/Variable speed</td>
<td>Variable speed for radial type/Blade pitch controlled for axial type</td>
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<td></td>
<td>FD Fan</td>
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<td>Nos: Working/Standby</td>
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<td>Drive: Fixed/Variable speed</td>
<td>Blade pitch controlled</td>
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<td>Dust Extraction System</td>
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<td>Nos. of Fields</td>
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<td>Outlet dust Concentration</td>
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<td>With one field out</td>
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<td>Collection Efficiency</td>
<td>%</td>
<td>&gt;99</td>
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<td>Flue Gas Desulpharisation System</td>
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<td>Passenger cum Goods Elevators with all controls (SG)</td>
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<tr>
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<td>Capacity</td>
<td>Kg</td>
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</tr>
<tr>
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<td>Turbine</td>
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<tr>
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<tr>
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<td>No. of Cylinder</td>
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<td>At Reheat</td>
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<td>2x50%-TDBFP+1x50%MDBFP</td>
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<td>Type: Motor driven/Turbine driven</td>
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<td>No/Unit</td>
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<td>TPH</td>
<td>As per system requirement</td>
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<td>Condenser on load tube cleaning system</td>
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<td>Ball type</td>
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<td>Pipe conveyor (1x 100%)</td>
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<td>Belt Conveyors (main)</td>
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<td>1W+1S</td>
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<td>Capacity/streams</td>
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<td>1600</td>
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<tr>
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<td>Type</td>
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<td>Ring granulator</td>
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<td>Nos: Working/standby</td>
<td>To be decided during bidding stage</td>
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<td></td>
<td>Capacity</td>
<td>T/hr</td>
<td>To be decided during bidding stage</td>
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<tr>
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<td>Type</td>
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<td>Capacity</td>
<td>T/hr</td>
<td>1600</td>
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<td>Stacker/Re-claimer at Nabipur coal stack area</td>
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<td>Type</td>
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<td>Bucket wheel type with bi-directional trunk conveyor</td>
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<td>Nos</td>
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<td>Capacity</td>
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<td>1600 Stack yard/reclaiming</td>
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<td>Boom Length</td>
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<td>Coal Stock</td>
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<td>Open at 85% PLF</td>
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<td>No. Of Days</td>
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<td>Mill Reject System</td>
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<td>Type: Belt Conveyor/ Pneumatic conveying / any other</td>
<td>Manual mill reject handling system</td>
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<td>Fuel Oil Storage Tanks</td>
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<td>LDO</td>
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<td>Unloading Pumps</td>
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<td>Nos: Working/Standby</td>
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<td>Description</td>
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<td>Nos: Working/Standby</td>
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<td>Bottom Ash Handling Plant</td>
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<td>Type:</td>
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<td>Submerged conveyor &amp; Wet slurry</td>
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<td>Capacity/unit</td>
<td>T/hr</td>
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<td>9.2</td>
<td>Fly Ash Handling Plant (Dry Collection)</td>
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<td>Type:</td>
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<td>Capacity/unit</td>
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<td>Reservoir/ Canal/ Bore Wells/ River /Sea</td>
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<td>Raw Water System</td>
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<td>River water Pumps</td>
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<td>Nos: (Working / Standby)</td>
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<td>Capacity</td>
<td>M³/hr</td>
<td>As required for balance water requirement</td>
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<td>In-plant Raw water Storage Capacity</td>
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<td>10.3</td>
<td>Condenser Cooling system</td>
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<td>(Director/Indirect/Once through/pond cooling)</td>
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<td>Recirculating</td>
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<td>CW Pumps</td>
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<td>Nos. (Working/Standby)</td>
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<td>4/0 for two units</td>
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<td>Cooling Tower</td>
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<td>Type: (I.D./N.D./Dry)</td>
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<td>Natural draft, One per unit</td>
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<td>Flow</td>
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## Proposed Infrastructure

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<th>Technology Features of Equipment / System</th>
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<td>°C</td>
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<td>Wet Bulb Temp</td>
<td>°C</td>
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<td>Dry Bulb Temp</td>
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<td>Evaporation &amp; Drift Loss</td>
<td>m³/hr</td>
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<td>5</td>
<td>Blow Down</td>
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<td>6</td>
<td>Make-up water Quantity</td>
<td>m³/hr</td>
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<td>Quality of Water (Clarified/Filtered/DM Water)</td>
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<td>Clarified Water &amp; RO per mease</td>
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<td>10.4 Auxiliary Water System</td>
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<td>Effluent Collection Storage Capacity</td>
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<td>13.0 Compressed Air System</td>
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<td>five(5),(4W+1S)</td>
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<td>Three(3), (2W+1S)</td>
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<td></td>
<td>Nos</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Detailed Project Report
2x1000 MW Coal Based TPP at Paguthan, Bharuch District, Gujarat (India)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>Technology Features of Equipment/ System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity: Main Hook/ Aux. Hook</td>
<td>Tonnes</td>
<td>Adequate</td>
<td></td>
</tr>
<tr>
<td>14.2</td>
<td>Other Cranes &amp; Misc. Hoists (specify and give details)</td>
<td></td>
<td>For more then 3000 Kg electrically operator Hoist &amp; for more then 40 kg manually operated Chain Pulley Block.</td>
</tr>
<tr>
<td>15.0</td>
<td>Coal Transportation</td>
<td></td>
<td>Railway Wagons (BOXN type)/Conveyors</td>
</tr>
<tr>
<td>16.0</td>
<td>Air Conditioning System</td>
<td></td>
<td>Chilled water system / packaged AC units</td>
</tr>
<tr>
<td>17.0</td>
<td>Ventilation System</td>
<td></td>
<td>Mechanical Forced Ventilation as per requirement.</td>
</tr>
</tbody>
</table>

5.2 Electrical Equipment & System Design

5.2.1 Arrangement of Electrical System

The electrical power distribution system for the proposed power plant is shown in the enclosed drawing: Dwg. No. LII-GEOE14006-E-00140-001, Key Single Line Diagram.

Each proposed Generator unit of nominal rating 1000 MW at 0.85 pf shall be directly coupled with its respective steam turbine. The generation voltage is envisaged as 24 kV (or other voltage as per manufacturer’s standard design) ± 5%, 3 phase, 50 Hz, (+) 3% to (-) 5%. Each generator unit will be connected to 765kV or 400 KV Switchyard through its respective Generator step-up Transformer (GSUT) for evacuation of power.

Each GSUT will consist of three nos. 415 MVA,(800/√3)/24kV or (420/√3)/24 kV, single phase transformers.

Isolated Phase Bus Duct (IPBD) will be provided for connection of each Generator with its respective GSUT & Neutral Grounding Equipment. Delta connection of LV side of GSUT will be done by IPBD. Tap off connections to 1No. Unit Auxiliary Transformer, Static Excitation Transformer, Voltage Transformers and Surge Protection Cubicles shall be provided from main run of IPBD.

Two nos. 120/60/60 MVA, 24/11.5/11.5 kV, three-phase, three-winding, oil immersed, outdoor type, Unit Auxiliary Transformer (UAT) have been envisaged to cater total auxiliary loads for 2x1000 MW (nominal) units. Further, One (1) nos. 120/60/60 MVA, 765 /11.5/11.5 KV or 400/11.5/11.5 KV, Startup/Stndby three winding transformer is proposed for the 2X1000MW (nominal) units. This arrangement will provide redundancy in power supply to the unit and station auxiliaries of the proposed power plant. In case of failure of power supply through Unit Auxiliary Transformer, automatic Fast Bus Changeover Scheme is envisaged.

Normally, the unit auxiliary load on one unit and almost half of the station load will be supplied from one Unit Auxiliary Transformer (UAT). Two nos. 11 kV Unit Switchgears have been envisaged for power distribution to various 11 kV motors and downstream 415 V switchgears for each unit. Start up/ Stand by transformer will also be connected to these Unit switchgears through NSPBD. On Loss of supply to any Unit switchgear, the respective loads of UAT shall be fed by this Start up/ Stand by transformer through automatic fast bus changeover scheme. Suitable numbers of 415 V switchboards are envisaged for unit and station loads.
For supply of unit and station auxiliary loads of the proposed power plant, following voltage levels have been envisaged:

- **11kV, 50kA for 1 sec, 50Hz, 3-phase, 3-wire, medium resistance grounded AC supply for motors rated above and including 200 kW.**
- **415V, 50kA for 1 sec, 50Hz, 3-phase, 4-wire, solidly grounded AC supply through 11/0.433 kV auxiliary/service Transformers for motors rated below 200 kW and other LT services.**
- **415 V emergency power through Emergency DG set**
- **220 V DC for emergency drives, emergency lighting, Protection, Control and Indication systems**
- **24 V DC for Power Line Carrier Communication (PLCC) systems**

The power supply for various 11 kV unit/station auxiliary motors and auxiliary/service transformers for unit/station services will be fed from 11 kV Unit Switchgears. The service transformers will be three-phase, two winding, 11kV/433 V.

Suitable number of unit and station services transformers will be provided. The transformers will be suitable for outdoor applications having Dyn11 Vector group. The star point will be solidly earthed.

The transformers will be located at different load centres to feed the respective 415V switchgears in that area. All 415V switchgears will have 2x100% incoming feeders, to be fed by 2x100% LT auxiliary/service transformers, and bus coupler to achieve maximum redundancy and reliability during operation. In order to limit the fault level of 415V switchgears, paralleling of two incomers has not been envisaged, except during momentary paralleling in case of manual live change over, wherever provided.

Plant emergency power will be provided from emergency Diesel Generator (EDG) sets to take care of any emergency situation particularly in the case of grid failure condition. One 100% capacity 415V, 3-ph, 4W, 50 Hz Emergency DG Set has been envisaged for each unit with automatic starting facility to restore the supply at respective 415V Turbine Switchgear for supplying emergency power required for safe shutdown of the respective unit.

The redundancy of the overall system will be such that failure of any individual equipment will have the minimum possible effect on the plant’s performance capability and ensure safe shut down of the unit.

On loss of supply from either of Unit Auxiliary Transformers, the respective 11 kV Unit Switchgear will be fed through Start up/ Stand by Transformer with the help of microprocessor based fast bus transfer system.

Fast bus transfer scheme is envisaged at 11kV switchgears and automatic slow bus changeover scheme is envisaged at 415 V switchgears. In case of total power failure, diesel generator will start automatically to feed power to respective 415 V Emergency Switchgear where all essential loads will be connected.

All electrical equipments for the proposed power plant including 765kV or 400 kV switchyard equipment shall be designed for the following conditions:

- **Voltage Variation** : ±10%
- **Frequency variation** : - 5% to + 3%
- **Combined voltage & frequency variation (absolute sum)** : 10%
- **Design ambient temperature** : 50°C
However, the equipment fed from 220V DC supply shall be suitable for voltage variation of +10% to -15%. Following tentative fault levels will be considered for design of all electrical equipment at various voltage levels. Fault levels shall be restricted to the same.

<table>
<thead>
<tr>
<th>System</th>
<th>Fault Level</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>765kV</td>
<td>50kA</td>
<td>1 second</td>
</tr>
<tr>
<td>400 kV</td>
<td>40 kA</td>
<td>1 second</td>
</tr>
<tr>
<td>11 kV</td>
<td>50 kA</td>
<td>1 second</td>
</tr>
<tr>
<td>415 V</td>
<td>50 kA</td>
<td>1 second</td>
</tr>
<tr>
<td>220 V DC</td>
<td>25 kA</td>
<td>1 second</td>
</tr>
<tr>
<td>24 V DC</td>
<td>25 kA</td>
<td>1 second</td>
</tr>
</tbody>
</table>

The insulation level for the transformer windings, bushings and other insulators will be as given below:

<table>
<thead>
<tr>
<th>Nominal System Voltage (kV)</th>
<th>Highest System Voltage (kV)</th>
<th>Rated 1 Min Power Freq. Withstand Volt (kV rms)</th>
<th>Rated Lightning Impulse Withstand Voltage (kV peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>12</td>
<td>28</td>
<td>75</td>
</tr>
<tr>
<td>400</td>
<td>420</td>
<td>630</td>
<td>1425</td>
</tr>
<tr>
<td>765</td>
<td>800</td>
<td>830</td>
<td>1950</td>
</tr>
</tbody>
</table>

For 765kV, switching impulse withstand voltage will be 1550 kV peak and for 400 kV class, switching impulse withstand voltage will be 1050 kV peak. Creepage distance for exposed bushing/insulators will be minimum 31 mm / kV.

The neutral point of each Generator will be grounded through single-phase neutral grounding transformer with a loading resistor, connected at its secondary side, to limit the earth fault current to about 10 amps. 11 kV systems will be low resistance earthed to limit the earth fault current to around 300 Amps. 415 V system will be solidly earthed. The DC systems will be unearthed. The 765kV or 400 kV system will also be solidly earthed.

### 5.2.2 Generator

Each Generator will be of 3-phase, two-pole, horizontal mounted, cylindrical rotor type, directly driven by the steam turbine and rated for 1000 MW at 0.85 lagging to 0.95 leading power factor. The generation voltage is envisaged as 24 kV (or any other voltage as per manufacturer’s standard design) ± 5%, 3 phase, 50 Hz (+) 3% to (-) 5%. The Generator will generally comply with the requirements specified in IEC-60034.

The insulation of stator and rotor winding shall be of Class-F with a temperature rise limited to Class-B. The Generator neutral will be grounded through a single-phase neutral grounding transformer with a loading resistance, connected at its secondary side.

The stator winding will be directly cooled by water flowing inside the hollow stator conductor. The stator core will be directly cooled by hydrogen. The rotor winding and core will be cooled by hydrogen. Hydrogen will flow in a closed loop circuit and in turn will be cooled by DM water in a closed loop circuit.
The generator excitation system will be selected to provide the following basic requirements:

- To maintain the Generator terminal voltage within $\pm 5\%$ of the pre-set value over the entire load range of the machine.
- To control the Generator during system disturbance or transients in which rapid changes in excitation are required to maintain system stability margins both in steady state and transient condition.
- The excitation system will be static type. The ultimate aim of the excitation system selection will be focused to achieve an ideal rate of response, simplicity, reliability, accuracy and sensitivity.

Each Generator will consist of the following auxiliaries:

- Static excitation system
- Automatic Voltage Regulator (AVR)
- Power System Stabilizer (PSS)
- Vibration Monitoring System
- Hydrogen cooling complete with hydrogen coolers and seal oil system
- Overheat monitoring system
- De-mineralized water stator cooling system, if applicable
- Alkaliser unit, if required
- Connection to isolated phase bus duct
- Current transformers for metering and protection
- Voltage transformers for metering, protection and synchronization
- Lightning arresters and surge capacitors

5.2.3 Generator Bus Duct

Each Generator will be connected to its respective Generator Step-up Transformer through main run bus duct and to respective Unit Auxiliary Transformers, Voltage Transformers and Surge Protection Cubicles through tap-off bus duct. Tap-off connection to Static Excitation Transformer will also be provided. The isolated phase bus duct on generator neutral side shall be complete with generator neutral side current transformers, neutral point formation, neutral bushing of appropriate voltage class and shall be connected to the Neutral Grounding Equipment. The bus duct will be of isolated phase, continuous type with aluminium conductor in aluminium enclosure.

The continuous rating of the main run of the bus duct shall be arrived at considering the maximum output of the generator at 95% of the generator voltage with VWO condition.

The bus duct enclosure will be of welded construction. The bus ducts will be naturally cooled, dust tight and weather proof in construction. Generator IPBD shall be dry air pressurised to prevent infiltration of dust & moisture to maintain the di-electric strength of the air inside. The pressurization system shall be complete with filter & dryer pressure reducer and pressure gauges with electrical potential free contacts for remote monitoring.

The main run of the Generator bus duct will be designed to withstand the higher value of the fault current fed from either the Generator or the utility grid through Generator step-up transformer & fault current through Unit Auxiliary Transformer. The tap off runs will be designed to withstand the fault current fed from the generator, the utility grid through Generator step-up transformer and the Unit Auxiliary Transformer. The bus duct will be designed to withstand a through fault of 1sec. duration.
5.2.4 Generator Step-up Transformer

The generated voltage will be stepped up and fed to 765kV or 400 kV by a step-up transformer connected to the Generator terminals through isolated phase bus duct. Each GSUT will be a bank of three single-phase, oil filled, outdoor type transformers, each rated for 415 MVA, (800/√3)/24 kV or (420/√3)/24 kV, 50 Hz suitable for maximum utilization of generator capacity. The three single phase units will be connected to form YNd11 vector group. Each single phase transformer will have ONAN/ ONAF/ OFAF or ODAF type of cooling arrangement. It will be provided with Off Circuit Tap Changer (OCTC) having range of ±5% of nominal voltage at 2.5% per tap. The high voltage terminals of each Generator Transformer will be connected to the 765kV or 400kV switchyard by overhead conductors. One 415 MVA, single phase unit will be provided as spare and will be located in the transformer yard.

To protect the Transformer against lightning strokes/surges, lightning arresters will be provided near HV terminals of the transformer.

The transformer will be designed in conformance with the following requirements:

- Continuous internal pressure withstand capability of tank: 35 kN/m² over normal oil pressure and short circuit forces
- Over-fluxing (V/f) withstand capability: 110% continuous at all operating conditions
  - 125% for at least one minute
  - 140% for at least five seconds
- Through fault current withstand time: 2 seconds
- Temperature rise over 50°C ambient temperature:
  - Top oil (by thermometer) 50 °C
  - Winding (by resistance) 55 °C
- Loading capability of the transformer: In accordance with IEC 354
- Maximum Noise Level when energised at normal voltage and frequency with fans running: In accordance with NEMA TR-1
- Degree of protection for all outdoor kiosks like cooler control cabinet, marshalling box etc.: IP 55

5.2.5 Plant Switchyard

a) General

A 765kV or 400kV Gas Insulated Switchyard has been envisaged for evacuation of power and for availing start up / shut down / Unit backup power for the proposed power plant. This switchyard will be located in an area separate from the main power house building. The switchyard will be provided with the following 765kV or 400kV Bays:

1) Generator Step-up Transformer #1 Feeder
2) Generator Step-up Transformer #2 Feeder
3) Start up/ Standby Transformer Feeder
4) Outgoing line Feeders #1
5) Outgoing line Feeders #2
6) Future bay
7) Tie between existing and new 400kV switchyard main Bus #1 (this tie connection will be applicable only if the power is evacuated at 400kV lines).

8) Tie between existing and new 400kV switchyard main Bus #2. (this tie connection will be applicable only if the power is evacuated at 400kV lines).

9) Bus Reactor #1 Feeder (if required)

The switchyard will have its own Control Building for control, protection and supervision of the equipment in 765kV or 400 kV switchyard. Separate room will be provided to accommodate batteries for 220 V DC System for control & supervision of the switchyard equipment and 24 V DC System for PLC systems. Separate rooms will also be provided for Tariff Metering Panels for line feeders.

The 765kV or 400 kV switchyard will be designed based on the following parameters:

**Table 5.5**

<table>
<thead>
<tr>
<th>S No.</th>
<th>Parameters</th>
<th>Rating / Value (400kV)</th>
<th>Rating / Value (765kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Design Voltage Levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Nominal Voltage</td>
<td>400 kV</td>
<td>765 kV</td>
</tr>
<tr>
<td>(b)</td>
<td>Highest system voltage</td>
<td>420 kV</td>
<td>800 kV</td>
</tr>
<tr>
<td>(c)</td>
<td>Basic impulse level</td>
<td>1425 kV peak</td>
<td>1950 kV peak</td>
</tr>
<tr>
<td>(d)</td>
<td>Switching surge</td>
<td>1050 kV peak</td>
<td>1550 kV peak</td>
</tr>
<tr>
<td>1.1</td>
<td>Fault level (kA rms for 1 sec)</td>
<td>40 kA rms</td>
<td>50 kA rms</td>
</tr>
<tr>
<td>2.0</td>
<td>Bay width</td>
<td>27 m</td>
<td>45 m</td>
</tr>
<tr>
<td>3.0</td>
<td>Minimum Clearances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Phase to Phase</td>
<td>7000 mm</td>
<td>9400 mm</td>
</tr>
<tr>
<td>(b)</td>
<td>Phase to Earth</td>
<td>3500 mm</td>
<td>6400mm</td>
</tr>
<tr>
<td>(c)</td>
<td>Section Clearance</td>
<td>6500 mm</td>
<td>10300 mm</td>
</tr>
<tr>
<td>(d)</td>
<td>Ground Clearance</td>
<td>8000 mm</td>
<td>14000 mm</td>
</tr>
<tr>
<td>3.1</td>
<td>Minimum creepage distance</td>
<td>31 mm/kV</td>
<td>31 mm/kV</td>
</tr>
</tbody>
</table>

b) Supervisory Control and Data Acquisition (SCADA) System

In addition to the conventional hard wired control and metering panels, microprocessor based Supervisory Control and Data Acquisition (SCADA) System has been envisaged for 765kV or 400 kV Switchyard for control and monitoring. The system will be designed to work on 220 V DC System.

The 765kV or 400kV Line side Circuit Breakers shall be controlled from Switchyard Control Room only. Switchyard controls would be implemented in Substation Automation System (SAS) having serial interface to DDCMIS for monitoring purpose only. SCADA shall be located at Switchyard Control Room and the DDCMIS shall be located in central control room.

The SCADA System will perform the following functions as minimum:

- Monitor and display the status of various equipment like circuit breakers, isolators and earth switches
- Real time monitoring of various electrical parameters like voltage, frequency, current, active power, reactive power, oil and winding temperatures of transformers, transformer tap positions, integrated demand, etc.
- Manual closing and tripping operations of various circuit breakers, isolators and earth switches through interactive dynamic graphics during “normal conditions."
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Chapter 5: Proposed Infrastructure

- Acquire / transmit the relay / protection information for all the feeders, transformers and other electrical equipment.
- Generate alarm signals of various electrical abnormalities.
- Display, log, trend and archive the various analogue and digital parameters acquired by the system and perform waveform analysis for pre and post trip analysis, keeping records of all system faults and sequence of faults.
- Interfaced with the plant Digital Control System (DDCMIS) through dual redundant communication link to facilitate the exchange of various digital and analogue parameters for control, monitoring and information purpose only.
- Interfaced with the DDCMIS system for the Load Despatch Centre (LDC) of CTU/STU through a dual redundant communication port to facilitate the transmission of various digital and analogue parameters for information and monitoring purpose.
- Will support a software system suitable for truly real time operation and execute all performance required. It will meet some general requirements viz. simple & easy to learn editing language for editing and on-line operation, efficient memory management, etc.

An integrated and functionally distributed microprocessor based SCADA system has been envisaged to meet the above mentioned functional requirements and reliable operation. In order to reduce response time and to process incoming information as fast as possible, the total functionality will be distributed in function based parts on separate servers which will help to achieve higher computation power.

The SCADA system will consist of the following broad sub-systems:

- Application (Control and Logic Implementation) Sub-System.
- Man-Machine Interfacing (MMI) Sub-System.
- Data Acquisition and Communication Sub-System with Ethernet LAN and Gateways for Interfacing with the Plant DDCMIS and with the SCADA System located at LDC of CTU/STU.
- Printer Server with its Associated Peripherals (inkjet colour printer, dot matrix printer) Sub-System.
- Input / Output Signal Acquisition Sub-System.

c) Power Line Carrier Communication (PLCC) Equipment

PLCC equipment has been envisaged to be installed at the 765kV or 400 kV line feeders to provide for speech communication between the proposed power plant and substation of CTU/STU. The PLCC system will also be used for tele-protection and tele-metering systems. The equipment will be designed to work on 24 V DC system.

The PLCC system will be consistent with the system provided by CTU/STU at the other end of the transmission lines. Proper co-ordination will be taken care of during specification / procurement stage.

5.2.6 Power System Arrangement to Auxiliaries

a) Unit Auxiliary Transformers

For power supply to all unit as well as station auxiliaries, one nos. oil filled, outdoor type, three phase, three winding Unit Auxiliary Transformer (UAT) have been envisaged for each unit. These transformers will be directly connected to the respective Generator Bus duct. Each transformer will be rated for 120/60/60 MVA tentatively, 24/11.5/11.5 kV, Dyn1yn1, 50 Hz, ONAN/ ONAF cooled and provided with on load tap changer (OLTC) having range of ±10% of nominal voltage at 1.25% per tap (tentatively).
The actual rating of these transformers will be finalized during detail engineering stage. Transformers will be designed in conformance with the following requirements:

- **Continuous internal pressure withstand capability of tank**: 35 kN/m² over normal oil pressure and short circuit forces
- **Over-fluxing (V/f) withstand capability**: 110% continuous at all operating conditions, 125% for at least one minute, 140% for at least five seconds
- **Through fault current withstand time**: 2 seconds
- **Temperature rise over 50°C ambient temperature**: Top oil (by thermometer) 50 °C, Winding (by resistance) 55 °C
- **Loading capability of the transformer**: In accordance with IEC 354
- **Maximum Noise Level when energised at normal voltage and frequency with fans running**: In accordance with NEMA TR-1
- **Degree of protection for all outdoor kiosks like cooler control cabinet, marshalling box etc.**: IP 55

**b) Startup/Standby Transformers**

One number, three winding, Startup/Standby Transformer has been envisaged in the project. The HV winding of the Startup/Standby Transformer will be connected to the 765kV or 400kV system. LV windings shall be connected to 11 kV Unit switchgear buses.

In case of outage of Unit Auxiliary Transformer (UAT), Startup/Standby transformer secondary winding will take the load of one UAT. Hence, Startup/Standby Transformer secondary winding will be sized equivalent to the rating of one UAT.

The transformer will be 120/60/60 MVA tentatively, 765/11.5/11.5 kV or 400/11.5/11.5 kV, 50 Hz, ONAN / ONAF cooled and provided with on load tap changer (OLTC) having range of ±10% of nominal voltage @ 1.25% taps tentatively. The capacity of these transformers will be finalized during detail engineering stage. Further, the capacity and impedance of the transformer shall be such as to ensure that the total voltage dip on bus bars and the motor terminals shall be within permissible limits on direct-online starting of the motors. The selected impedance shall not be low enough to cause increase in the fault level of 11 kV switchgear design rating. Transformers will be designed in conformance with the following requirements:

- **Continuous internal pressure withstand capability of tank**: 35 kN/m² over normal oil pressure and short circuit forces
- **Over-fluxing (V/f) withstand capability**: 110% continuous at all operating conditions, 125% for at least one minute, 140% for at least five seconds
- **Through fault current withstand time**: 2 seconds
Temperature rise over 50°C ambient temperature:  
- Top oil (by thermometer) 50 °C  
- Winding (by resistance) 55 °C  

Loading capability of the transformer:  
- In accordance with IEC 354  

Maximum Noise Level when energised at normal voltage and frequency with fans running:  
- In accordance with NEMA TR-1  

Degree of protection for all outdoor kiosks like cooler control cabinet, marshalling box etc.: IP 55  

c) 11 KV Switchgears  
For power supply to all unit and station auxiliary motors & loads, the following 11 kV Switchgears have been envisaged, as shown in enclosed Electrical Single Line Diagram: LII-GEOE14006-E-00140-001.  

1. For each Unit, two (2) nos. 11 kV Unit Switchgear, each of them to be connected to respective Unit Auxiliary Transformer and Startup/ Standby Transformer.  
2. 11kV sub distribution for facilities like Coal handling Plant, Ash handling plant and other balance of plants.  
Each 11 kV switchgear will supply the 11 kV motors rated above and including 200 kW such as BFP, CWP, CEP, ID, FD, PA fan motors, 11 kV/ 0.433 kV Service transformers required for feeding the Unit and Common system loads connected to the respective 415 V switchgear buses. Each switchgear will be connected to the secondary side of the respective Unit / Auxiliary Transformers. 11 kV Unit Switchgear are proposed to be connected with UAT and Startup/ Standby Transformer by 11 kV Non-phase segregated bus ducts.  
Facilities for manual live change over scheme with synchronization, automatic fast bus change over followed by slow bus change over scheme will be provided for the operation of 11 kV switchgear system. All 11 kV switchgears will be provided with positive safety electrical interlocking and bus bar / Feeder earthing facilities for operational and personnel safety.  

All 11 kV Switchgear will be of indoor, single front, metal clad, fully draw out type, sheet steel units, assembled to form a rigid, free-standing, floor mounted structure with IP 4X degree of protection as a minimum. The material of bus bars will be aluminum alloy. Vertical units will be assembled to form a continuous line up of panels with breaker. All Circuit Breakers will be SF6 or Vacuum type having draw-out facilities. Where vacuum circuit breakers are used for motors, surge limiters will be installed on the cable side to limit switching over voltages to motors.  

d) MV Bus ducts  
11 kV Busducts shall be metal enclosed, phase Non-segregated and natural air-cooled.  
Non-Segregated phase Busduct (NSPBD) will be rated for secondary side current of Unit Auxiliary Transformer at minimum tap plus 10% margin rounded off to the next higher rating.  
Rated voltage of the busduct shall be equal to the highest maximum continuous system voltage. All buses and connections shall be supported and braced to withstand stresses due to maximum short circuit current.  
Short circuit rating of MV (11kV) Non-Segregated phase busduct shall be 50 kA for 1 sec.
e) Neutral Grounding Resistor (NGR)

11 kV systems will be low resistance earthed to limit the earth fault current to about 300 Amps for 10 seconds. For this purpose, Neutral Earthing Resistor (NGR) of adequate rating will be connected between neutral point of secondary side winding of all Unit Auxiliary Transformers, Startup/standby transformer and ground.

Each NGR unit will be air-cooled and self supporting type.

The resistor elements will be made of non-aging stainless steel or equivalent corrosion resistant material having high electrical resistivity and low temperature co-efficient of resistant. All element connections will be bolted type to ensure stable resistance value throughout the working life of the unit.

f) Low Voltage (LV) Service Transformers

For power supply to all 415 V auxiliary motors & loads, 2 x 100% LV Service Transformers have been envisaged. 11/0.433kV, Oil type/resin cast insulated dry type transformer, suitable for Outdoor/indoor installation may be considered for auxiliary LV loads Connected through 415V Switchgears, Motor Control Centers (MCC) and AC Distribution Boards (ACDB).

For power supply to 415 V auxiliary motors & other loads, suitable nos. of 415 V Switchgears, Motor Control Centers (MCC) and Distribution Boards (DB) have been envisaged, which will be located suitably in the load centers to the extent possible considering the space availability and operational advantages for the proposed power plant. The distribution system is shown in enclosed Electrical Single Line Diagram.

415 V switchgear will receive power from its respective 11/0.433 kV service transformers through 415 V non-phase segregated bus duct/415V cables. Each switchgear will have 2x100% incoming feeders and a bus coupler to have maximum redundancy and reliability in the operation. In case of outage of one incoming feeder, the bus coupler breaker will be closed by automatic slow bus change over scheme. However, manual live change over scheme with check synchronization will also be employed for transfer of power in both directions.

Each 415 V MCC/ACDB will receive power from its respective 415 V switchgear through 415 V cables. Each of them will have 2 x 100% incoming feeders and a bus-coupler to have maximum redundancy and reliability in the operation. In case of outage of one incoming feeder, the bus coupler will be closed manually.

Each 415 V MCC/ACDB will be provided with positive electrical interlocking facility to ensure that different power supply sources will not operate in parallel to avoid fault level exceeding their designated capability.

415V switchgears will be of indoor, single/ double front and fully draw out type. 415V MCCs shall be of indoor, single / double front and fully draw out type. ACDBs will be of indoor, single/double front and non-draw out type. These will be CRCA sheet metal enclosed; assembled to form a rigid, free-standing floor mounted structure. Vertical units will be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration will be provided. The degree of protection will be IP52 for indoor and IP55 for outdoor use as a minimum. 10 % spare feeders with at least one fully equipped feeder of each type and rating will be provided in each switchgear/MCC/DB. The material of bus bars will be aluminum alloy.

The switchgears/MCCs with Auto changeover facility shall be provided with Air Circuit Breakers (ACBs) at in-comers and buscoupler. The other MCCs with in-comers and buscouplers of rating upto 630A shall be provided with MCCBs/SFUs. However, the in-comers and buscouplers of MCCs shall be provided with ACBs if the rating exceeds 630A. The outgoing feeders shall be provided with moulded case circuit breakers (MCCB)/SFU for all other outgoing feeders which will not be closed from remote.
All AC motor starters will be suitable for Direct On Line (DOL) starting. Motors rated above 160 kW will be breaker controlled, provided with micro-processor based comprehensive motor protection relay and will be fed from 415 V switchgears. Motors rated for 160 kW and below will be provided with MCCB/SFU, contactor and over load relay. The motor starter module will comply with Type-2 coordination conforming to IS 13947 (Part 4 / Sec 1) / IEC 947-4-1 and will be installed within 415 V MCCs.

The rating of circuit breakers/MCCBs/load break isolators for incomers and bus coupler of each 415 V switchgear / MCC / ACDB will be identical. However, the rating of starter modules / MCCBs for motors and other feeders will be selected based on their ratings. Inter-changeability of components will be given due consideration during selection of their ratings. The rating of main bus bars will be similar to that of the rating of circuit breakers/MCCBs/switch fuse unit for incomers/bus coupler.

DC Starter Panels for DC motors and Local Push Button Stations for all drives will be provided as per requirement.

g) Emergency Power Supply System

The emergency power system will provide a source of power to essential auxiliary loads required to permit a safe shut down of the units in the event of a plant blackout (i.e. loss of AC power supply through Unit Auxiliary Transformers). In addition, emergency power is provided for auxiliaries and services required for personnel safety and minimum plant maintenance during the blackout.

In order to meet above requirement, one no. 415 V, 3-phase, 4-wire, 50 Hz Emergency Diesel Generator (EDG) Set has been envisaged for each unit. Emergency loads for each unit will be fed from the respective Emergency DG Set through the respective 415V Turbine Switchgear. The exact rating of DG set will be decided during the detail design stage.

Provision will be made to start the DG Set/s automatically in case of failure of power supply to the respective 415V Turbine Switchgear. Provision for operation of emergency DG set from the Central Control Room will also be provided.

h) Motors

To feed power to various drives, the voltage rating for the motors will be as follows:

- Below 0.22 kW --- 240V, single phase
- From 0.22 kW up to 200 kW --- 415V, 3 phase
- Above and including 200 kW --- 11kV, 3 phase
- DC Motors --- 220 V DC

All AC motors will be squirrel cage three/single phase induction motors. Lifts/Crane motors may be of slip ring type. DC motors will generally be of shunt/compound wound type rated for 220V DC. All motors will be rated for continuous duty. Lifts/Crane motors will be rated for intermittent duty. Inchng type motors as per the requirement will be provided.

Motor enclosures will conform to the degree of protection IP-54 (indoor) and IP55 (outdoors). For hazardous areas, approved type of flameproof and increased safety enclosure will be provided.
The motors will generally be of self-ventilated type totally enclosed fan cooled (TEFC). Alternatively for large motors, closed air circuit air cooled (CACA)/closed air circuit water cooled (CACW)/totally enclosed tube ventilated (TETV) type cooling arrangement will be adopted.

MV motors will have Class F insulation with temperature rise limited to class B. LV motors will have class B insulation

i) Plant DC System

General
To feed power to various unit / station emergency DC drives/loads, the following DC Systems have been envisaged:

- 2 x 100% rated 220 V Battery charger and 2 x 100% rated battery for catering DC loads of Unit-1 and 50% station DC load requirement for one (1) hour.
- 2 x 100% rated 220 V Battery charger and 2 x 100% rated battery for catering DC loads of Unit-2 and 50% station DC load requirement for one (1) hour.
- 2 x 100% rated 220 V Battery charger and 2 x 100% rated battery for catering DC loads of 400 kV Switchyard for one (1) hour.
- 2 x 100% rated 220 V Battery charger and 2 x 100% rated battery for catering DC loads of coal handling plant for one (1) hour.
- 2 x 100% rated 220 V Battery charger and 2 x 100% rated battery for catering DC loads of ash handling plant for one (1) hour.
- 2 x 100% rated 24 V Battery charger and 2 x 100% rated battery for catering DC Emergency loads of PLCC System for one (1) hour.

The float cum boost charger will be paralleled with its battery and feeding to one bus section of its respective DCDB.

Battery Chargers
Each battery charger will be able to supply one of the following, whichever is higher.

- (Continuous load current + trickle charging current) x 1.2 - considering 20% margin
- Boost charging current for the battery to full state of charge within 10 hours.

Boost charger unit will be rated such that the completely discharged battery can be fully charged in about 10 hours.

The charger will have provision of manual control if the auto mode fails. The load limiting features will be provided with the charger. The charger will be provided with automatic voltage regulation in float mode and automatic constant current regulation in boost mode.

The DC voltage regulation will be within ± 1% for a 0-100% load variation, DC voltage variation shall be +10% to -15% and combined input AC voltage and frequency variation on the AC side shall be 10%.

Battery will be of storage type plate lead acid. Each battery will be rated for a minimum period of one hour, considering design margin as 15% and aging factor as 1.10 and minimum electrolyte temperature of 5 deg. C. The minimum voltage at the end of the load cycle will not be less than 1.85 V per cell.

DC Distribution Board (DCDB)
Each DCDB will receive power from its respective DC system cables. Each of them will have 2x100% incoming feeders and a bus-coupler to have maximum redundancy and reliability in the operation.
Each DCDB will be provided with positive mechanical interlocking facility to ensure that different power supply sources will not operate in parallel to avoid fault level exceeding their designated capability.

Each DCDB will be of indoor, single / double front and non-draw out type. These will be CRCA sheet metal enclosed; assembled to form a rigid, free-standing floor mounted structure. Vertical units will be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration will be provided. The degree of protection will be IP52 for indoor and IP55 for outdoor use as a minimum. 10% spare feeders with at least one fully equipped feeder of each type and rating will be provided in each DCDB. The material of bus bars will be aluminum alloy.

5.2.7 Plant Illumination System

The Plant Illumination System will provide illumination to all plant areas within the proposed power plant. In addition, it will also provide illumination to selected / critical areas during plant emergency conditions. This will be achieved by artificial lighting. The basic illumination system will include the following:

- Normal AC lighting system
- Emergency AC lighting system
- Emergency DC lighting system
- Aviation lighting

**Normal AC Lighting System**

The normal AC lighting system will be provided by AC lighting fixtures which will be located throughout the plant and will provide bulk of the normal lighting load. These lighting fixtures will be ‘on’ as long as normal AC supply is available. This system will be designed for approximately 80% of the necessary illumination level, where it will be installed together with emergency AC lighting system. Otherwise, it will be designed for 100% of the necessary illumination level.

Power for normal AC lighting system in the Turbine Building, Boiler, ESP, ID/FD fan areas and transformer yards etc. will be supplied from 415V, 50 Hz, 4 wire Main Lighting Distribution Boards (MLDB). The power for these MLDBs will be obtained from 415 V Switchgears through suitable nos. of adequately rated 2x100% 415/415 V dry type transformers. The illumination system in other ancillary areas/buildings will be supplied from 415V MCC/ACDB located in respective ancillary areas/buildings.

2 x 100% lighting transformers will be unitized with their respective MLDB at its both ends. The incomers of each MLDB will be interlocked in such a way that only one incomer can be made ‘on’ at a time.

**Emergency AC Lighting System**

The emergency AC lighting system will be provided by AC lighting fixtures which will be located at strategic points throughout the plant where lighting is required for emergency operation and / or maintenance and personal safety during loss of normal power. These lighting fixtures will be ‘on’ whether normal AC supply is available or not. This system will be designed for approximately 20% of the necessary illumination level for station building, steam generator areas & switchyard areas. This lighting system will not be provided for River Water Intake Pump House.

Power for emergency AC lighting system will be supplied from 415V, 50 Hz, 4 wire Emergency Lighting Distribution Boards (ELDB). The power for these ELDBs will be obtained from 415V Unit Switchgears when normal AC supply is available and from Emergency DG Set when normal AC supply is not available, through adequately rated 2 x 100%, 415/415 V dry type transformers.
2 x 100% lighting transformers will be unitised with their respective ELDB at its both ends. The incomers of each ELDB will be interlocked in such a way that only one incomer can be made ON at a time.

Emergency DC Lighting
At strategic locations in the main plant, a few lighting fixtures fed from 220 V, DC supply, shall be provided to enable safe movement of operating personnel and access to important control points during an emergency, when both the normal AC and Emergency Lighting system fail. These lighting fixtures will be fed from 220V DC LDBs which in turn will be fed from DC lighting panels.

The supply to the DC lighting panels shall be automatically switched ON in case of loss of AC supply at station service switch gear as well as Emergency switchgear. The DC supply will be automatically switched OFF after about 3 minutes following the restoration of supply to normal AC or emergency AC lighting system.

In auxiliary /off site buildings, emergency DC lighting is to be provided through self contained DC emergency fixture at strategic locations. The fixtures shall be switched ‘ON’ automatically in case of failure of AC supply. Emergency DC lighting will be provided in specific areas such as control room, switchgear rooms, areas near local panels, staircases and other strategic areas during AC supply failure.

Power for emergency DC lighting system will be supplied from 220 V, 2 wire DC Lighting Panels (DCLP). The power for these DCLPs will be obtained from Plant 220 V DC systems.

Suitable number of Lighting Panels (LP) will be located in each area to feed various lighting fixtures for both normal and emergency AC lighting systems. The power to these LPs will be supplied from MLDB / ELDB, as applicable. The LP will be installed at convenient locations for ease of operation.

Lighting Fixtures
The illumination levels at various places will be maintained as per Indian / internationally accepted codes. The lighting system design will ensure uniform illumination at working levels by using suitable nos./ type/ rating of lighting fixtures.

For indoor application, fluorescent / energy saving compact fluorescent (CFL) / mercury vapour / sodium vapour / incandescent lighting fixtures will be used to suit the requirement and application. For outdoor application, pole/tower mounted sodium vapour lighting fixtures will be used. The lighting fixtures will industrial / decorative / recess mounted / corrosion proof type as per application.

Aviation Lighting
This lighting system will be provided by aviation lighting fixtures which will be located at the following places:
- Various levels of Chimney
- Top level of Power House
- Top level of Steam Generators
- Top level of Coal Bunker / Mills Building
- Top level of Cooling towers

These lighting fixtures will be ‘on’ whether normal or emergency AC supply is available or not. These lighting fixtures will be of high intensity cluster LED (light emitting diode) type with flashing feature. For this system, all lighting fixtures will be fed by 240 V, 1 phase, 50 Hz AC supply available from Plant UPS System.
Welding and Small Power Receptacles
At least one 6/16A, 240V AC universal socket outlet with switch will be provided in offices, cabins, etc. 20A, 240V AC industrial receptacle with switch will be provided strategically in all industrial area. Suitable number of 63A, 3ph., 415V AC industrial receptacles will be provided for entire plant for welding purposes, particularly near all major equipment and at an average distance of 50m. At least one 63A, 3ph. 415V AC receptacle will be provided in each off site building.150A, 3ph, 415VAC receptacle will be provided at transformer yard for oil filtration.

5.2.8 Communication System
For effective communication in the plant, public address system, private automatic branch exchange system (EPABX) with P&T telephones and walkie talkies system with features described below will be provided:

Public Address System
This system will have paging and party channels comprising handset stations with amplifiers, transmitters, receivers, and loud speakers. This system will facilitate paging, communication and also private conversation as in conventional telephone.

EPABX System
This system will have adequate number of push button type handset stations, central automatic telephone exchange, etc. The handsets in the control room would be provided with priority service facility to enable them to have immediate access to any handset even if it is already engaged. Interface between the EPABX, PA, walkie-talkie and radio paging systems will be provided to enable communication between these systems.

Necessary interface with P&T telephone would be provided in EPABX system.

Walkie-talkie Systems
Walkie-talkie systems will be provided for mobile communications. These systems will be of particular use during commissioning stage as well as subsequently for convenience during maintenance.

5.2.9 Cables
For sizing of power cables, the following factors will be taken into consideration:

- Short-circuit current and duration
- Continuous current
- Installation conditions
- Voltage drop under normal running and starting of induction motors
- Standardization of cable sizes to avoid too many sizes of cables.

HV Power Cables
The 11KV power cables shall be of single / multi core, 90 Deg C rating under normal running condition & 250 Deg C under short circuit condition, heavy duty with stranded annealed copper / aluminium conductor, extruded semi-conducting conductor screen, XLPE insulation, extruded semi-conducting insulation screen, extruded PVC inner sheath, round wire armour (galvanized steel for multi-core and aluminium for single core) and extruded FRLS PVC overall sheath. These cables will have phase identification colour coding.

LV Power Cables
1) XLPE Cables
1100 volt grade, single / multi core, 90 Deg C rating under normal running condition & 250 Deg C under short circuit condition, heavy duty with stranded copper / aluminium conductor, XLPE insulation, extruded PVC in-
ner sheath, round wire armour (galvanized steel for multi-core and aluminium for single core) and extruded FRLS PVC overall sheath. These cables will have phase identification colour coding.

2) PVC Cables
1100 volt grade, single/multi core, 70 Deg C rating under normal running condition & 160 Deg C under short circuit condition, heavy duty with stranded copper / aluminium conductor, HR PVC insulation, extruded PVC inner sheath, round wire armour (galvanized steel for multi-core and aluminium for single core) and extruded FRLS PVC overall sheath. These cables will have phase identification colour coding.

For conductor cross section up to 4 sq.mm copper conductors shall be used, Aluminium conductors shall be used for cable sizes more than 4 sq. mm.

3) Control Cables
1100 volt grade, heavy duty, multi core, stranded copper conductor, PVC insulation, extruded PVC inner sheath, round wire galvanized steel armour and extruded FRLS PVC overall sheath. These cables will have phase identification colour coding. The size of the conductor will be 2.5 or 1.5 mm².

4) Fire Survival (FS) cables
These cables will be used for the following essential auxiliaries:
- DC emergency lube oil pump
- DC hydrogen seal oil pump
- DC emergency lighting for main building
- DC cable from battery to charger and DC distribution board
- Auxiliary lube oil pump (AOP) for turbine
- Jacking oil pump
- Emergency turbine trip by push button in control room
- Boiler, turbine, generator inter-trip which include the interconnecting cable between
- Boiler master fuel trip and turbine trip relays
- Generator trip relays and turbine trip relays
- Generator trip relays and generator field breaker

5) Cable Raceway System
The cable raceway system will be provided to protect and support power, control and instrumentation cables from power source to the load. The raceway system will include cable tray, conduit, pull box etc. This system will consist of the following:
- Hot dip galvanized prefabricated ladder type cable trays for power and control cables
- Perforated type trays with covers for dusty areas prevailing in mill and boiler region
- Above grade metallic conduits
- Below grade PVC conduits
- Pull boxes

The design will be based on individual tray and conduit systems being established for the following services:
- 11 kV power cables
- 415 V power cables
- Control cables
Fire barriers will be provided for all wall and floor penetrations and all floor openings beneath cabinets, switchgears, MCCs, ACDBs, DCDBs etc. to prevent propagation of cable fires through walls and floors.

5.2.10 Earthing and Lightning Protection Systems

1) Design Criteria
The station earthing system will provide a safe environment for personnel and equipment in the event of earth faults or lightning strikes. All major electrical equipment will be connected to the earth grid to provide a low resistance path to earth. For earth mat design, the size of the earthing conductor will be arrived, considering the maximum fault current for duration of 1 second and suitable corrosion factor. The spacing of the conductors will be such that the touch and step potential are within the limits of permissible values. The earthing resistance will be less than 0.5 ohm. The earthing system will be designed for a life expectancy of at least 40 years.

Design of earthing and lightning protection system will be carried out as per IEEE 80, IEEE 142, IS 3043 and IS 2309.

The Earthing requirement of a power station complex can be divided into the following two main categories viz. System Earthing and Equipment Earthing.

2) System Earthing
The system earthing is adopted to facilitate earth fault relaying and to reduce the magnitude of transient over voltage. The system earthing involves primarily the earthing of the generator and transformer neutrals.

High resistance earthing is envisaged for generator neutrals, which will be achieved through a distribution transformer shunted by a resistance in its secondary side to limit the earth fault current to about 10 amperes. The transformer and resistor will be rated for 5 minutes of operation.

To facilitate identification of earth fault and isolate faulty section from rest of the system with a minimum damage to the equipment / system, 11 kV systems have been envisaged to be low resistance earthed to limit the earth fault current between 300 Amps. The resistor will be rated for 10 seconds of operation.

Solidly earthed system has been envisaged for 765kV or 400KV and 415 V systems. The DC systems will be earthened.

3) Equipment Earthing
The equipment earthing is adopted to provide protection to personnel from potentials caused by earth fault and lightning discharges by providing a low resistance conducting path to the earth. A stable earth grid will be provided for earthing of equipment and structure for maintaining the step and touch potentials within safe limits. An earth mat will be laid in and around the power station and also in other hazardous area as necessary.

The mat will be buried at a suitable depth below the earth and provided with earth electrodes at suitable intervals. All metallic parts of equipment including structures, buildings, transmission towers, rail tracks, the perimeter-fencing etc., supposed to be at earth potential would be connected to the earthing mat.

4) Lightning Protection System
The lightning protection system will be installed for protecting the building / structures against lightning discharge. This will be achieved by providing lightning masts on stacks, powerhouse building, towers in switchyard, flood light towers etc. and connecting them with the earth grid. Over and above, the shielding wires and
/ or lightning masts will be used to safeguard the equipment of 765kV 400 kV switchyard and transformer yard.

5.2.11 Control Systems

1) Control Rooms

The following control rooms have been envisaged for the proposed power plant:

- Main Control Room in Power House Building to take care of Boiler & Turbine auxiliaries for both units
- Control room near ESP area for ESP and its auxiliaries for each unit
- Control Building for 765kV or 400 kV switchyard.
- Control Room for the following off-site packages as required:
  - Coal Handling Plant
  - Ash Handling Plant
  - Plant water System
  - Intake Water Pump House

2) Plant DDCMIS / SCADA Systems

The complete control, indication, annunciation and supervision of the electrical systems for the proposed power plant will be performed from the monitor through plant DDCMIS for main power plant and through SCADA system for 765kV or 400 kV system. An optional hardwired control panel will be provided; the provision of this control panel will be finalized during detail engineering. Necessary mimics with ‘On Line’ dynamic graphics will be provided. Necessary command signals, feedback signals and measurement signals will be wired up from various equipment through transducers and interposing relays to the plant DDCMIS/SCADA system. Numerical relays will be directly connected to this system through soft links. It will be possible to display and control any electrical system up to 415 V switchgear level on the monitor of the plant DDCMIS/SCADA system. Entire mimic from 415V switchgear level to 765kV or 400kV system will be available on the monitor itself. Synchronization of generators will be carried out from DDCMIS Communication interfaces and protocol adaptation will be provided as required.

Control of all 11 kV circuit breakers of BTG & BOP areas and 415 V incomer & bus coupler breakers located at BTG areas will be done from DDCMIS. 415V incomer and bus coupler breakers located at all BOP areas shall be controlled by PLC available at respective BOP areas and the same shall communicate to remote DDCMIS at CCR through soft link.

The measurements / indications available on the monitor of the plant DDCMIS and/or SCADA system will include, but not be limited to, the followings:

- Current, voltage, power, MVAR, MWh, MVARh, power factor and frequency for all generators, all transformers and all switchyard bays
- Stator core, winding, bearing and cooling system temperature for generators
- Winding / oil temperature and tap position for all transformers
- Current, voltage and power for each 11 kV /415 V incomer & buscoulers
- Current for each HV motors, LV large motors and motors for important process
- Current for each outgoing feeder for each 11 kV /415 V switchgears
- Voltage for each 11 kV /415 V bus
- Voltage for DC system
- Voltage for UPS system
- Excitation system parameters
- Emergency DG set parameters
  The status of the following shall be monitored as a minimum, on the monitor of the plant DDCMIS and/or SCADA system:
  - Status (ON, OFF and Trip) of 765kV or 400 kV circuit breakers, isolators & earth switches
  - Status (ON, OFF & Trip) of all 11 kV / 415 V circuit breakers (up to 415 V switchgear bus)
  - Status (ON, OFF & Trip) of all motors operated through CRT
  - Status (ON, OFF & Trip) of DC system
  - Status (ON, OFF & Trip) of UPS system
  - Operation of all protection relays for 765kV or 400 kV / 11 kV / 415 V systems (up to 415 V switchgear bus)
  - Operation of protection relays of Generators, Generator Transformers, Unit Transformers and Startup/Standby transformer
  - Operation of transformer protection mounted on transformers for all HT and LT transformers
  - Generator capability curves indicating actual operating point

3) Control Panels with PLC
The control panels with PLC have been envisaged for the Balance of Plants as mentioned above.

4) Synchronization Panel
A hardwired synchronizing panel will be provided. It will consist of all synchronizing equipment viz. double voltmeter, double frequency meter etc., generator selector switch, ‘Auto/Manual/Remote’ selector switch, auto-synchronizer and other necessary relays/components. A mimic showing associated circuit for synchronization of generators will be provided in this panel.

a) Protection System
For protection of equipment against abnormal system conditions, adequate protective devices will be installed in the respective switchgear and/or relay panels. A group of such protective devices will be necessary to protect the equipment under different abnormal conditions arising in the system. In all cases, proper discrimination would be achieved to isolate the faulty elements only keeping the healthy part of the system in service.

All protective relay panels will be of free standing, floor mounting, and sheet steel enclosed with a degree of protection of not less than IP 31. The panels will be located in air-conditioned rooms.

All protective relays will be comprehensive numerical type capable of measuring all electrical parameters like voltage, current, power, power factor, frequency etc. The relays will be capable of communicating all analogue and digital signals with plant DDCMIS/SCADA system, as applicable. In that case, separate indicating instrument and transducers may not be required. All protective relays will be of draw out type with built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle. All relays will have hand-reset means for visual indication of their operation.

Fully graded protection system with requisite speed, sensitivity and selectivity will be provided for the entire power station. Critical equipments/systems will be provided with double protection.

The protection system will be arranged to provide two independent, high performance and reliable systems with separately monitored DC supplies, separate CT/VT cores, separates cables & trip/hand reset lock out relays to obtain 100% redundancy. Associated trip relays of these two systems will be separate, having sufficient no. of contacts for all the functions. Each protection will energize both trip coils of the circuit breakers to be tripped. The unit protection relays will be divided into two independent groups including separate power supply so that in case of failure of one group, the protection system would be still functioning and protection of the unit is guaranteed. Set of duplicated hand reset lock out relays (86), one for each protection channel fed
from different DC bus supplies, will be provided separately for Generators, Generator Step-up Transformers and Unit Auxiliary Transformers and Station transformer. All relays will have hand-reset flags or other means for visual indication of their operation.

Supervision relays will also be provided to monitor DC supply for each trip relay.

All current and voltage transformer’s required for protection system, will have adequate VA burden, knee point voltage, instrument safety factor and other characteristics suitable for the application.

b) Power Import and Export (Tariff) Metering System

The net power generated by the proposed power plant will be exported directly through 765kV or 400 kV lines. For metering export/import of power to/from the grid, one Main Meter and one Check Meter will be provided for 765kV or 400kV lines. The meters will conform to the CEA guidelines of Availability Based Tariff (ABT) type. Each of the main and check meters will have the following features:

- Microprocessor based.
- Carry out measurement of import / export active energy (MWh), reactive energy (MVARh) and apparent energy (MVAh). It will also measure voltage, current, power factor, kW, kVAR, kVA etc.
- Accuracy of measurement of 0.2.
- Compute the energy imported / exported to / from the proposed power plant during each successive settlement period and store in the respective register.
- Display on demand the energy imported/exported during previous settlement period.
- Continuously integrate the energy readings up to the previous settlement period. All these readings will be stored in a separate non-volatile memory and displayed on line on demand.
- The reading will be stored for a period of forty (40) days before being erased.
- Built in clock and calendar having an accuracy of at least one minute per month or better without assistance of external time synchronizing pulse.
- Date / time will be displayed on demand. The clock will be synchronized by GPS time synchronization equipment.
- Facility for downloading data.
- The meter will have means to test accuracy and calibration at site and test terminal blocks will be provided for the same.

In addition to Tariff Metering System, suitable energy meters of 0.2 class of accuracy will be provided at generator terminal to record the generated gross energy. This meter will also be used for calculation of auxiliary power consumption.

c) Construction Power

Construction power can be sourced from existing Phase I plant with a permission of GUVNL. For construction activities, power supply at 33 kV or 11kV, 3 Phase, 50 Hz will be made available by Customer at one point within power plant area. The further distribution upto LV levels with required nos. of step-down transformers and distribution switchgears / boards will be arranged by the electrical contractor/s during construction of the proposed power plant. The peak requirement of construction power will be about 5 MVA(Tentative)."

5.3 Control and Instrumentation System

5.3.1 Design Concepts

The following Design concepts shall be used:
Redundancy
Use of redundancy in an extensive manner to ensure safety, availability and, flexibility of operation. The basic concept of redundancy shall be that, as a minimum, a single failure shall not cause any failure of any plant equipment or trip the unit (single failure tolerance criterion).

Reliability and Availability
Each component of the system and the system as a whole shall be of established reliability. The minimum target reliability of each electronic module/card, Power supply, Peripheral etc. shall be established considering its failure rate/Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.

Uniformity of Hardware
Although sometimes difficult to achieve due to packaging concept, it will be attempted to have, various C&I instruments/equipment, field instruments like 4-20mA electronic transmitters/ transducers, control hardware, and other instruments/local devices etc. of the same make, series and family.

Fail Safe Operation
The design of the control systems and related equipments shall adhere to the principle of ‘Fail Safe’ Operation wherever safety of personnel/plant equipment is involved. ‘Fail Safe’ operation signifies that the loss of signal, loss of excitation or failure of any component shall not cause a hazardous condition due to factors like failure of sensor or transmitter, controllers, power supply, instrument air etc.

Easy Maintainability
The system design shall be done to achieve sound maintainability and techniques through interchangeability, better diagnostics, standardization, modular devices etc.

Obsolescence
The equipment/system design shall ensure provision of latest state of the art technology to guard against obsolescence. Further tie up shall be attempted with various suppliers for long term support and supply of spare parts.

5.3.2 Design Philosophy
The Control and Instrumentation system for each unit of the plant will be designed to ensure safe, efficient and reliable operation of the plant under all regimes of operation namely start up, shutdown, normal operation, part load operation and under emergency conditions resulting in cost effective power generation with optimum fuel consumption and reduced emission levels.

The state of the art control and instrumentation system will relieve the operator from continuous duties, minimize operator interventions required and would take pre planned actions required in case of change in the process condition from desired values of process parameters. There shall be safety system mechanism which will bring the plant in partial or complete shut down condition in case of unsafe condition or trend in the process parameters in any regime of operation. The control and instrumentation system shall be provided with facility to alert the operators as to any abnormal conditions or situations requiring manual intervention in a timely manner.

The design of the control and instrumentation system would be such as to permit on line localization, isolation and rectification of fault in the minimum possible time. Ease of maintenance would be given due importance at system design stage.

The operation, control and monitoring system envisaged for each unit of the plant would be based on a state of the art microprocessor based Distributed Digital Control and Monitoring Information System (DDCMIS).
The DDCMIS will provide a comprehensive control and monitoring system to operate, control and monitor the Steam Generator auxiliaries, Steam Turbine-Generator auxiliaries and power cycle equipment and auxiliaries systems with a hierarchically and functionally distributed structure of control and monitoring system. Operation and monitoring of CW/ACW shall be from DDCMIS via remote I/O.

Monitoring and control, Data acquisition, alarm annunciation, fast response time, fail safe design, sequence of events recording, online diagnostic and online maintenance are some of the inherent features of the DDCMIS to be designed for the proposed Power Plant.

Steam Generator Control System shall be proprietary control system having interface with DDCMIS.

Steam Turbine Control system will be proprietary control system having interface with DDCMIS.

All Balance of plant control system like CHP, AHP, Water Treatment Plant etc shall be PLC based standalone Control System having soft interface with DDCMIs for Monitoring.

Plant operation and control will be through the Operator Interface Units (OIU) located on the Unit Control Desk (UCD) in the Central Control Room which will consist of colour graphic LCD (TFT) monitor, keyboard/Mouse and also through Large Video Screen (LVS) driven by its driving server computer connected to the LAN of the OIU, will be placed behind the UCD for the purpose of alarms generated in DDCMIS. There shall be provision for the display on LVS of other screens being selected as per the requirement of the Operator. DDCMIS will include the modulating controls of the plant including Co-ordinated Master control, Steam Generator auxiliaries modulating controls & power cycle modulating control etc.

All open loop control functions for the main plant and their auxiliaries and systems will be implemented into the DDCMIS. DDCMIS will also include sequential start up, shutdown of the main plant and power cycle Equipment and Systems and their auxiliaries.

The control functions will be backed up by protection, interlocks and safety functions. This would cause preplanned actions in cases where unsafe conditions develop faster than the control capability of modulating controls or before the operator can be expected to respond to the plant upset conditions in any regime of plant operation.

The Balance of Plant (BOP) off-site systems like Water treatment, Coal handling, Ash handling, Instrument and Service air system etc. will be controlled and monitored through the respective Local Control Panels and control systems. Independent and Stand-alone PLCs in hot redundant configuration with stand alone UPS systems will be used for control and monitoring of these offsite systems. PC based Operator Interface Units (OIU) with TFT Monitor/ KBD/ Mouse will be provided, which will be kept in the respective Local Control Rooms. Redundant Software link will be provided between the offsite Package PLCs and DDCMIS for data exchange for monitoring from DDCMIS Operator Interface unit and Large Video Screen (LVS) housed in Central Control Room.

Operation and Monitoring of Plant Electrical 11 kV and Downstream System will be performed through DDCMIS. Additionally, DDCMIS will have a redundant Software link with SCADA System for monitoring of 765kV or 400 kV switchyard systems. Switchyard system equipments will be primarily controlled and monitored from its local network control room with redundant workstations and the same facility shall be provided through plant DDCMIS also interfacing by redundant soft link.

Plant abnormal conditions will be alarmed through the Operator Interface Units. Alarm printer will be provided to print out all alarms with time tagging and in the chronological order.
Sequence of Event Recording function will be provided for recording and printing occurrence of events in a chronological order for quick diagnosis of fault and remedial action.

DDCMIS will perform online performance calculations to determine plant/equipment efficiency and to detect and alarm unit/equipment malfunctions.

5.3.3 Major Control and Instrumentation Systems

Major protection and control systems of the plant including FSSS, TPS, ATRS, ATT, EHG shall be implemented as per Boiler and Turbine manufacturer’s proven systems. The plant DDCMIS will interface with boiler and turbine control systems for centralized monitoring and control. The MFT functions shall be implemented in a fault tolerant 2 out of 3 triple redundant configuration. FSSS shall comply with NFPA Code and TUV certified SIL 3 level protection. The major components of Control and Instrumentation system of the 2x1000MW (nominal) unit will comprise of the following:

a. Distributed Digital Control, Monitoring & Information System (DDCMIS) with redundant plant wide data Highway
b. Steam Generator Control and Protection System as per manufacturer’s standard design interfacing with the Plant DDCMIS
c. Steam Turbine Generator Control & Protection System and Turbine Supervisory Instrumentation (TSI) as per STG manufacturer’s standard design interfacing with the Plant DDCMIS. TDBFP control & protection along with TSI shall be implemented in STG control system.
d. Vibration monitoring and predictive analysis system for major plant auxiliaries including BFP.
e. Master and Slave Clock System.
f. Central Control Room, Unit Control Desk
g. Measuring Instruments & flow elements
h. Steam and Water Analysis System (SWAS)
i. BOP Package Control Systems
j. Stack Emission Monitoring system
k. Uninterruptible Power Supply and Distribution
l. Final Control Elements
m. Instrumentation & special cables
n. Maintenance and Calibration Instruments
o. Erection Hardware
p. Close circuit Television (CCTV) System.

5.3.4 Distributed Digital Control, Monitoring & Information System (DDCMIS)

An integrated functionally Distributed Digital Control, Monitoring & Information System (DDCMIS), synthesized from one general family of interchangeable multifunction hardware has been envisaged for the Plant. DDCMIS for each unit of the plant will consist of following basic functions / Subsystems:

- Close Loop and Open Loop Control Systems, which include Interlock and Protection systems, Sequential Controls, Plant Automation features and Measurement Systems
- Interface with SG & TG integral control systems
- Interface with standalone PLC based Balance of Plant (BOP) control systems
- Operator Interface Units (OIU) and Large Video Screens in Central Control Room
- Data Communication System
Chapter 5: Proposed Infrastructure

- Historical Storage & Retrieval systems
- Plant Performance Calculations System
- Plant Optimization Package
- Management Information System
- Sequence of Events Recording System
- Alarm Annunciation System
- Unit Control Desk
- Smart Transmitter Diagnostics & Maintenance Facility
- System Programming and Documentation Facility

Necessary interfaces between DDCMIS of all the units of the plant will be provided. DDCMIS will be of Open Architecture type having high system availability and reliability. The general configuration of DDCMIS is indicated in Drawing LLI-GEOE14006-I-00180-001. The configuration diagram enclosed is preliminary and only generic in nature.

The DDCMIS will be of proven and latest configuration and will be provided with suitable Open Protocol Connectivity (OPC) like Ethernet TCP/IP communication for high speed LAN so that it can be connected seamlessly with other OPC compliant system. Data transmission speed will be sufficient to meet the response of the DDCMIS.

Modular system design will be adopted to facilitate easy system expansion. It should be possible to remove or replace various modules on line without creating any disturbance in the plant operation and monitoring.

DDCMIS will include online self-surveillance, monitoring and diagnostic facility so that a failure or malfunction can be diagnosed automatically down to the level of individual channels of modules with display and print out.

Facility of Engineering & Modification of programs has been envisaged from each of the redundant Engineering Work Stations to ensure availability in case of failure of any one of the Engineering Work Station. Engineering Work Station would be provided in the Computer Room with on-line downloading facility. Diagnostic alarm will be available in the all the workstations including Operating Interface Units (OIU). Each EWS will be provided with DVD writer.

DDCMIS will be fault tolerant to provide safe operation under all plant disturbances and component failure.

The control and automation system, including plant protection systems, operator interface and information system will employ fully integrated modern distributed control system technology.

The system will employ a uniform approach across all plant areas with respect to design philosophy, hardware and software application, basic functional characteristics, system interfaces, documentation, standard function blocks and engineering systems and tools.

The control and automation system will be suitably designed to achieve the plant performance and safety requirements, and will be highly reliable, fail-safe, self-checking with comprehensive internal diagnostics. No single random fault in the entire automation and control system will cause a load loss, forced outage or unit trip, and no two simultaneous faults will lead to or potentially cause damage to plant. Safety-related instrumentation and control will be designed with a fail safe mode. Fault in any of the sub system will be suitably alarmed in the DDCMIS Operator Interface Units.
Adequate redundancy in Processor, Power Supply and communication interfaces will be provided so that no single failure will jeopardize the functioning of the entire system. Fault in any of the sub system will be suitably alarmed in the DDCMIS Operator Interface Units.

Interfaces of the control and automation system to specialized equipment or standalone equipment will be standardized, based on internationally accepted norms. Provision for minimum 30% reserve capacity in respect of Processor memory, 40% spare capacity in the Controller processing including all type of task to be performed by the controller and minimum 40% reserve capacity in respect of all loading of the networks will be included in the base design of the control and automation system. The DDCMIS shall have provision for expansion up to 20% hardware and 30% software without requiring redesign of the configuration.

Measured data will be continuously checked for validity, whether used for operator information, for control, calculations or plant history. All signals have data quality attributes, which will be carried forward to the control system, operator interface or information system.

The control and automation system and the field measurement and actuator systems will comply with Process Control Security Requirements, meeting international standard norms and requirements.

**Close Loop and Open Loop Control System**

The Control system along with its measurement system will perform functions of Closed Loop Control System (CLCS), Open Loop Control System (OLCS) including protection functions, measurement and monitoring of signals and alarm function.

The plant will be functionally subdivided into groups, subgroups and drive control levels. The Close Loop Control System (CLCS), Open Loop Control System (OLCS) and protection system for different groups with its subgroups will be implemented through separate controllers. However, CLCS and OLCS of same group/ subgroup will be implemented through same controllers, which will have multifunction and multitasking facilities.

The main and hot standby controllers will be identical in hardware and software implementation and there will be automatic and bumpless switchover from main controller to hot standby controller in case of main controller failure and vice versa without resulting in any change in control status. Major protection systems of the plant including Furnace Safeguard and Supervisory System (FSSS) and Turbine Protection System (TPS) will be implemented through triple redundant controllers.

Dual redundant sensors / transmitters will be provided for closed loop and open loop control systems. For those measurements, which are important for the safety of the plant and equipment, triple redundant sensors will be provided.

The control and automation system and the field measurement and actuator systems as well as and its support systems, power suppliers and data networks will be immune to electrostatic and electromagnetic interference, and will conform to internationally accepted EMC standards for power plant.

**Power Cycle and Auxiliary System Control:**

Control Interlock, Protection, Start-up and Shutdown of equipments and sub-systems associated with Power Cycle and auxiliary systems and also required for integration of plant main systems and subsystems will be carried out through the open loop and close loop control system configured in plant DDCMIS.

Close loop controls will be configured in the DDCMIS.
Start / stop sequence control of all power cycle and auxiliary system drives and equipments like Boiler feed pump, Condensate extraction pump, HP/LP heaters, Make-up water pumps, equipment cooling water pumps and all motorized drives will be configured in the DDCMIS.

**Operator Interface Units (OIU)**

Operator Interface Units will be designed for safe, efficient, reliable and convenient control, operation and monitoring of the plant. Each OIU will consist of Operator Terminals (OT) based on latest PC or Work Station with redundant communication link, 24” Colour Graphic LCD (TFT) Monitor, Keyboard and mouse. Large Video Screen (LVS) based Operator Station will also be provided.

Printers, hard copiers etc. will be provided for generation of logs, reports and miscellaneous printouts.

Control and monitoring of plant through OIU / LVS will be performed through different displays which will include Process and Instrumentation mimic displays, control displays, bar graph displays, X-Y and X-T displays, alarm displays and messages, operator guide displays, system status displays etc. Logs, summaries and reports will be printed on the printers.

A comprehensive and integrated alarm handling system will be employed, which clearly distinguishes between different alarm types. Alarm information will not be lost or inaccessible whilst navigating through displays, and alarm presentation will dynamically provide the operator with information matched to the current situation and its criticality.

**Data Communication**

Different subsystems of the DDCMIS are interconnected through redundant bus communication system. This includes redundant Data Bus, redundant Plant Data Highway and other applicable bus subsystems. The communication bus system will be in hot redundant configuration with no loss of data or loss of configuration in case of failure of one bus.

All the subsystems will be connected to the data bus and plant data highway through hot redundant communication controllers.

LAN and network components in redundant configuration will be envisaged to provide information exchange of Plant DDCMIS with plant management and administration facilities, wherein, the offices PCs are connected to the LAN.

Open Architecture based DDCMIS with Global Database and intelligent distributed configuration has been envisaged. It will be capable of handshaking with any third party system following standard protocol. The primary objective will be centralized monitoring, presentation & report of data for information and analysis of the entire plant. Main Data Highway will be high-speed dual redundant type with a bus speed of minimum 100 MB/Sec or higher. Communication link between DDCMIS and control system of other plant areas such as Ash Handling Plant (AHP), Coal Handling Plant (CHP), Demineralised Plant (DM Plant), Instrument Air & Process Air Plant will be redundant.

All the Controllers will be connected to a common high-speed data highway for global distribution and access of data. Any data will be available at any point of the network as and when required. The Control System will be modular, expandable and flexible so that expansion of the system is possible by adding extra stations on the data highway.

**Historical Storage and Retrieval (HSR) System**

Historical Storage and Retrieval system (HSR) in redundant configuration will collect and store data and parameters including trends, alarms and events from DDCMIS database periodically and automatically to removable dual magneto optical disk data storage devices, once every 24 hours for long term storage and retrieval.
A separate terminal with 24” colour graphic LCD (TFT) Monitor and Laser jet Printer will be provided for HSR System.

**Performance Calculation**

The performance calculation shall use a high level language. Calculations shall be made using floating point arithmetic. These equations shall be changeable on line at the job site. An extensive set of steam property subroutines based on 1967 ASME steam tables shall be included in the system. The calculation results shall automatically be quality coded according to the worst quality of any of the inputs to each calculation. The results of these calculations shall be available through the data base, for appropriate logs and operator displays as determined by the owner / consultant. A dedicated terminal with 24” colour graphic LCD (TFT) monitor and laser jet printer will be provided for the performance calculation package.

The performance calculations shall be broadly subdivided into two classes.

Class – I: Equipment protection Calculations.
Class – II: Plant / equipment efficiency calculation.

**Plant Optimization Package – (Optional Package)**

PC based on-line plant performance analysis, diagnosis & optimization (PADO) system for the station shall be provided. The PADO system shall incorporate the complete thermal design model of each unit. The system shall use the measured data from the C&I system through appropriate interface to be provided. Instruments, which are specifically required for implementation of PADO, shall also be provided.

The PADO system will provide the following functions in a modular and seamlessly integrated environment, using a common plant model and a dynamically shared database. The PADO system shall include the following:

- Performance analysis and monitoring of systems and components.
- Emission Analysis and Monitoring
- System and Performance Diagnosis

Boiler performance optimization packages including the optimized operation of soot Blowing System.

- Boiler stress condition analyzer.
- Interactive water and gas chemistry management system
- Regenerative Cycle performance optimization system.
- System and Performance Optimization

The hardware will include a computer server and sufficient numbers of workstations along with the complete networking in a LAN network. The implementation of all the associated hardware, networking and related work will be made in order to successfully operate the software. Values calculated by PADO software will be available as calculated data base points in database of DDCMIS through appropriate interface for Display and recording.

**Management Information System**

Management Information System will be provided for critical Analysis of the Plant Performance and Optimization. The System will analyze dynamically the status of the process and the equipment of the Power Generating Units and will automatically generate the instructions for operator guidance to maintain the process parameters and the system and take necessary action for maintaining the process and the System / Equipment in the Plant to their optimum performance.
Proper safety and security system will be adopted for protection of the system against corruption and virus.

**Sequence of Event Recorder (SER)**
Sequence of events recording system (SER) of 1 milli sec resolution with adequate redundancy features and input capacity would be provided as an integral part of DDCMIS to log trips, cause of trips and other important faults to diagnose the cause of plant & measure equipment trip. The system will be provided with a dedicated printer located in the main control room.

**Alarm Annunciation System**
The central alarm system will be a part of the functions performed by the DDCMIS. The alarm systems will contain all alarms for a safe and reliable operation of the plant. The alarm system will cover all pre trip and trip alarms related to unit and auxiliaries. Alarms will be given when important plant values exceed their limits or when abnormal operating conditions occur in the plant.

The alarms will be displayed on DDCMIS Operator Interface Unit and will be printed on alarm printer chronologically.

It will be possible to configure several alarm priorities. For alarms with the highest priority, a separate acoustic signal will be generated which can be acknowledged.

**Electrical Systems Operation and Monitoring:**
Operation and Monitoring of Plant Electrical and downstream system will be performed through DDCMIS.

DDCMIS will have a redundant Software Link with SCADA system for monitoring of Switchyard system.

**Interface with Balance of Plant (BOP) Control System:**
Suitable communication gateways will be provided between all PLC based Control Systems and DDCMIS for Monitoring of Balance of Plant off-Site Packages from the Central Control Room through DDCMIS Operator Interface Units.

The main BOP control systems to be interfaced with DDCMIS are indicated below.

- Coal Handling Plant
- Ash Handling Plant
- Water Treatment including Chlorination & DM plant
- Waste Water Treatment
- Raw Water Pretreatment System
- Air Compressors
- Mill Reject System
- HVAC
- Fire Detection and Protection System
- Condenser On-line Tube Cleaning System
- Condensate Polishing System
- River Water Intake System

Information from other stand-alone systems shall be made available to DDCMIS of each unit through hard-wired signal exchange, if required.

**5.3.5 Steam Generator (SG) Control System:**
The Steam Generator control system will include the following functional blocks:
Furnace Safeguard and Supervisory with Flame Monitoring System (FSSS)
Secondary Air Damper Control (SADC)
Soot Blower Control System
Electromagnetic Relief Valve Control, Furnace Temperature Probe Control and other miscellaneous controls
Air Heater Leakage Control System and Fire Detection System
Acoustic Steam Leak Detection System
Furnace Flame Viewing System

The Steam Generator protection system is integrated with the unit control and automation system and software communication (signal exchange) from and to it will be redundant. In the event of this interface not being able to handle time critical signals, they and other critical parameters will be hardwired.

The Boiler Protection System will be a fully electronic, fail safe multi channel system. The Boiler Protection System shall be implemented in a fault tolerant 2 out of 3 triple redundant configuration.

FSSS shall comply with NFPA Code and TUV certified SIL 3 level protection.

Proprietary Steam Generator control system by manufacturer shall be provided. It will be complete with all the functional blocks described above with operating interface arrangement. The control system will have redundant software link with the Plant DDCMIS and some of the critical signals for protection of the boiler will be hardwired to the plant DDCMIS.

5.3.6 Steam Turbine Generator (STG) Control System

The TG control and governing system is configured as a dual redundant system, which allows for bumpless control transfer from the one to the other channels in the event of a channel failure

The Turbine Protection system shall be implemented in a fault tolerant 2 out of 3 triple redundant configuration.

A turbine stress limiter/controller is also included, to control stress in the turbine via measurements at predetermined locations in the turbine. This function will be continuously active under all operating conditions.

The STG control system will typically include the following functional groups:

Electro Hydraulic Governing Control System (EHGC)
Automatic Turbine Run-Up System (ATRS)
Turbine Protection System (TPS)
Automatic Turbine Testing System (ATT)
Turbo-Supervisory Instrumentation (TSI)
Turbine Stress Evaluator (TSE)
HP-LP Bypass Control System
Generator Auxiliaries Control System

The turbine over speed protection is an independent SIL 3 /TUV certified system in accordance with IEC 61508 and IEC 61511, integrated in the protection system. As a minimum four speed measurement probes and measuring wheel are provided, of which three probes are operational and one standby. The speed trip signal is based on a 2-o-o-3 voting signal which trips the turbine directly.

The turbine protection philosophy to be implemented is based on the respective required regulations.
Proprietary STG control system by manufacturer shall be provided. It will be complete with all the functional blocks described above with operating interface arrangement. The control system will have redundant software link with the Plant DDCMIS and some of the critical signals for protection of the STG will be hardwired to the plant DDCMIS.

Turbine Supervisory Instrumentation will be complete with Sensors, Amplifiers, Special Cables and monitors with all necessary equipment and accessories. Radial, Axial and thrust Bearing Vibrations, Axial Shift, Eccentricity, differential expansion etc., will be some of the important measurement for the Steam Turbines and its driven equipment like Generator.

5.3.7 Vibration monitoring system for major plant auxiliaries

The Vibration Monitoring System will be provided for all critical equipments including BFP (both Turbine & Motor Driven), ID Fans, FD Fans, PA Fans, CEP, CW Pumps etc for condition monitoring and analysis of critical mechanical equipment. The System will be complete with Proximity Type Vibration Sensors, Amplifiers, Special Cables and monitors with all necessary equipment and accessories.

The vibration monitoring system will be provided both at Driving and Non-Driving ends of fans, pumps and their drive motors both at X- and Y- directions at each measuring points.

A Redundant Common PC based diagnostic station will be provided, which will be knowledge based with the capability of dynamic data analysis and provides complete information about machines. This will also include latest Machinery Management Software for data acquisition and predictive maintenance of the machinery/equipment. The vibration monitoring system will be provided with necessary interfaces with DDCMIS for centralized monitoring purpose.

5.3.8 Unit Control Desk

Unit Control Desk
The unit, functional group or drive level control and operation of all main plant equipment including non-synchronizing breakers of 765kV or 400 kV, 11 kV and 415V system will be done from a set of consoles OIUs. The unit control desk (UCD) would house OIUs, including Monitor, Keyboard, Mouse and the Emergency pushbuttons for Tripping of Boiler, Steam Turbine and major auxiliaries. The UCD will also house Telephone Hand set for communications.

5.3.9 Central Control Room Equipments

The Central Control room will accommodate the following equipment.

- Unit Control Desk (UCD) and printers in the main control room.
- DDCMIS system cabinets and electrical relay cabinets and other systems panels (as required) in the Control Equipment room
- Shift charge Engineer’s monitor with key board and printers in Shift Charge Engineer’s room.
- System Maintenance Engineer’s monitor with key board along with the printer in System Maintenance engineer’s equipment room
• Redundant 240 VAC UPS for all DDCMIS panels, its computers & peripherals including control panels of SG, TG, station C&I & other auxiliaries. In each panel 2 Nos. 240 VAC to 24 VDC converters will be provided to feed 24 VDC to the hardware of DDCMIS.

• Public Address System panels, Fire alarm system panels etc will be suitably housed in main control room.

5.3.10 Closed Circuit TV
Closed circuit TV and plant cameras along with redundant switching system, keyboards, monitors, interconnecting cables and interface to LVS has been envisaged for surveillance, safety and security of various plant areas. The monitoring stations will be in Central control Room as well as in plant centralized security room.

5.3.11 Smart Transmitter Maintenance Station
Dedicated standalone PC based Smart Transmitter Maintenance Station (STMS) will be provided for centralized configuration, maintenance, diagnostic and record keeping of all electronic smart transmitters. Transmitter signals will be wired parallel to DDCMIS control system and HART modules of STMS, which will be connected to PC through suitable communication modules. Complete diagnostic, record keeping, calibration and configuration, event and log reports, historical database records of all transmitters will be possible from the STMS.

5.3.12 Master and Slave Clock System
Master and Slave Clock System in redundant configuration would be provided in order to maintain uniform timing throughout for the DDCMIS of both the units including sequence of event recorder, all offsite PLC control system and monitoring and Electrical SCADA system including Digital fault recorder for the electrical system.

The system will include two master clocks in 100% redundant configuration (one working and the other standby) and slave clock display units. Master clocks will have own synchronizing pulse generation facility as well as the facility to receive synchronizing Pulses from the Global Positioning Satellite (GPS) system. The GPS receiving System will be complete with Antenna and other electronic devices.

In the event of non-availability of GPS Pulses, the time synchronizing pulse from the Master Clock itself will be utilized for time synchronization of the Plant DDCMIS with other Systems.

5.3.13 Steam and Water Analysis System (SWAS)
A centralized comprehensive Steam and Water Analysis System (SWAS) for each unit will be provided for continuous on line monitoring of water and steam purity in the plant cycle. Measurements of Conductivity, pH, Hydrazine, Dissolved Oxygen, Silica, Sodium and Phosphate will be provided.

Various steam samples with primary coolers and water samples would be routed to a centralized place and cooled to the required temperature before entering analyzers / cells. The complete hardware associated with this sampling system and cells is mounted in a sampling rack with facility for grab sample. The analyzers are located in a separate panel near the sampling rack in an air-conditioned environment. Both the sample rack and analysers are located in a central place with the analyzer panel section partitioned for air-conditioning. The SWAS room will be suitably located in the Main Plant Building.

Following Table provides a guideline for analysis of Samples taken from different streams:
### Table 5.6
Types of Analysers envisaged in SWAS

<table>
<thead>
<tr>
<th>Stream</th>
<th>Analyser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make up water</td>
<td>Specific Conductivity</td>
</tr>
<tr>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td>Hotwell Condensate</td>
<td>Specific Conductivity (Both Sides)</td>
</tr>
<tr>
<td>CEP Discharge</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Specific Conductivity</td>
</tr>
<tr>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td></td>
<td>Sodium</td>
</tr>
<tr>
<td></td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>Condensate Polisher outlet</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Specific Conductivity</td>
</tr>
<tr>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td></td>
<td>Sodium</td>
</tr>
<tr>
<td></td>
<td>Silica</td>
</tr>
<tr>
<td>Deaerator Outlet</td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>Feed water at economizer inlet</td>
<td>pH,</td>
</tr>
<tr>
<td></td>
<td>Specific Conductivity</td>
</tr>
<tr>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td></td>
<td>Hydrazine</td>
</tr>
<tr>
<td></td>
<td>Silica</td>
</tr>
<tr>
<td>Drain from Separator</td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td>Main Steam outlet</td>
<td>pH,</td>
</tr>
<tr>
<td></td>
<td>Specific Conductivity</td>
</tr>
<tr>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td></td>
<td>Sodium</td>
</tr>
<tr>
<td></td>
<td>Silica</td>
</tr>
<tr>
<td>Reheated Steam</td>
<td>Cation conductivity</td>
</tr>
<tr>
<td>Condenser cooling water</td>
<td>pH,</td>
</tr>
<tr>
<td></td>
<td>Specific conductivity</td>
</tr>
</tbody>
</table>

### 5.3.14 Stack Emission Monitoring System

Continuous Emissions Monitoring System (CEMS) for monitoring of Flue gas Emissions from the Stacks of the Plant will be provided, which will consist of the following analyzer Instruments:

Oxides of Nitrogen NOx
Detailed Project Report

2x1000 MW Coal Based TPP at Paguthan, Bharuch District, Gujarat (India)

Chapter 5: Proposed Infrastructure

5.3.15 Ambient Air Quality Monitoring System

Analytical Instruments for Ambient Air Quality Monitoring will also be provided to check upon the ambient air quality around the Power Plant.

5.3.16 Uninterruptible Power Supply (UPS) and Distribution

The power supply for the control and monitoring systems takes into account the following guidelines:

- The total requirement of C&I power supply is fed from 240V AC industrial graded parallel redundant UPS and redundant sealed maintenance free Ni-Cd batteries having 20 yrs life. 240V AC UPS supply is fed to MMI. 24V DC supply requirement for DDCMIS cards/transmitters etc is met from 240V AC UPS supply. The UPS system shall have following features:

  - High degree of reliability and availability to ensure that under no condition does the supply to the control system of the plant fail.

  - Backup power to be available (for minimum 1 hour) for the control when the main electric supply in the plant may not be available.

  - To provide regulated and clean power sources for the Micro-processor based control and monitoring systems.

  - Synchronization of the redundant AC sources to ensure that any transfer to back-up supply does not cause damage to the sensitive computer equipment.

  - Redundant ACDB/DCDB with redundant feeders will be provided for UPS supply in order to ensure no-break power supply of 240V AC.

  - The control supply to Micro-processor based control systems cannot have any breaks as this leads to the loss of memory and consequent halting of the systems. Therefore a non-break supply is ensured for such systems.

5.3.17 Field Instruments

All field transmitters are envisaged to be smart type having 4-20 mA DC signal output with 100:1 turndown ration and with superimposed digital signal conforming to HART or any other internationally accepted protocol. Four (4) nos. portable digital calibrator/HART communicator are envisaged for on line calibration of the transmitters. Accuracy of process transmitters is envisaged as 0.1%. Accuracy of local gauges (PG, TG etc) is envisaged as 1%.

All temperature elements (RTD/Thermocouple) will be duplex type. Thermocouple will be mineral insulated type.
Measurement of HP bypass steam flow (when bypass system is in operation) feed water flow, condensate flow, SH & RH attemperation flow and BFP recirculation flow is proposed with the help of flow nozzles. In light oil & heavy oil flow service Coriolis type mass flow meters have been envisaged. Orifice plates will be used in other water services. Latest and Suitable method for main steam flow measurement is to be adopted for the system.

All level switches would be external chamber displacer or float operated type. All level switches and level transmitters for vacuum service will be displacer type or guided wave radar type.

Field instruments would be suitably grouped and clustered area wise and would be terminated in local junction boxes for onward connection to the DDCMIS marshalling cabinets.

5.3.18 Final Control Elements

In general, control valves, dampers and other final control elements would be of pneumatically operated type except for HP / LP bypass and other critical valves, which will be of hydraulic operated type and Fan/Pump flow/speed control devices which will be operated by electric/hydraulic actuating mechanisms. Control valves will have wide range of controllability, less noise and have adequate fail-safe feature.

Electric to pneumatic converters will be provided for pneumatically operated final control elements to interface with the DDCMIS. Each final control element will be provided with pneumatic positioners, smart type electronic position transmitter of 4-20 mA output, air lock relay, air filter regulator, hand wheel, limit switches, solenoid valves and other accessories in accordance with the system requirements. In case of control signal or pneumatic supply failure, the final control element should go to fail safe position.

For special applications such as hazardous areas, actuators/electric-pneumatic converters will be selected based on specific application requirements.

5.3.19 Instrumentation & special cables

Instrumentation Cables

Individual / pair shielded and overall shielded twisted pair multistrand colour coded copper cables would be used for analogue signals and overall shielded cables would be used for digital signals. All the insulation including overall sheath would be FRLS quality. The size of the wire would be 0.5 Sq.mm. FRLS 2.5sq.mm copper control cable would be used for cabling for services like field solenoid valve to the control system. Compensating cables will be provided for connecting the thermocouple inputs to the measurement system of DDCMIS and up to temperature transmitters for closed loop control system. The interconnecting cables between any two cabinets and between cabinets and panels would be of prefabricated type. The communication bus of the DDCMIS would be coaxial / OFC / twisted pair cable.

Instrumentation Interconnection Philosophy

Cable interconnection philosophy is to be adopted such that extensive grouping of signals at field will be done by use of junction boxes so that multi pair cables can be used from junction boxes to system cabinets.

Prefabricated cables would also be used for interconnection between DDCMIS Cabinets, TFTs, LVS, printers and operator stations and other related equipment.

5.3.20 Maintenance and Calibration Instruments

One set of Maintenance and Calibration Equipment for instrumentation and control systems, common for both Units of the plant will be provided. This would consist of calibration equipment such as electronic test
bench, pneumatic test benches, dead weight tester, manometers, air sets, RCL Bridge, digital channel simulator, logic probe, testing meters / devices / calibrators for at site testing and calibration, etc.

5.3.21 Erection Hardware

All required installation hardware including impulse pipes, tubes, valves, manifolds, fittings, cable trays, holders, angles and conduits etc. required for proper installation and interconnection of instrumentation and control system shall be provided. All materials and installation thereof shall confirm to latest editions of American National Standard Code for pressure piping, ANSI B 31.1, ANSI B 16.11, ASME Boiler and Pressure Vessel codes, IBR and other applicable ASME, ANSI and local Standards.

5.3.22 Control Room

One (1) common Control Room for Two (2) units shall be provided. Control Room shall be partitioned into different rooms to house the following equipments:

- Unit Control Desk (UCD) in the Main Control Room common for both the units with different Section for each unit consisting of HMI, printers and other peripherals.

- The system cabinets, marshalling cabinets and electrical auxiliary cabinets in the Control Equipment Room adjacent to Main Control Room which shall be independent for each of the unit with mirror image arrangement of the cabinets.

- EWS station with keyboards, printers and other peripherals unit wise in EWS Room.

- Shift Engineer’s TFTs and printers in Shift Engineer’s room common for both the units.

- Un-interrupted power supply system (UPS) Unit wise in UPS room

5.4 Civil Works

5.4.1 Land Development

Existing plant FGL is at 15.7m from MSL. Similar FGL will be adopted for the extension plant. The site for the proposed unit is undulated ground which will require minimum grading and leveling. However, the detailed topographic survey report will be able to establish the actual cutting and filling for site grading. Plant will be designed for adequate surface runoff drainage system. FGL will be fixed taking care of HFL, area drainages and surrounding elevations, while minimizing cutting and filling activities.

5.4.2 Boundary Wall and Permanent Gate House

The plant area is already in the possession of the PCCPP. The plant area is already with boundary wall. No separate boundary wall will be required. However, fencing may be required as per the requirement of the Plant within the Project Site.

5.4.3 Soil Properties and Load Bearing Capabilities

Geotechnical Investigation of the Project Site is yet to be carried out. Geotechnical Investigation has been conducted for the existing plant, which is also in the vicinity of the Project Site. As per the Geotechnical Report carried out for the existing plant, the soil consist of high to medium plastic and swelling clay upto around 3.0m depth followed by plastic clay of 20.0m depth of termination. The top soil is not useful for back or plinth filling purpose. Safe bearing capacity at a depth of 4.0m varies largely from 16 t/m² to 21 t/m², considering 50mm settlement for isolated foundation of size 2.0m x 2.0m to 3.0m x 3.0m. The Safe bearing capacity of soil for
isolated foundation of size 2.0m x 2.0m to 3.0m x 3.0m is varying from 11 t/m$^2$ to 15 t/m$^2$ at 2.0m depth. At present, pile foundation may be considered for major equipment of BTG area and Chimney.

Actual safe bearing capacities of the site will be collected from Geotechnical Investigation Report after conducting test at site.

### 5.4.4 Foundation Design Philosophy

Foundations for various structures shall be of reinforced concrete to resist the expected loading and to meet the durability & serviceability requirement.

For foundations of the steam turbine-generator, boiler feed water pumps, fans, mills, crushers etc. detailed static and dynamic analysis, shall be done. Abnormal loads like loss of blade unbalance, wind and seismic force shall be considered in the analysis. The dynamic analysis shall consist of both free vibration analysis and forced vibration analysis and foundations of steam turbine generators, boiler feed pumps, fans, mills, crushers etc., shall be designed in accordance with the manufacturers’ recommendations. For foundations supporting minor equipment weighing less than one tonne or if the mass of the rotating parts is less than one hundredth of the mass of the foundations, no dynamic analysis is regarded as necessary. However, if such minor equipment is to be supported on building structure, floors etc., suitable vibration isolation shall be provided and such vibration isolation system shall be suitably designed.

All foundations shall be designed in accordance with the provisions of the latest revision of Indian standards. For machine foundations the provision of ISO/ DIN standards and recommendations of the manufacturer shall also be considered. The foundations design shall further ensure that settlements/ differential settlements are within permissible limits from the following considerations:

- Code requirement.
- Serviceability consideration.
- Structural design consideration.
- Limitation due to equipment performance.

### 5.4.5 Plant Buildings and Structures - Design Considerations

The design of civil and structural works shall generally be in accordance with relevant Indian Standards, International Standards can be followed only when it is more stringent than Indian standards.

#### Design Inputs

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Unit</th>
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</tr>
<tr>
<td>Minimum ambient</td>
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<td>Heaviest monthly rainfall</td>
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<td>Wind Velocity</td>
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</tr>
<tr>
<td>Seismic Zone</td>
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</tr>
</tbody>
</table>

#### Design Aspect

Before performing the design, “Basis of Design” shall be compiled for each major area of works. This document shall describe concisely:
a) The form of each section of the works.
b) The performance objectives.
c) The design approach selected and the design parameters.
The design criteria indicating the load and load combinations for design of RCC/Structural/foundation works shall be made based on relevant Indian Standard Codes/ equivalent International Codes/ Manufacturer’s recommendation.

Consideration to the following effect of environment and required protection of structure shell —
a) Architectural requirement.
b) Assessment of risk.
c) Any other pertinent information.

5.4.6 Power House Building including Control Room

Main Power House Building common for all the units shall comprise of following buildings/foundations.

- Station building consisting of TG Hall, Control Bay and Deaerator Bay
- TG Foundations
- BFP & CEP Foundations
- Control room area

The building shall be of steel framed structures with expansion joints placed to suit the equipment layout, the area of each unit separated by expansion joint. The structure will consist of moment resistant frames in transverse direction, which will be braced in the longitudinal direction, to resist horizontal forces.

The building will be steel framed structures clad in metal sheeting above masonry/ precast dado wall of approx height of 3.0 M. The superstructure will support an electrical overhead traveling crane of required capacity, which will traverse the length of the building. The TG at operating floor will be supported on reinforced concrete structures with necessary vibration isolation system. The reinforced concrete ground slab shall be constructed on compacted fill. The roof of TG bay shall be provided with troughed metal sheet decking of minimum 0.8 mm thickness with phosphate coating and primer on both sides to act as a permanent shuttering for cast-in-situ RCC slab. Underside of metal roof decking shall be finally painted with synthetic enamel paint. Roof will be provided with arrangement of natural light. The floor slabs at intermediate levels will be of cast-in-situ RCC and supported on steel beams & columns.

The building shall have steel staircase from ground floor to roof slab and emergency exit staircase shall be provided separately.

Control room will have provision of false ceiling and false flooring. External & internal walls shall be of brick masonry. Fire doors will be of 4 hrs fire resistance rating.

All foundation for building and equipment shall be supported on shallow/ Strip foundation as per soil report. However, the final foundation design criteria will be established based on geo-technical investigation report.

5.4.7 Equipment Foundations

All foundations for equipment shall be designed and constructed matching with the layout and levels of the relevant structures.

The foundation systems for rotating equipment will be sized and proportioned not to exceed the bearing and settlement criteria and to assure satisfactory performance of the equipment. In addition to static analysis, dynamic analysis will be performed to determine the fundamental frequencies of the foundation system. Am-
amplitudes shall be kept within the allowable limits specified by the manufacturer or in absence of manufacturer's specified value, as specified in the IS Codes/ DIN Codes.

The dynamic behavior of the foundation will meet the requirements of IS: 2974 (Part I to IV) – Code of Practice for Design and Construction of Machine Foundations. Foundations for rotating equipments like Turbo-generator, Boiler feed pumps, ID/FD/PA fans and Coal mills shall be designed to carry loads furnished by the equipment manufacturer.

All rotating equipment will be provided with vibration isolation system. The designs of the vibration isolation systems shall meet the requirements of the equipment suppliers. The vibration isolation foundation system will be provided for Turbo-generator, Boiler feed pumps, ID/FD/PA fans and Coal mills. Equipment foundation will be separated from adjoining part of building and other foundations. Joints at floor/slab will be suitably sealed.

The vibration isolation system will be capable of vibration isolation at least 95%.

Foundations for static equipment e.g. Boiler, ESP shall be designed to carry the loads furnished by the equipment Manufacturer.

If minor equipments with dynamic load are required to be supported on building structures, floors etc., suitable vibration isolation shall be provided.

5.4.8 Boiler Supporting Structure

The boilers shall be suspended from a steel structure provided by the boiler supplier, which shall be supported on reinforced concrete foundation considering isolated /strip foundation based on soil investigation report.

The FD fans and PF Mills sited adjacent to the Boilers shall similarly be supported on isolated /strip foundations based on soil investigation report.

The foundations to the PF Mills and FD Fan units shall include reinforced concrete blocks with anti-vibration mountings.

The reinforced concrete ground slab in the Boiler Areas shall include drainage channels with water-jets for removal of boiler ash to transfer pump houses and subsequent transport to off-site ash pond.

5.4.9 Mill & Bunker Building

The coal Conveyor Towers, Coal Bunkers & bunker building will comprise of structural steel framework supporting the coal bunkers, feeder floor and tripper floor. The structural frame will be designed as braced frame in longitudinal and in transverse direction. In transverse direction, wherever bracing is not feasible due to functional reason, moment resistant frame/ removable bracings may be adopted. Coal bunkers will be of structural steel plates and will be lined with stainless steel liner plates in the entire conical portion. The floors will be of reinforced concrete with hardened top and supported on steel beams. The column foundation and mill foundations will be supported on isolated/ strip foundations based on soil investigation report. Tripper bay and conveyor galleries will be provided with metal sheet cladding.

5.4.10 Chimney

The chimney shall be 275m high comprising a tapered cylindrical concrete windshield containing two steel flues which will project two time flue diameter above the roof of the wind shield.
The superstructure shall be supported on a reinforced concrete raft/strip foundation based on soil investigation report.

The flue shall be fabricated from mild steel except for the uppermost 2 times flue diameter of height, which shall be in stainless steel. The mini-shells, bottom surface of roof slab, top surface of external platforms and the top few meters of the internal surface of the windshield shall be painted for acid and heat protection with bituminous paint.

Mineral wool mattresses secured by stainless steel anchorages shall be used to insulate the whole exterior of the flue.

The flue shall be hung from top platform and restrained laterally at several levels via a system of tie beams/brackets attached to the windshield and liner. Self-supporting steel flues from ground level are also acceptable.

As an alternative, top hung steel flues self-supporting steel flues from ground are also acceptable with proper design.

Gas entry to the flue shall be via 2 inlet ducts. Each inlet duct shall have a movement control bellows unit located just outside the windshield to isolate the chimney superstructure from other gas ducting loads.

Aircraft warning lights shall be fitted in accordance with Indian Civil Aviation regulations, at least, at roof level and at three equal intervals over the upper half of the chimney height. The external portion of the wind shield shall be coated with alternate bands of red and white colors to meet the aviation safety requirements.

Light units at each of the four levels shall be spaced at 120° of arc on the windshield exterior giving a total of twelve (12) units on the chimney. Light units shall be mounted on pivoting panels set in openings in the windshield for maintenance from platform levels inside the chimney.

Steel platforms comprising open mesh/chequered plate panels on a beam grid shall be installed at a minimum of five levels within the chimney to assist in maintenance of the structure and its fittings and for use in flue gas monitoring.

An electrically operated hoist cage with rack-and-pinion climbing track fixed to the windshield shell shall provide access to all platforms over the full height of the chimney up to the platform at about 6m below roof level. Access from this platform to roof stab shall be by vertical ladder with safety cage.

A second means of access to all levels shall be provided via a steel staircase. Handrails for platforms and staircase shall be of tubular construction.

An opening shall be included in the windshield at ground level for use in installation of the flue. The opening with louvre near to the top of the windshield shall be used to ventilate between shell and flue.

Openings (with caps) will be provided at two levels along with access stairs and platform for collecting samples for Pollution Monitoring. At each level three openings at a spacing of 120° of an arc shall be provided.

The roof slab structure shall be designed to serve as a lifting platform for supporting the self-weight of the flues during erection.

The chimney shall be fitted with a lightning protection system.
Roof drainage shall be through UPVC or steel pipe mounted mainly on the inner surface of the windshield and discharging to the site drainage system.

The embedment shall be provided in the wind shell for providing strakes at top part of the chimney.

Acid resistant flooring at roof level & acid resistant paint in the wind shield at top should be provided.

The other components of the chimney include cast iron caps over mini-shells, liner test ports (for continuous pollution monitoring), liner hatches, reinforced concrete roof slab protected for acid and heat protection, grade level slab of reinforced concrete with a metallic hardener floor finish, a large electrically operated grill type roll-up door (with only the bottom small portion of the curtain of solid shutter type) at grade level and personnel access metallic doors at grade level and at all floors, a personnel access hatch in the roof slab, rain water drainage system, flue liner drainage system, roof drain basin, louvers with bird screens for ventilation openings and all gaps in the wind shield, mild steel discrete strakes, painting of chimney shell surfaces and painting/coating of all structural steel work and miscellaneous ferrous components (for a maintenance free life of at least ten years), all finishing works, electrical power, distribution boards, lighting panels, power and control cabling and wiring systems, cable conduits, stair and platform lighting, socket outlets, lightning protection and grounding system, aviation obstruction lighting and communication system.

5.4.11 Electrostatic Precipitator / Bag filter

Electrostatic Precipitator shall be supported by steel structure designed & supplied by ESP/Bag filter manufacturer. ESP columns shall be supported by RCC pedestal resting on RCC strip/raft foundation based on soil investigation report. Area below the ESP/Bag filter shall be paved.

ESP/Bag filter Control Room shall be a two storied reinforced concrete portal frame structure with RCC beams, slab and columns. The building columns shall be supported by RCC strip/ isolated foundation. The building shall have dimensions in accordance with functional requirements.

ESP/Bag filter Control Room shall be on the first floor and cable cellar with other facilities on the ground floor of the building. Control Room shall be provided with false ceiling and air conditioned.

External walls shall be in masonry construction.

5.4.12 Water in-take pump house and raw water supply arrangement

Cooling water requirement will be drawn from Angareeshwar at a distance of about 23 km from the site. The existing system will be utilized for conveying water.

There is an existing Water Pumping System. Necessary enhancement will be carried out to meet the water requirement of extension plant.

Cooling Water System

The CW Pump house shall house circulation pumps with wet-pit pump. The fore bay area shall be of RCC structure. In between the fore bay and CW pump pit travelling water screen and gates shall be provided. Proper handling system shall be provided for the travelling screen and gates. Adequate numbers of stop gate shall be provided for the maintenance work. Anti corrosion measure shall be taken for the carbon steel material by epoxy coating. The CW pump house shall be of an enclosed building structure with proper roof and ventilation arrangements. Electrical switchgear/ control room shall be provided adjacent to pump house.

CW Pipe

CW pipe shall be steel pipe encased with PCC, and RCC in case of road crossing, which shall be laid below ground level from the CW Pump house to steam turbine building. Access manhole with proper manhole cover
and air vent system shall be provided at an interval for maintenance of the pipe. Location of air vent system shall be based on transient analysis of CW system.

5.4.13 Natural Draft Cooling Tower

Two (2) numbers hyperbolic shaped natural draft cooling towers for cooling the circulating water shall be constructed in RCC. Construction of each NDCT shall include water basin, shell, hot water distribution pipe network, nozzles, orifices, fill, drift eliminators, cold water out flow channel, supporting structures, access stairs, ladders, walkways, NaClO dosing arrangements, sludge collection and discharge arrangement, trash screens / racks, stop logs / gates, area lighting, Aviation warning lights, lightning protection, cables, earthing, etc. Reference shall be made to relevant Indian & International standards for NDCT design.

5.4.14 Water Reservoirs

Raw water reservoir shall be of storage capacity for 3 days requirement of the plant. It shall be constructed as earthen bund reservoir. It shall be properly lined. The reservoir shall be partly below NGL and partly above. Suitable measures shall be adopted to take care of the water level increasing above the maximum water level.

The pump house shall be cladded on all sides with roof shed supported with fabricated steel structure.

5.4.15 Water Treatment Plant Building

The pretreatment plant shall consist of RCC reactor type clarifier, gravity filter house & pump house for DM plant, potable & service water, chlorination system, central monitoring basin, effluent disposal pump house, RCC CW chlorination building and clarified water tank of required capacity.

The pretreatment plant structures shall be of RCC & no. of stores shall be as per requirement.

The DM Plant cum regeneration building shall be provided with control room, Chemical house, laboratory, Service & potable water pumps. The building shall be of structural steel frame enclosed with brick wall for the switchgear, control room, chemical house and laboratory. The columns of the building shall be supported on isolated/ strip foundation. Suitable monorail shall be provided for erection and maintenance of pumps & motors.

DM water storage tank shall be covered steel tank supported by RCC raft foundation.

5.4.16 Sludge Sump

Sludge sump in Water Treatment Plant area shall be of RCC structure supported by RCC raft, with walkways, handrails, as required for easy and hazardless maintenance and operation of the plant.

5.4.17 Fuel Oil Handling

Fuel oil unloading area
Existing Fuel Oil Unloading System will be utilized.

Fuel Oil Pump House
Existing Fuel oil Pump House will be utilized. Necessary changes required for the extension plant will be installed.

Fuel Oil Tank Farm area
Existing dyke will be utilized along with the existing fuel tank.

Fuel oil Tank
Existing fuel tank 2 nos of 600KL each will be utilized to store LDO.
5.4.18 Effluent Treatment Plant

The Effluent Treatment plant shall be a reinforced concrete multi-cell tank of adequate size and as per process requirement. The structure shall be mainly below ground. No roof is envisaged.

The effluent treatment pump house will be open on all sides and covered with roof, and supported with fabricated structures.

5.4.19 Diesel Generator and Compressor House

The Diesel Generator and Compressor House shall be a single storey structural steel framed building. The building shall be enclosed with metal deck sheet roof with RCC overlay and permanently colored metal sheet cladding with proper doors and windows.

PLC room shall be enclosed with brick wall, with false ceiling and shall be air conditioned.

Monorail of adequate capacity shall be provided for erection and maintenance of the equipment.

5.4.20 Coal Handling System

Conveyor galleries and Transfer Towers

Belt conveyors will be provided in conveyor galleries. Conveyor galleries shall be made of structural steel with hood cover. Adequate walkways will be provided on either side of conveyor. Bottom of the galleries shall be provided with M.S. seal plates to arrest spillage of material at facilities crossing from conveyor.

Conveyor galleries shall be supported on steel trestles (2 /4 legged) at regular intervals. Trestle shall be supported by RCC pedestals resting on isolated/ strip foundations. The galleries will also support cables and pipes routed along the conveyor.

Transfer Towers will be provided at every change of direction of the conveyors. Foundations to Transfer Towers adjacent to the coal unloading and storage areas shall comprise reinforced concrete raft and pedestals supported on isolated footings, supporting steel stanchions for the tower superstructure. Transfer points would be structural steel works with permanently color coated steel sheet cladding on sides. Floors shall be of RCC with ironite finish. Roof will be of metal deck sheet with RCC laid over it.

Crusher House Building

The crusher house building shall be framed structure of structural steel works with permanently colored metal sheet side cladding. Floor in crusher house shall be of RCC with ironite finish. The roof will be with metal deck sheet with RCC laid over it, and properly sloped to drain rainwater. The crusher shall be supported on vibration isolation system. The vibration isolation system shall consist of helical spring units and viscous dampers supporting an RCC deck which would support the machine. Foundations for main building column and crusher foundation shall rest on strip/ isolated footings. Adequate steel doors and windows shall be provided for lighting and ventilation of crusher house.

For the purpose of maintenance and dust suppression, a partition wall shall be provided between operating & standby crushers.

Peripheral drain shall be provided at the ground level.

Coal Handling Plant Control and MCC Room Building

The Coal Handling Control Building shall be RCC framed structure with brick cladding. Roofs will have waterproofing treatment finishes will conform to specified requirement. The foundation of columns shall be supported on isolated/strip foundation based on soil investigation report.
Coal storage yard
Coal will be store in two coal storage Domes.

The entire coal storage area shall be provided with properly sloped PCC paving over rubble soling with properly compacted sub grade. RCC drains with removable pre cast RCC slotted cover shall be provided on either sides of each coal stack. These drains shall be so designed to carry the drainage from coal yard to the coal yard run off pit for separation of coal dust.

Coal Receiving Area
Coal will be received through a railway system outside the Plant periphery. The unloading area is at present utilized for unloading of Naptha. Unloaded coal will be transported through a cross country conveyor for a distance of about 7km.

5.4.21 Ash Handling System
Three RCC fly ash silos/ unit, pipe racks and compressor house shall be provided for fly ash handling system. Pipe trenches as required shall be provided in compressor house.

Bottom ash hopper, submerged chain conveyors, clinker grinders, Air Compressors, etc. shall be provided for bottom ash handling system. Compressor hose, and all equipment foundations shall be provided for both fly ash and bottom ash handling system. Bottom ash will be transported to the ash ponds by trucks.

Ash Handling control Room
The building shall be double storied RCC frame structure covered with RCC roof slab and brick masonry side cladding, plastered internally and rendered externally with adequate doors, windows and louvers. Control room shall be provided with false ceiling and air conditioned. Water proofing of roof is to be done with polymeric membrane. Building columns shall be supported on RCC isolated/strip foundation.

5.4.22 Transformer Yard and Switchyard
The Transformers shall be mounted on rails and shall be supported by concrete foundation resting on isolated/strip footings. The transformer rails shall be laid up to the road for erection and removal of transformer. Oil catch pit of adequate size to hold transformer oil, rain water and fire fighting water shall be provided. Proper slope in screed shall be provided to the bottom slab of oil catch pit. The oil catch pit shall have grating cover over which stone boulder shall be laid. The oil catch pit of transformers shall be connected to a common oil recovery sump pit. RCC fire-wall shall be provided between the transformers.

5.4.23 Switchyard
The Switchyard will be outdoor type. The Switchyard shall have a 2.4m high chain link fencing along the perimeter with two lockable double gates. The Yard shall contain equipment foundations and a network of reinforced concrete cable trenches fitted with pre-cast concrete covers at ground level. Adequate drainage shall be installed in the yard as well.

The Switchyard surface shall have 200 mm thick crushed stone paving, with anti-weed treatment and an internal peripheral and internal road of 4m width shall be provided inside the switchyard.

5.4.24 Switchyard Control Building
The Switchyard Control building shall be a two storied RCC framed structure with RCC beam slabs & columns housing all equipment including MCC and switch gears and situated adjacent to the Switchyard. The building shall have dimensions in accordance with functional requirement. Switchyard Control Room shall be on the first floor & Cable Cellar with other facilities shall be on ground floor of the building. The building shall have a
reinforced concrete floor slab and roof slab (adequately sloped for drainage) and full height masonry walls, with proper doors, windows and ventilators. The building columns shall be supported on isolated/strip foundation based on soil investigation report. The control room shall be provided with false ceiling. Water proofing of roof is to be done with polymeric membrane.

5.4.25 Cable and Pipe Rack

The cable and pipe rack will be structural steel. All the structural steel shall be welded/ bolted. The foundations for the supports shall be of reinforced concrete. Grating supported on structural steel framing would be placed for walkway portion.

No cabling shall be underground in Main plant area.

5.4.26 Pipe/Cable duct bank

Pipes shall in general be routed above ground and on pedestals, road crossings within the plant shall be constructed with RCC pipe/box culvert

All underground cables in the plant shall be laid in plain cement encased duct bank. Duct bank at road crossing shall be encased with reinforced cement concrete. The manholes for duct bank will also be of RCC Construction.
The cables in BOP area, Switchyard area and also to the Raw water Intake (RWIT) shall be underground also (as required). The cable to the RWIT shall be underground in Hume pipes.

5.4.27 Miscellaneous Plant Buildings

The Power Plant shall also be provided with the following buildings:-
- Service Building
- Chlorination building.
- Weigh bridge.
- Central monitoring basin.
- Chemical and environmental laboratory.
- Bulldozer shed.
- Any other plant buildings as needed based on the contractor’s design requirements.

Each of the above mentioned buildings/ facilities shall be sized as required to house and maintain the equipment. Electrical and control equipment shall be housed in a separate adjoining enclosed area as applicable. The buildings shall be complete with drains, plumbing, sanitary drainage and treatment piping, air conditioning as required, ventilation for non-conditioned areas, building lighting, station communications and fire protection.

Dedicated hoists and trolleys; and EOT cranes as applicable shall be provided for maintenance of the equipment housed in the buildings.

The foundations of the buildings shall consist of reinforced concrete raft/ strip/ isolated footing based on soil investigation report.

The above mentioned miscellaneous buildings shall have structural frames consisting of either structural steel or reinforced concrete columns and beams with concrete floors and roofs as required.

The roof shall be either permanently coated metal sheet with concrete overlay or reinforced cement concrete, with necessary water proofing treatment.
Exterior walls shall be of plastered brick masonry or pre-color coated metallic cladding construction. Inside walls with bricks shall be cement plastered and shall be provided with oil bound distemper paint of approved shade. The other partition shall be of wooden wall and finished accordingly.

Adequate natural ventilation shall be provided for all the above mentioned miscellaneous buildings through the use of doors, windows, and ventilators. All the buildings shall be provided with electrical, water supply, drainage & sewage services as applicable.

All roofs shall be provided with access through staircases/cage ladders as applicable.

5.4.28 Roads

The Plant roads would initially be of water-bound macadam type with shoulders on either side of carriage width. After major construction activities are completed, these would be surfaced with bituminous carpet. The main plant road shall be 10.0m wide. All internal plant roads (Double lane roads) shall be 7.0 m wide black topping with 1.5 m wide shoulders on both sides of the road. Single lane roads shall be of 4 m wide black topping with 1.0 m wide shoulders on both sides of the road. Access roads to building/facilities shall generally be single lane roads without shoulders.

Extra width would be provided on either side, of the road for tree plantation, footpath and storm water drains. It is also considered to provide RCC pavement around SG and transformers.

Culverts would be provided for road crossings over the drains. All culverts would be designed for the Class – AA/ Class – A loading condition, whichever is critical.

All roads shall be surfaced with gravel during the construction period. Occasional applications of a dust palliative material shall be used to minimize the dust problem during the dry seasons.

Access roads to all buildings and areas such as transformer areas, boiler area and other equipment areas (where access is necessary for inspection, operation and maintenance point of view) shall either be single or double lane road depending upon the functional requirement.

Design and construction of roads shall be in accordance with Indian Road Congress standards. Suitable Hume pipe and box culverts shall be provided at road crossings for drains and trenches for cables and pipes.

5.4.29 Paving/Plinth Protection

Plinth protection of 1m wide all around building and paving in main plant area will be provided. Paving / hard surface will be provided for vehicle parking and covered vehicle parking for cycles, scooters, and cars / jeeps near technical and administrative buildings, entire area behind the station building towards the chimney will be paved for the full length of the building, taking care of grade slopes suitably to meet surface drainage requirements. SG & ESP areas will be paved with RCC slab 200 mm thick. Suitable soling will be provided below the concrete slab. Switchyard and Transformer area will be provided with 200 mm thick gravel filling.

5.4.30 Landscaping

Landscape of the entire Power plant area including supply of plants, maintenance and sprinkling of water through distribution pipe network will be provided. Sprinklers will irrigate landscaped areas with the treated water from the sewage treatment units. Sufficient green belt as per standard norms will be provided.
5.4.31 Plant and Storm Water Drainage

The plant and storm water drainage shall take into account the topography of the plant area, intensity of hourly rainfall and the existing area drainage pattern.

An additional intercepting drain will be developed to cater surface runoff from the surrounding area. Sufficient drain capacity will be installed. Effluent from the battery room, water treatment plant and fuel oil handling system, and other areas where pollution is likely to occur, shall be disposed of only after suitable treatment.

In general, all plant effluent drainage shall be through buried concrete pipes and all storm water drainage shall be through open drains/pipe drains as required.

The Storm water drainage system consists of a network of open drains. Drainage from the roofs of buildings shall be taken down by down comers. These down comers shall discharge water into open peripheral drains. The runoff from plant areas, open areas, buildings and installations shall be carried through the network of open drains running all along the road system and finally joining the main drain. Drains shall be designed for a minimum self cleaning velocity of 0.6 m/sec and the maximum velocity shall not exceed 1.8 m/sec.

Open drains shall be of two types: namely catch drains and main drains.

Interceptor drains shall be constructed to collect water from surrounding areas to convey to the main drain. Open drains shall be provided on one side or both sides of the road as required. Surface drains shall be open drains of either RCC rectangular drains or brick lined drains trapezoidal in section. All drains in the power plant area and around Buildings shall be covered drains.

5.4.32 Rain Water Harvesting

The rain water is collected in the storm water drain running all around the plant. Rain water harvesting pits are connected at regular interval to the storm water drain. Thus, giving preference of the rain water to recharge the ground water. Excess rain water will flow into the river through a properly designed outfall structure.

5.4.33 Sewerage and Sewage Treatment Plant

The sewerage system shall be designed to provide cleansing conduit for speedy and efficient conveyance of foul water, such as wastewater from closets, urinals, bathrooms and pantries. An independent network of lines to carry the storm water drainage and sewerage shall be provided. Sewers shall be designed for desired minimum and maximum velocities.

The plant area shall be divided into different parts based on layout consideration. The sewerage flow shall be made by gravity. Routing of these shall ensure no interference with underground facilities. Manholes shall be provided at every 30 meter along the length of any pipe, at connection points and at every change of alignment, gradient or diameter of sewer pipeline.

A permanent sewage treatment plant (aerobic or anaerobic treatment) shall be provided to ensure adequate cleaning of the sewerage discharge of the plant. The treated effluent shall be utilized for the irrigation of the landscaped areas. The treatment plant shall be designed to meet all requirements of applicable local by-laws/pollution standards, as well as the conditions stipulated by the State/Central agencies during the environmental clearance to the project.

5.4.34 Non Plant Buildings

Workshop
Workshop building shall be structural steel framed building covered with metal sheet with concrete overlay and permanently coated metal sheet side cladding with doors, windows and louvers. E.O.T crane facility will be provided. Workshop building should have enclosed office area, locker room, toilet, store and sufficient large maintenance area. Building columns shall be supported on strip/isolated footing foundation. Floor shall be finished with abrasion resistant material.

**Permanent Store**

Permanent Store building shall be structural steel framed building with brick masonry cladding and with tubular steel roof truss having pitch roof of colored metal sheet. It shall be provided with rolling shutter. It should have office area and toilet, apart from the store area. Building columns shall be supported on strip/isolated footing foundation.

**Canteen**

Sufficient storage space for foods, gases, kitchen area, washing area, storing area, common waiting area, Dining area, and toilets shall be provided.

The building shall be RCC frame structure covered with RCC Slab and brick cladding with adequate doors, windows and louvers.

Proper drainage and disposal arrangement shall be provided for the kitchen and pantry area.

Building columns shall be supported on isolated footing / strip footing.

**Car park / Cycle Shed**

Car parking/ cycle shed of structural frame with regular rolled /circular section with metal sheeting shall be provided. Floor will be of R.C.C construction placed on well compacted hard base. Floor will be constructed with proper expansion joints.

**Residential Colony**

The Provision for additional housing required for phase-II shall be constructed in the existing residential colony. As per the requirement additional quarters shall be constructed. All the other existing common amenities in the planned township for phase I shall be utilized and hence no additional provision is required.

All building shall be permanent concrete frame structures (R.C.C) with brick cladding. Separate soil investigation is to be made to adopt suitable foundation system. Civil and architectural specification of the township structures shall be same as plant structures.

### 5.5 Environmental Aspects

#### 5.5.1 Type & Source of Pollution

The various types of pollutions likely to be created by the proposed power plant, which has a socio economic impact, can be broadly classified into the following categories:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Pollution</th>
<th>Source of Pollution</th>
</tr>
</thead>
</table>
| 1.      | Air Pollution     | Dust particulates from fly ash in flue gas  
|         |                   | Sulphur dioxide in flue gas  
|         |                   | Nitrogen oxides in flue gas  
|         |                   | Coal dust particles during storage/handling of coal |
### Proposed Infrastructure

#### 5.5.2 Pollution Monitoring and Control Measures

A Greenfield project of the proposed scale is bound to exert certain adverse as well as beneficial impacts on the immediate surroundings. Primary impact on environment due to installation of a power plant comes from the combustion of fuel and discharge of chemicals and effluents from the plant through wastewater.

Environmental Management Plant (EMP) is proposed to be established for the plant to detail out the environmental quality measures to be undertaken during the construction and operational phases. EMP will also discuss the post project monitoring measures to be adopted by the plant authorities in order to maintain the

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Pollution</th>
<th>Source of Pollution</th>
</tr>
</thead>
</table>
| 2.      | Water & Sewage Pollution| Effluent from sewerage treatment plant  
Effluent from ash disposal area (if any)  
Effluent from water treatment (WT) plant  
Cooling tower blowdown  
Plant drains  
Effluent from coal pile area run off |
| 3.      | Noise Pollution          | Steam turbine generator  
Other rotating equipment  
Combustion induced noises  
Flow induced noises  
Steam safety valve  |

The proposed plant will be provided with necessary equipment and systems to meet all applicable environmental regulations. The plant has been envisaged to have the following features, which will help in reducing emissions and effluents.

Low NOx burners have been envisaged to reduce the NOx generation and consequent emission. High efficiency Electrostatic Precipitators/ bag filters have been envisaged to limit the particulate emissions to 50 \( \text{mg/Nm}^3 \) notified by MoEF vide notification dated 13th October 2010.

275 M tall bi-flue chimney has been envisaged for the plant, in line with the MoEF guidelines, which will help dispersion of air borne emissions over larger area and thus reducing the impact of the power plant on ground level concentrations.

Closed cooling water system with cooling towers envisaged, thus reducing significantly the water requirement for the plant.

The Plant shall treat all effluent. The effluent generated from cooling Tower blow down will be used for ash handling plant, to the extent possible.

Minimum liquid effluent discharge scheme has been envisaged for liquid effluent generated in the Plant. Majority of effluents in the plant will be treated and recycled / used to a large extent.

Dust extraction and dust suppression systems have been envisaged in the coal handling plant.

Various aspects of the environmental impact due to the proposed Power Plant are discussed below.
effluent qualities within the acceptable limits specified by the Gujarat Pollution Control Board (OPCB) and the Ministry of Environmental & Forests (MoEF), Government of India.

The environmental monitoring programme will be provided with trained and qualified staff who will monitor the ambient air as well as stack flue gas quality to ensure that the quality of effluents are maintained within the permissible limit. On-line emission monitoring equipment shall be provided to monitor the SPM, CO, NOx and SOx constituents in the flue gas continuously, not periodically on daily basis.

The plant effluents will be periodically analyzed on a weekly basis so that the effluents are maintained within the permissible levels of the pollution control board regulations.

The environmental standards as prescribed by the Ministry of Environment & Forests (MoEF) and Indian Pollution Control Authorities is shown in the Annexure - 1.

The pollution control measures proposed to be adopted for the project are summarized as follows:

**Air Pollution**

High efficiency Electrostatic Precipitators/ bag filters will be installed to control the emission of ash particles. The precipitators would be designed to limit the particulate emission to less than 50 mg/Nm$^3$ at 100% MCR when firing worst coal.

In order to meet the guidelines of State Pollution Control Board for SOx emission, a chimney of 275 m height has been envisaged. The chimney would be provided with personal access for regular monitoring of stack emissions.

For the control of fugitive dust emission within and around the Coal handling plant, dust extraction and suppression systems will be provided. Dust suppression system will be installed at all the transfer points in Coal Handling Plant and at Coal stockyard. Dust extraction system would be provided in crusher house and transfer points. The bottom portion of all the conveyors will be provided with seal plates within the power plant area and above roads.

During the construction phase, no significant impact on air quality is expected. However, fugitive dust emissions and NOx levels may temporarily increase in the immediate vicinity of construction site due to soil excavation and vehicular movement. Such impacts will be confined to the construction site. These will be minimized by sprinkling water and proper maintenance of vehicles.

Dust collection system with ventilation system having bag filters will be provided to evacuate dust and hazardous gases like Methane from the coalbunkers. Collected dust will be returned to coal bunker. The dust collector outlet emission will be restricted to 100 mg/Nm$^3$ to trap the dust in the bunkers.

Plant equipment design and operation will ensure SO$_x$ emissions are limited below the State PCB norms. Ground level concentration will be verified for compliance with local pollution control board prescribed ambient air quality norms.

To control NO$_x$ emissions from the Steam Generator, adequate technical measures will be adopted during the design & engineering stage. The latest available technology will be used to control these emissions eg. Low NOx burners which generate NOx below 400 mg/Nm$^3$ will be used in the Boiler.

**Dry Ash Disposal**

Three (3) fly ash storage silos are proposed to be provided. Fly ash evacuated from the ESP collecting hoppers, APH hoppers, Economizer hoppers and bag filter hopper shall be transported by mobile truck means.
time of unloading fly ash into the silos, some ash laden air would get vented out. In order to restrict the fly ash dust particles to the limits of 50 mg / Nm3, a vent filter will be installed on top of each of the fly ash silos. Each fly ash silo shall be equipped with two dry type fly ash unloaders for unloading into totally enclosed ash tankers and one wet type fly ash unloader for unloading into open trucks.

The following pollution control measures will be installed for ash disposal:

- To reduce the dust nuisance while loading the ash into the trucks from fly ash silos, the fly ash is conditioned with water spray.
- Water sprinkling system will be commissioned in the ash disposal area to restrain flying of fine ash to wind.

The dust nuisance in the ash disposal area will be contained by ensuring that the ash is always kept wet.

**Ash Pond Effluent**
The complete ash disposal area would be suitably lined with suitable Geo-membrane to prevent seepage of ash water into the ground/adjoining area, which may be finalized based on the soil investigation report.

If top soil is laid to a depth of about 500mm, a large range of vegetation can be grown on the site. However, the type of vegetation should be tolerant to the fly ash characteristics to achieve growth on ash. It is found that vegetation of the clover family and grasses such as rye are very tolerant. Planting of trees and shrubs are also important factors in the vegetation of ash ponds. Some type of trees and shrubs which would be grown on the ash are furnished below:

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder</td>
<td>Southern wood</td>
</tr>
<tr>
<td>Honey locust</td>
<td>Tree purslane</td>
</tr>
<tr>
<td>Sitka spruce</td>
<td>Barberry</td>
</tr>
<tr>
<td>White poplar</td>
<td>Bladder senna</td>
</tr>
<tr>
<td>Black poplar</td>
<td>Oleaster</td>
</tr>
<tr>
<td>Willow</td>
<td>Heather, Gold flowering current Tamarisk</td>
</tr>
</tbody>
</table>

During the periods of ash dumping, the vegetation would be grown on the ash bunds. Tree plant nursery and trial planting area would be set up near the ash disposal area for effective growth of vegetation in and around the ash disposal area in order to prevent wind carrying away the exposed ash. 50 m wide green belt will be maintained along the boundary wall adjacent to road and around the ash pond area.

**Noise Pollution**
The plant is expected to increase the noise level in the surrounding due to operation of plant and machinery. Necessary noise control and abatement measures will be adopted to minimize the noise level from the plant during construction and operation phase to a maximum of 85 dBA as per the requirement of OSHA (Occupational Safety and Health Administration) Standards.

The major sources of noise during the construction phase are vehicular traffic, construction equipment like dozers, scrapers, concrete mixers, cranes, generators, pumps, compressors, rock drills, pneumatic tools, saws, vibrators, etc. All the equipment in the power plant will be designed/ operated to have the noise level not exceeding 85-90 dBA measured at a distance of 1.5m from the equipment. Also, all measures will be taken to limit the noise levels at the plant boundary with in the stipulated limits.
Water Pollution
Notwithstanding the regulations indicated in Annexure -1 it is proposed to utilize the power plant effluents to the extent possible. It is envisaged to utilize a part of cooling water blow down for ash handling purposes after treating through the CMB. Rest of the waste water will be used for dust suppression and horticulture and gardening after proper treatment.

Streams of effluents emanating from the power station sources during operational phase will be treated individually based on the effluent quality. Treated effluents will be collected in a Central Monitoring Basin (CMB) for final monitoring. The treated effluent will be recycled for plant use and for green belt development. Therefore, there will be no impact on the ground and surface water resources.

The major effluent generated from the plant like DM Plant discharge will be treated in an effluent treatment plant and recycled. No discharge of liquid effluent to the other public boundaries is foreseen from the proposed power station. The coal pile area runoff water during monsoon season will be led to a pond. Coal particles will settle down in the pond and clear water will be allowed to overflow to the central monitoring basin for treatment.

In the power plant, some specific locations in TG / SG area require washing, to maintain good plant housekeeping and prevent build up of dirt and waste material, which generates waste water. This waste water along with process drain will be led to an oil water separator for separation of oil. The clear water will be led to the central monitoring basin. The dirty oil will be recovered separately in a drum.

The rain (storm) water removed from the building roofs, non-process area and grade level surfaces will be directed through the open ditches and culverts to the storm drainage piping. The storm water from the storm water drainage piping discharges outside the plant boundary. All ditches will be concrete lined and located along the roads. All drainage ditches will be located to provide the shortest practical drainage path while providing efficient drainage for the yard. Grade level will be contoured such that storm water runoff is directed on the ground by sheet flow, to well defined drainage paths leading to the ditches.

Solid Waste Management
Sewage from various buildings in the power plant area will be conveyed through sewer lines to sewage treatment plant.

The power plant, being Coal-fired, would generate coarse as well as fine ash. All efforts will be made to utilize the fly ash for various purposes. Ash Management Plan will be developed for 100 % utilisation of fly ash within the time period prescribed by MoEF. The unused ash, till such time, would be disposed in the ash pond.

Afforestation and Green Belt Development
Extensive afforestation at plant area is planned which would not only act as lung space in the area but would also improve aesthetics and will be continued in all available space.

Storage of hazardous materials
Hazardous material anticipated to be stored at site during construction include petrol, diesel, welding gas, weld inspection material, radiographic material, paints, cleaning chemicals, DM plant chemicals etc. These materials will be stored in accordance with prescribed safety norms in ventilated enclosures. Safety instructions and signage will prominently displayed at appropriate points/locations.

Rehabilitation
Land for the project has already been acquired by PCCPP. As there are no inhabitants in the acquired area, no displacement and rehabilitation of local population is envisaged.
5.5.3 Rapid Environment Impact Assessment (REIA) Studies

Environment Impact Assessment (EIA) studies will be carried out and base line data collection will be completed. Rapid EIA Report will be prepared to identify the impact of the proposed power plant on the flora, fauna, human inhabitations, etc. in the surrounding area and prescribe mitigation measures.

Rapid Environmental Impact Assessment (EIA) report will elaborate the assessment of the impact on the environmental scenario around the proposed Power plant, with regard to the main environmental attributes viz., air, water, soil, noise, ground level concentration (GLC) and socio-economic conditions.

The success of any EIA study will primarily depend on the accuracy of assessing the baseline environmental situation prior to superimposing the predicted result on the ambient situation to arrive at the post project scenario.

The baseline environmental situation will be assessed with respect to land use, soil, demography and socio-economics, meteorology, hydrology, water quality, terrestrial ecology and aquatic ecology. Suitable remedial / mitigation measures will be incorporated in the plant, to comply with pollution control authorities norms.

5.5.4 Post Project Environmental Management Plan

Air Environment

The major source of air pollution is from combustion of coal, which results in release of SOx, NOx and SPM.

Prediction for SPM is made taking into consideration the design efficiency of the ESP/ Bag filter. It is observed that the emissions from the power plant, on implementation of the control measures, will be negligible. Increase in Ground Level Concentrations (GLC) of dust after installation of the power plant will be estimated by EIA Consultant to verify compliance with the GLCs within prescribed levels.

The predicted ground level concentrations of SPM, SOx, NOx will also be verified within the limits of the National Ambient Air Quality standards prescribed for rural use.

Coal handling areas are potential sources of causing occupational health hazards such as asthma, tuberculosis and bronchitis. To control dust generation, dust suppression and dust extraction system will be provided at appropriate locations. In addition, frequent wash downs of these areas, with plant service water, will be undertaken.

Noise Environment

The major sources identified as contributing towards noise pollution from the power plant are Compressors, Steam turbines, other rotating equipment, inlet & exhaust systems etc. However the impact of such noise on the neighborhood is predicted to be negligible.

The turbine & generators will be provided with acoustic enclosures, if required to meet the noise limit and shall be housed in buildings that would considerably reduce the transmission of noise to the outside environment.

Noise levels will be periodically monitored and corrective action taken as and when required.

Water Environment

The common effluent treatment plant, which receives discharges from neutralization pit of DM Plant, clarified effluent from Oil Water Separator, etc will be designed to enable maximum re-use/recycling. The treated water will be utilized for plant consumptive requirements and for green belt development.

Green Belt Development

Sufficient green belt (around 127 acres) as per standard norms will be provided. A green belt development program in line with the MoEF guidelines will be prepared for the project. The objective of the green belt development around the plant site is to capture the emissions, attenuate the noise generated, improve the aes-
thehetics in general and maintain a balanced environment. The green belt of the project site will form an effective barrier between the plant and surroundings.

Tree plantation will be undertaken in a large scale on land vacated after cessation of construction activities. Open spaces, where tree plantation is not possible will be planted with shrubs and grass to prevent erosion of topsoil. Appropriate type of trees and plants suitable for this region would be planted in compliance of conditions of environmental clearance.
6  PLANNING BRIEF

6.1  Energy Absorption Plan

6.1.1  Capacity Building

CEA has prepared a Draft National Electricity Plan – Transmission in July 2005, which is a long-term transmission system development plan for integrated utilization of hydro and thermal power to be generated throughout India through a network of 765 kV AC, 500 kV HVDC and 400 kV AC systems. The development plan focuses on formation of the National Power Grid, which has been recognized as a flagship endeavour towards planned growth of power sector on the path leading to fulfilment of the objective of ‘Electricity for All’ at affordable prices. A strong All India Grid would enable exploitation of unevenly distributed generation resources in the country to their optimum potential by providing enhanced margins in inter-regional transmission system. These margins, together with open access in transmission, would facilitate increased real time trading in electricity leading to market determined generation dispatches thereby resulting in supply at reduced prices to the distribution utilities and ultimately to the consumers. Development of National Grid has been necessitated by the large thermal plant of the country and equally large hydro generation potential in northeastern part. It has also been spurred by the opportunity provided by open access, variation in hydrology / hydro potential and diversity of load across the country.

PGCIL has implemented various inter regional transmission schemes to continuously enhance interregional transmission capacity. Private transmission licensees are implementing some transmission schemes. By the end of 11th plan the Country has total inter – regional transmission capacity of about 28,000 MW which is expected to be enhanced to about 65,000MW at the end of 12th plan. All the five power regions of the country namely North – Eastern, Eastern, Western, Northern and Southern are now operating as one synchronous grid. This is facilitating free flow of power from surplus to deficit regions bringing much needed economy. The Southern Grid was recently synchronized to the Central Grid on 31st December, 2013 with the commissioning of 765 kV Raichur – Solapur Transmission Line thereby achieving “ONE NATION – ONE GRID – ONE FREQUENCY”.

With the sustained growth of the national grid and continuous enhancement of inter-regional transmission capacity, the proposed 2x1000 MW (nominal) Power Plant will reduce the energy deficit of power-starved regions of India. There will be no difficulty in connecting the proposed power plant to this system and evacuate total generation through 765kV or 400 kV AC transmission system with connectivity to nearby CTU (PGCIL) substation.

6.1.2  Energy Sales

It is envisaged the energy generated from the power plant will be sold to the Distribution Utilities and nodal agencies of states through Case-I Tariff Based Bidding route. Considering the existing energy and peak deficit situation in most of the states of India, the power generated from the 1000 MW plant will readily find buyers.

6.2  Energy Evacuation Plan

6.2.1  Average Yearly Generation

Evacuation of power from the proposed 2x1000 MW (nominal) units would be through 765kV or 400kV system. The average yearly gross electrical generation from the Power Plant is estimated to be approximately 14892 MUs based upon a Plant Load Factor (PLF) of 85 % which is typical for 1000MW respectively. Auxiliary power consumption is considered approximately 6.75% (5.25% as per CERC Tariff Regulation + 1.5% assumed for FGD) of gross plant output.
The net power generation at the 765kV or 400kV switchyard bus will be approximately 13886 MU at 85% PLF.

6.2.2 Dispatch Plan

The Power Plant will be operated as a base load station for meeting the requirement of DISCOMs all over India.

Ultimately power will be dispatched as per the dispatch schedule of the regional load dispatch centre and the Power Purchase Agreements indicating the requirement of each beneficiary. Power evacuation is planned considering the nearest EHV transmission systems.

6.2.3 Power Evacuation

Evacuation of power from the Power Plant is proposed to be done through 765kV or 400kV level. A 765kV or 400kV indoor, gas insulated type with double bus scheme will be constructed to evacuate the power from the proposed Power Plant. Power evacuation of 1865 MW power (2000 – 6.75% auxiliary power) from the plant will be done through 2 Nos. 765kV or 400 kV transmission lines.

The exact requirement of transmission lines would be based on the results of system studying and quantum of power requirement by the beneficiaries as for PPAs.

The terminal points of the 765kV or 400 kV transmission lines will be the take-off structures inside the power plant Switchyard fence. However, depending upon the requirement of PPA the exact terminal point of the transmission line will be decided during execution stage of the project.

6.3 Risk Assessment & Disaster Management Plan

Risk Assessment

Environmental risks are inherent in design and operation of any power plant. Risk involves the occurrence or potential occurrence of an accident consisting of an event or sequence of events.

The main objectives of risk assessment are as follows:

- Identification of hazard prone area and estimation of damage distance for the maximum credible accident scenario visualized for storage.
- Computation of frequency of occurrence of hazards and evaluation of risks

Identification of hazards in a power plant is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. Hence, all the components of a process/system/plant need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

As coal is subject to spontaneous combustion, it may catch fire given the slightest opportunity. This fire hazard is greatly influenced by the amount of airflow through the mass of coal.

Thus, storage of coal will be designed in such a way that the air content in the coal pile is minimized. Dimension of the coal stack, particularly the height, is a very important parameter for making storage of coal safe. Fuel oils (LDO) will be used in small quantity for initial start-up. The hazards associated with the use of these materials need careful consideration and it is necessary to take due precaution for safe handling at various stages of usage.
Disaster Management Plan

A major emergency in a plant is one that has the potential to cause serious injury or loss of life. It may cause damage to property and serious disruption, both inside and outside of the plant. The disasters identified as most likely to occur in the power plant are:

- Fire at oil storage area
- Fire at coal storage area
- Toxic release of chemical

Hazard analysis has revealed that the damage distance is mainly confined to plant boundary only.

The main objective of the disaster management plan is to prevent or at least reduce the risk of accidents through design, operation, maintenance and inspection. An important element of accident mitigation is emergency planning, which would consist of:

- Recognizing the possibilities and probabilities of each kind of accident
- Assessing the on-site and off-site implications of such incidents and deciding the emergency procedures that would need to be carried out.

A number of elements make-up a good and workable disaster management plan. They are briefly discussed below:

Identification and assessment of hazards

Experience has shown that for every occasion that the full potential of an accident is realized, there are many other occasions when some lesser event occurs or when a developing incident is made safe before reaching full damage potential.

Procedure for personnel and equipment

This involves setting up of an emergency communication system, formation of an emergency response team and setting up of an emergency control centre.

It is essential that the emergency plan be regularly tested so that any defect may be corrected. The plan should be reviewed and updated and any changes made should be disseminated to all concerned.

Emergency plan needs to consider emergency shutdown procedure so that phased and orderly shutdown of the plant & systems can take place when necessary.

Depending upon the methodology adopted for the co-ordination of various aspects of disaster management, specific responsibilities should be fixed for civil and government agencies. Outside agencies support is required for the emergency responses such as:

- Augmenting the fire fighting service and firewater
- Emergency medical help for the injured personnel of the plant
- Evacuation of personnel
- Law enforcement, traffic control and crime prevention
- Co-ordination with other nearby industrial establishments
- Communication facilities
- Procuring fire-fighting consumables such as foam compound, fire hose etc.
Maintenance and Monitoring
The safety of a plant and function of safety related systems could only be as good as the maintenance and monitoring of these systems. It is of great importance to establish plant maintenance & monitoring schedule, which includes the following tasks;

- Checking of safety related operating conditions in the control room and at site / on the field.
- Checking of safety related parts of the plant on site by visual inspection or by remote monitoring.
- Monitoring of safety related utilities such as electricity, steam, coolant and compressed air.
- Preparation of maintenance plan and documentation of maintenance work specifying the different interval and type of works to be performed.

In addition, the maintenance and monitoring schedule will specify the qualifications and experience required by the personnel to perform their tasks.

Reporting to Authorities
In the management of a major hazard, in an installation, it is likely that the incident is to be reported to the concerned authorities. Reporting will be carried out in three steps.

- Identification/notification of a major hazard installation
- Preparation of a safety report
- Immediate reporting of the accident

The safety report gives the authorities the following opportunities:

- To carry out specific inspection in order to learn about hazards arising from these installations.
- To establish contingency plans.

Emergency planning rehearsals and exercises will be monitored by senior officers from the emergency services. After each exercise, the plan will be thoroughly reviewed to take account of omissions or shortcomings.

Increase in concern of disaster management plans has prompted the Ministry of Environment and Forests, Govt. of India to make risk assessment and disaster management a mandatory requirement for the power industry.

6.4 Ash Utilization Plan

All possible measures are being undertaken to maximize utilization of ash produced in the proposed project. Supply of ash to cement plants in the region, for manufacture of cement, will be taken up as a priority area.

Towards this objective the following are actions proposed to be taken-up:

- In order to supply quality ash to users requiring only dry fly ash, such as, manufacturers of cement, concrete and allied products, etc. The owner will be providing systems and facilities for 100% extraction of dry fly ash along with storage and unloading facilities.
- The owner will encourage utilization of ash-based products in all its construction activities.
- The owner will utilize ash stored in the ash pond for raising ash dykes, when required.

6.5 Amenities / Facilities

As it’s an expansion project so the amenities and facilities shall be same as in phase I of the project.
7 REHABILITATION AND RESETTLEMENT (R&R) PLAN

Land for the project has already been acquired by PCCPP. As there are no inhabitants in the acquired area, no displacement and rehabilitation of local population is envisaged.
Chapter 8: System Design & O&M Philosophy

8 SYSTEM DESIGN AND O&M PHILOSOPHY

8.1 Overall Requirement

The station will be basically designed to operate as a base load station. The design of the plant will provide for the following:

a) Capability of unloading from full load to no-load conditions in the minimum possible time to minimize turbine cooling.

b) Capability to achieve full load within the shortest possible time after synchronization, subsequent to an overnight shutdown (8 hours).

c) The main plant control systems will be designed to permit participation in load frequency control in the event of system disturbances.

8.2 Design Philosophy

8.2.1 System Design for high Unit availability

The objective of high availability of the Unit and associated auxiliaries will be achieved by adopting the following principles for ensuring high PLF and low partial loading;

a. Use of equipment and systems of design performance and high availability which has been fully established by a considerable record of successful operation for similar service conditions in coal fired utility stations.

b. Use of only proven design concepts and conservative designs.

c. Strict implementation of quality assurance norms during design, manufacture as well as installation and commissioning stage.

d. Strict compliance with the project company approved pre-commissioning and commissioning procedures as well as standard checklists forming a part of commissioning documents for the project.

8.2.2 Sizing of critical equipment- margins & redundancy/standby

Adequate margins will be provided while sizing all important auxiliaries and sub-systems to ensure operation of the Unit at full rated capacity under the worst conditions and taking into consideration normal wear & tear.

8.2.3 Design for efficient operation

The basic and detailed engineering will be carried out to ensure achievement of high standards of operational performance especially with respect to the following key indices:

a. Low auxiliary power consumption.

b. Low make-up water consumption.

c. No oil support above 30%-40% MCR operation with any combination of mills.

d. Optimum efficiency and heat rates for the Units and sub-systems

Provision would be made for accurate and reliable measurement of coal receipt, coal consumption per Unit, oil receipt & consumption per Unit, total DM water production and make-up water consumption, flue gas oxygen content etc. Daily reports regarding receipt, consumption and stock position will be prepared. Also provision would be made for on-line calculations for the performance of the Units and their major-subsystems in the DDCMIS. The operation of the plant would be optimized and the performance of the plant would be reviewed on a regular basis.
8.2.4 Operation Performance Management System (OPMS)

The operation of the plant will be optimised by implementation of OPMS. This system will clearly define the responsibilities of all key O&M personnel including the shift-in-charge. This will also cover the system of daily reporting to the project company Corporate Office and monthly O&M review meetings.

8.3 Operation & Maintenance Philosophy

The proposed organization structure for operation and maintenance (O&M) of power station is presented in Annexure – 2(a).

In order to ensure that the design and construction of the power station incorporates all necessary features required for easy and efficient operation and maintenance of the proposed power plant, O&M team shall also be consulted during the review of plant design features, operational and maintenance features of plant systems and equipment.

8.3.1 O&M Organisation

As indicated in Annexure – 2 (a) the basic structure and broad functional area within the O&M organisation would as follows:

Setup of O&M team

O&M team head would have primary responsibility for the operation & maintenance of the power station. O&M team is expected to comprise four broad functional areas viz. operations, maintenance, engineering and administration. The basic duties covered under each of these functional areas would be as follows:

a) Operations

Operation of Power Plant, coal and ash handling systems, water systems including water treatment system, switchyard and other auxiliary plant, will be carried out by the personnel of operation section. Except for the Operations Manager who would be overall in charge of operations, all other operation personnel would be on three - shift basis. Shift personnel manpower planning for key areas will be generally done on (3+1) concept to take into account leave taken by shift personnel.

The shift operation of the power station shall be overseen by a Shift In charge, one in each main control room, one for coal, fuel oil, ash handling systems and water systems. Shift In charges will be assisted by Control Engineers and other operation staffs.

b) Maintenance

Maintenance of all mechanical and electrical plant, control systems, buildings, roads, drainage and sewage systems, etc., operation of the plant workshop, planning for scheduled maintenance works and deciding requirement of spare parts, will be done in general shift by the personnel of the maintenance section.

c) Engineering

Personnel of this section will be responsible for Monitoring of plant performance, maintenance of documentation, improvements in plant systems, plant safety aspects including, information services and training. All personnel in this functional area would be in the general shift.

d) Administration

Purchase of spares and other equipment/ materials, stores management, fuel supply coordination, plant security, finance & accounts, medical services, personnel services, secretarial and clerical services, will be taken care by this functional area.
e) Set up of the Project Company

Vice President (Operations) would represent the Project Company’s interest in the operation & maintenance of the power station and would oversee the functioning of O&M company. He would be assisted by a team covering the following functional areas:

1) Technical
For monitoring overall plant performance, purchase of spare parts, consumables, etc., metering energy sent to the grid and for resolving any other technical aspects required to be resolved.

2) Finance & Accounts
For monitoring the O&M company’s expenses in operation & maintenance of the plant, billing for energy sent into the grid, ensuring periodic repayment of loans and interest on loans, staff salaries and expenses and arranging for renewal of insurance covered at required intervals.

3) Administration & Personnel
For providing administration support such as secretarial, clerical and transport services, providing personnel services and managing the staff colony.

8.3.2 Maintenance Management System

The maintenance of the plant will be carried out as per the maintenance management system to be developed by the project company. This system should aim at maximising the availability of the generating Units while ensuring minimum maintenance cost and safety of plant & personnel. The system should cover organizational structures, preventive maintenance schedules, detailed work specifications covering all maintenance jobs, permit-to-work system, long term maintenance planning, safety aspects etc.

8.3.3 Spare Parts Management System

The primary objective of the system will be to ensure timely availability of proper spare parts without excessive build-up of non-moving inventory. The system will cover the following aspects

- Proper codification/identification & retrieval of all spares & consumables
- Proper storage & protection
- Spare parts indenting and procurement policy
- Judicious fixing of inventory levels and spare part ordering based on experience of similar Units or other benchmarks.
  a) Development of indigenous sources/in-house capability for imported spare parts.
  b) Development of more than one source wherever applicable.

8.3.4 Special Tools & Tackles

All equipment supply contracts will include the provision of supply of special tools & tackles, wherever required, for installation, commissioning, and maintenance of the plant & equipment. These will be handed over to the O&M department at the appropriate time after commissioning of the Unit.

8.3.5 O&M Training

An experienced O&M company will be placed at an early stage to introduce the best system and operational management and practices. O&M company will be assisted by a group of experienced technical personnel, to carry out the operation of the plant.
The O&M crew will be associated with the plant commissioning stage itself to get them fully familiar with plant. Suitable training schedule will be developed for this purpose.

### 8.3.6 O&M Manuals

All plant equipment supply contracts will include provision for supply of sufficient copies of detailed O&M manuals for distribution to the different user departments of Project Company.

The draft O&M manuals will be prepared by the EPC Contractor and submitted to the project group for review, who will ensure completeness and comprehensive coverage of all plant systems.

O&M manuals will be made available to all concerned at least 12 months prior to the commissioning date of first Unit to avoid problems in preparation of commissioning documents as well as proper installation & commissioning of equipment.

### 8.3.7 Coal Supply Management

The minimum requirement of coal will be based on operating norms. However, the monthly requirements will be finalized during the quarterly meetings with the concerned authorities or through the Coal Supply Agreements. The coal handling plant of the Power Plant will be designed to meet the peak requirement on daily basis with adequate reserve capacity to take care of normal breakdowns and maintenance requirements.

### 8.4 Employee Facilities

#### 8.4.1 General

The number of employees (including employees of Project Company and O & M contractor) required for the 2x1000 MW (nominal) units is assessed as shown in the Annexure – 2(b).

#### 8.4.2 In-Plant Facilities

In addition to the plants & equipment for generation of power the following facilities shall be provided in this station:

- Administrative Building and technical office
- Construction offices and stores (at construction stage only)
- Time and security offices
- First Aid and fire fighting station
- Canteen and welfare centre
- Toilets and change rooms
- Car parks and cycle/ scooter stands
- Training centre

Office space shall be provided as per good practice and canteens, toilets and restrooms according to norms laid down in relevant factories act. The above facilities shall also be adequately furnished and equipped.

#### 8.4.3 Colony

Colony to provide accommodation for the staff shall be built by augmenting the existing colony at site.

This shall include accommodation for managerial local staff and a good proportion of the rest of the staff. A few staff can be expected to come from neighboring villages and towns. Accommodation for such staff shall not be envisaged in the colony. It is considered prudent to plan for an accommodation of a higher percentage of staff within the colony itself.
Facilities like guest house, medical center, shopping centre, community centre, play ground etc., are already available at the existing colony and if required shall be augmented.
9 PROJECT IMPLEMENTATION SCHEDULE

The Project Company will establish Project Management Systems for close monitoring of the Project for quality, schedule and environment. The project will cover activities on all fronts including conflict resolution, drawing necessary expertise and support from Implementation Consultants on regular basis.

9.1 Project Implementation Schedule

The first Unit of the 2x1000 MW project would go in to commercial operation in 42 months from “Zero date”. The 2nd Unit would go in to commercial operation in 48 months from “Zero date”. Date of Financial closure shall be considered as the Zero Date/ Notice to proceed (NTP). Notice to proceed (NTP) will be issued to the EPC Contractor to commence construction of the project.

9.2 Project Management

The major phases of the project during its implementation are classified under the following heads:

- Planning & Contract Packaging
- Design, Engineering, Tendering & Contract award
- Manufacturing, Inspection and Expediting Phase
- Transportation/ Handling of Equipment
- Construction/Erection and Commissioning
- Operation & Maintenance and Manpower Training & Placement.

The Project will be managed by the Project Company under the overall direction and control of Project Incharge. Full-time project management responsibility shall be vested on the Project Incharge of the Project Company.

Project Incharge shall be responsible for overall project planning and monitoring, obtaining necessary clearances, all preliminary project works, co-ordination with concerned agencies, contract administration, certification of bills, liaison and co-ordination with statutory agencies, monitoring of project cost, recruitment of personnel etc.

The Project Company’s site establishment, headed by Project Incharge shall comprise three basic groups viz., Civil, Mechanical and Electrical/ Instrumentation. In addition, a separate group shall be established for project monitoring and control. The site establishment shall also have necessary administration and accounts departments.

Some of the Project Company site engineers shall be initially posted at the corporate office and moved to site progressively as construction/ erection activities pick up at the site. After commissioning of the power plant, most of these engineers would be seconded to the O & M contractor and would occupy suitable positions in the operations and maintenance (O&M) organisation for the power station.

The methodology adopted for executing the project is as detailed below.
9.3 Planning Phase

9.3.1 Contract Packaging

The Company intends to implement the project as a single EPC project. The EPC package shall then be executed by selected contractor who will cover complete mechanical, electrical, instrumentation and associated civil works of the package. The colony would be executed through a separate contract.

Indicative scope of the packages envisaged is as below:

EPC Packages

EPC Packages will include Steam Generator & Auxiliaries, Steam Turbine Generator & Auxiliaries, Power Cycle equipment including BFPs, CEPs, Regenerative system LP & HP Heaters, Deaerator, HP Piping, HP & LP Bypass Systems, Station C & I, plant electrical systems like Switchyard, HT & LT Transformers, packages like Coal Handling System, raw water intake structure, Ash Handling System, Water treatment & DM Plant, CW System, Plant Miscellaneous pumps, Piping and Systems; and Civil, structural and architectural work of the plant including Civil works for all equipment, all buildings in the plant, chimney, Cooling towers etc.

The Contractors will establish a comprehensive reporting structure, which broadly includes:

- Management Reports – Progress Reports, Exception Reports, etc.
- Quality Assurance and Control Programme – Shop and site
- Site Safety, Health and Environment
- Statutory Permits and Clearances
- Other Works:
  - This will be carried out by owner through separate contractors / suppliers. This will include procurement of standard tools, mobile equipment, fire tender and construction of residential colony (if required).

9.3.2 Master Project Implementation Programme – Master Network

The Master Network identifies the key milestone dates for each package in the area of engineering, procurement, manufacturing, dispatch, construction, erection, testing & commissioning. The Master Network, which is the overall programme of the project implementation, will be finalized in consultation with the Contractors. The date of Notice-to-Proceed of the contract will be the zero date of the Master Network.

9.3.3 Implementation Consultant

The Project Company will monitor the project in consultation with Implementation Consultant, who will assist them through out the development of the Project, from preparation of RFP document for the Contractors till handing over of the Plant by the Contractors.

The Implementation Consultant would undertake the various tasks related to the engineering, design, project implementation/management and monitoring. Apart from this, they would also provide necessary engineering back up support during construction, installation and commissioning at site.

The drawings and documents generated by the Contractors would be reviewed and checked/approved by the Implementation Consultant to ensure the following:

- Compliance to the contract requirements
- Compliance to the various local/statutory authorities
- Correct design and technology
- Various interfaces amongst various systems/equipment/sub-contractors

Further, Implementation Consultant will also be involved in shop inspection of various critical equipment/components in line with the agreed project quality assurance plan.
Implementation Consultant will also be involved in ensuring field engineering / construction quality as well as ensuring that the contractor meets all guaranteed parameters during performance testing of the Unit.

9.4 Tendering, Contracts & Engineering Phase

9.4.1 Engineering, Planning, Monitoring & Control

The basic engineering studies are initiated and documented elsewhere in this report along with detailed estimates of cost and quantities.

The engineering services plan and the schedule of the project engineering activities, within the time frame specified for the engineering milestones is finalized in the Master Network. The engineering programme at Level-2 which will be prepared during execution phase will show the dates for data availability, tender drawing release, specification release, bid evaluation and construction drawing release etc. The schedule drawn up by each engineering discipline will also take into consideration the assistance from the Implementation Consultant.

Departmental reviews will be conducted by the Project Coordinators of the Project Company to evaluate the work actually performed vis-à-vis detailed schedules. Corrective action will be identified and the plans updated.

9.4.2 Contracts Planning, Monitoring & Control

Based on the key event dates identified in the Master network, detailed plan for pre-award activities up to award of contract is finalized and monitored vigorously.

When contracts are awarded, detailed programme in the form of networks will be tied-up with the Contractor to clearly establish the Owner’s obligation and Contractor’s responsibilities. The Owner’s inputs in terms of land availability, construction power availability, etc., while that of the Contractor’s, in terms of drawing submission, manufacture, supply, transportation, erection & commissioning etc will be clearly brought out in the programme.

Monthly progress reports will be generated for monitoring & tracking purposes.

9.5 Manufacturing, Inspection & Expediting Phase

9.5.1 Inspection & Expediting

Visits will be made periodically to the works of equipment supplier, in coordination with EPC contractor, for inspection and ensuring that works progress as per schedules. The manufacturing & quality plans finalized at the time of contract award would be utilized for monitoring the manufacturing & quality status. Specified reports at regular intervals would be submitted highlighting the areas of schedule variations, if any, their likely impact on delivery schedules, any recommendations for improvement etc.

9.5.2 Quality Assurance

All Contractors would be asked follow a comprehensive Quality Assurance and Control Programme developed by the Project Company/Consultant for the entire project. The quality control and assurance activities would be supervised by the Project Company/Implementation Consultant and / or through the appointed offsite approved agencies for shop as well as field activities.

Before the award of any contract the QA Dept would finalize a mutually acceptable inspection programme and detailed quality plan with the prospective contractors.
The quality plans after discussions and finalization with the Contractor will form a part of the contract.

9.6 Transportation / Handling of Equipment

The proposed site is located near to the State Highways. The railway station is near from the site. Since, there are many heavy equipments to be transported to site, there is a need to develop suitable road till site from National / State Highways as well as from nearest railway station, if not available at present, as part of the project execution works.

The lists of main equipments, which fall in the heavy category, are Turbine Rotor, Turbine Stator, Generator Stator, Generator Rotor and Generator Transformer. Route survey will have to be conducted suitably by the project company for planning and implementation of transportation of all major equipment/materials.

9.7 Construction & Commissioning Phase

9.7.1 Construction Planning, Monitoring & Control

Site activities start progressively with the award of identified packages. Based on the Master Network Schedule (L1 network) prepared during the award of the Contracts, L-2 networks will be finalized, keeping in view the interface events required to be realized. Based on the L-2 network the Execution Group initiates securing of required drawings in sequence for continuous progress of works at site.

9.7.2 Project Review Team Meeting

A project review team headed by President & CEO of the Project Company with members from the Head Office and site will be constituted to review the progress of project on a monthly basis. The meetings will review both pre-award and post-award progress of each package.

Budgetary review will also be carried out during this meeting and shortfall, if any, will be identified and responsibility fixed to ensure correction.
10 PERMITS AND CLEARANCES

Certain Permits and Clearances are required for development of power generating plant, which are to be obtained by owner from different Government and Statutory Agencies at various stages of development of the project. These are classified into two broad categories i.e. statutory & non-statutory clearances. The list of permits and clearances required are given in Table 10.1 and Table 10.2 below:-.

### Table – 10.1: Statutory Permits and Clearances
(To be obtained prior to construction)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Registration of the Company</td>
<td>Registrar of Companies</td>
</tr>
<tr>
<td>2</td>
<td>Consent to Establish</td>
<td>State Pollution Control Board</td>
</tr>
<tr>
<td>3</td>
<td>Water availability</td>
<td>Water Resources Department of the State Govt.</td>
</tr>
<tr>
<td>4</td>
<td>Environmental and forest clearance</td>
<td>Ministry of Environment &amp; Forests (MoEF)</td>
</tr>
<tr>
<td>6</td>
<td>Civil aviation clearance for Chimney height</td>
<td>Airport authority of India</td>
</tr>
<tr>
<td>7</td>
<td>Rehabilitation and resettlement of displaced families by land acquisition</td>
<td>State Govt./MOEF</td>
</tr>
</tbody>
</table>

### Table – 10.2: Non - Statutory Permits and Clearances
(To be obtained prior to construction)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land availability</td>
<td>State Government</td>
</tr>
<tr>
<td>2</td>
<td>Foreign currency loan</td>
<td>Ministry of Finance, Govt. of India</td>
</tr>
<tr>
<td>3</td>
<td>Clearance from Archaeological department</td>
<td>Govt. of India</td>
</tr>
<tr>
<td>4</td>
<td>Real estate Rights &amp; right to access and use of site including right of way for all corridors to the Facility.</td>
<td>State Government / Concerned Agency</td>
</tr>
<tr>
<td>5</td>
<td>Consent of relevant Panchayat /Authority for the development of Project site and township site</td>
<td>Relevant Panchayat /Directorate of town planning of the State Govt.</td>
</tr>
<tr>
<td>6</td>
<td>Import licenses and formalities</td>
<td>Controller of Import Authorities</td>
</tr>
<tr>
<td>7</td>
<td>Tax concessions under Mega Power Project</td>
<td>Ministry of Power, Government of India; State Government</td>
</tr>
<tr>
<td>8</td>
<td>Tariff Approval</td>
<td>Electricity Regulatory commission of State /CERC</td>
</tr>
</tbody>
</table>

Chapter 10: Permit and Clearances
11 PROJECT COST ESTIMATE AND TARIFF DETERMINATION

In this section project cost estimate has been worked out and Capacity Charge as well as Energy Charge of generation (i.e. two part tariff) has been computed for the proposed project in order to assess overall tariff of the project. For this purpose, a comprehensive financial model has been developed based on CERC guideline (2014-2019), representing a complete simulation of the Project with regard to technical and financial aspects.

11.1 Basis of Project Cost

The project cost estimate has been worked out on the basis of following assumptions:

11.1.1 Assumptions for Hard Cost Input

The followings are the key assumptions made while estimating the project cost:

- **Total Two (2) Units of 1000 MW gross capacity each with ultra super critical steam condition has been considered.**
- **The cost of main equipment package including BTG package with auxiliaries and mandatory spares has been worked out on the basis of the in-house data and assumption. BTG package (Supply) is assumed to be imported. Domestic sourcing of BOP and other miscellaneous packages like Civil Contract, Erection Commissioning and Testing is assumed.**
- **No Foreign Exchange variation and Hedging Cost is assumed in determination of Project Cost.**
- **The cost of balance of plant equipment, auxiliaries and services has been estimated from in-house data available for similar items of other on-going projects.**
- **The cost of general civil and architectural works of the plant has been estimated based on similar works of other on-going domestic projects.**
- **Contingency @ 2% on Hard Cost has been assumed in the Project Cost estimate.**
- **The Tariff is calculated based on firing of imported coal only as the plant is primarily envisaged to be operated on imported coal. Coal cost at CIF Gujarat port is assumed @ Rs.4000/tone plus Rs. 300/tone for port and handling charges and a minimum railway freight charges of Rs. 210/tone (up to 125 kms.) i.e. The landed price of imported coal as on date (i.e. FY 2015-16) is assumed as Rs. 4500/tonne along with an escalation of 2 % YoY basis.**
- **In assuming the above mentioned Coal Cost, effect of Forex rate fluctuation is not considered.**
- **In addition to cost of secondary fuel, cost of limestone is also considered, as FGD is envisaged for this Proposed Plant.**
- **The completion schedule for Unit#1 & Unit#2 is considered as 42 months and 48 months respectively from zero date (NTP date), which is assumed as 1st January 2018.**

11.1.2 Assumptions for Soft Cost Input

The major assumptions made to compute the soft cost are as follows:

- **Capital Structure** – Debt Equity ratio is considered as 70:30 considering the security arrangement of typical Indian Power Projects of this nature. Promoter’s equity is considered as 30% and remaining 70% is assumed to be sourced from rupee term lender/External Commercial Borrowing.
- **Return on Equity** - Base RoE (Post Tax) is considered as 15.5%.
• **Interest on Rupee Term Loan** - Pre-COD rate has been assumed as 12.5% and Post-COD interest rate is assumed as 12%.

• **Interest During Construction (IDC)** – IDC has been worked out till Project COD (i.e. COD of 2nd Unit i.e. 31st December 2021) and Project Cost phasing is done based on proposed schedule of Unit#1 and Unit#2 as mentioned in Clause No. 11.1.1 above.

• **Working Capital** - The rate of interest on working capital loan is assumed to be 12% p.a.

• **Taxes and Duties** - All applicable Taxes and Duties including Custom Duty, Excise Duty, Service Tax, and Works Contract Tax as applicable are assumed in the Financial Model. Mega Power Benefits have not been considered in determining the Project Cost.

### 11.2 Project Cost

Based on the assumption and consideration as mentioned above, the estimated cost of the proposed Project of 2x1000 MW is worked out to be Rs. 12821 Crores. The specific cost of the Project appears to be Rs 6.41 Crores per MW based on the estimated Project Cost. The break-up of the Project Cost is given in Table 11.1 below.

#### Table – 11.1
Project Cost Break-up

<table>
<thead>
<tr>
<th>SI No</th>
<th>Project Cost</th>
<th>Rs Crores</th>
<th>% of total project cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land &amp; Site Development</td>
<td>22.5</td>
<td>0.18%</td>
</tr>
<tr>
<td>2</td>
<td>Sub Total Land</td>
<td><strong>22.5</strong></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Steam Generator &amp; Turbine Generator</td>
<td>4961</td>
<td>38.69%</td>
</tr>
<tr>
<td>4</td>
<td>Balance of P &amp; M - Mechanical</td>
<td>1245</td>
<td>9.71%</td>
</tr>
<tr>
<td>5</td>
<td>Balance of P &amp; M - Electrical</td>
<td>712</td>
<td>5.56%</td>
</tr>
<tr>
<td>6</td>
<td>C &amp; I</td>
<td>88</td>
<td>0.69%</td>
</tr>
<tr>
<td>7</td>
<td>Initial Spares</td>
<td>140</td>
<td>1.09%</td>
</tr>
<tr>
<td>8</td>
<td>Civil Works</td>
<td>941</td>
<td>7.34%</td>
</tr>
<tr>
<td>9</td>
<td>Erection, testing &amp; Commissioning</td>
<td>561</td>
<td>4.37%</td>
</tr>
<tr>
<td>10</td>
<td>Taxes &amp; Duties</td>
<td>1606</td>
<td>12.52%</td>
</tr>
<tr>
<td></td>
<td>Sub Total of EPC Cost</td>
<td><strong>10254</strong></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Preliminary &amp; Pre-operative Expenses</td>
<td>285</td>
<td>2.23%</td>
</tr>
<tr>
<td>12</td>
<td>Financing Charges</td>
<td>90</td>
<td>0.70%</td>
</tr>
<tr>
<td>13</td>
<td>Contingency</td>
<td>206</td>
<td>1.60%</td>
</tr>
<tr>
<td>14</td>
<td>Interest During Construction</td>
<td>1964</td>
<td>15.32%</td>
</tr>
<tr>
<td>15</td>
<td>Sub Total</td>
<td><strong>2545</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td><strong>12821.5</strong></td>
<td>100.00%</td>
</tr>
<tr>
<td></td>
<td>Cost per MW (Crores/MW)</td>
<td>6.41</td>
<td></td>
</tr>
</tbody>
</table>
11.3 Tariff Calculation

The tariff for the project has been arrived at on the basis of following technical and financial inputs.

11.3.1 Technical Input Assumptions

Basic operational inputs data for the purpose of estimation of tariff are as follows:

- Plant gross capacity has been considered as 2x1000MW.
- Unit heat rate has been considered as 2109 kCal/kWh including operating margin of 4.5% as per CERC norm.
- Normative Annual Plant Availability Factor (NAPAF) is considered as 85% as per CERC Norms. Though as per CERC norm, NAPAF is allowed to be considered 83% due to shortage of coal and uncertainty of assured Coal Supply, which will be reviewed based on the actual feedback after three years from 01.04.2014
- Normative Annual Plant Load Factor (NAPLF) is considered as 85% as per CERC Norms for incentive threshold.
- Auxiliary power consumption of plant with NDCT has been considered as 6.75% (5.25% for the plant facilities excluding FGD + 1.5% for FGD).
- Secondary Fuel Consumption of 0.5 ml/kWhr has been considered as per CERC stipulation.
- The gross calorific value (GCV) of imported coal has been considered as 5000 kCal/kg (design coal - as received basis) and GCV of Secondary Fuel (HSD) has been considered as 9180 kCal/Lit.

11.3.2 Financial Input Assumptions

The following are the financial assumption as considered for Tariff Determination:

Debt Structure

Rate of interest, the Repayment Period and Moratorium period is indicated in the Table-11.2 below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>RTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Rate (Pre COD)</td>
<td>%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Interest Rate (Post COD)</td>
<td>%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Repayment Mode</td>
<td>Installments</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

For tariff determination repayment period is considered as per CERC norm. CERC norm on this regard stipulates that “The repayment for each of the year of the tariff period 2014-2019 shall be deemed to be equal to the depreciation allowed for the corresponding year/period.” Hence, no Moratorium is applicable for Tariff determination based on the CERC norm as above.

Return on Equity

Base ROE has been considered as 15.5 % on Post Tax Basis.

Working Capital

Working Capital covers the following:
• Cost of Primary Fuel (Coal) towards stock (at NAPAF) – 30 days
• Cost of Primary Fuel (Coal) towards Generation (at NAPAF) – 30 days
• Cost of Secondary Fuel (HSD) – 2 Months
• Maintenance Spares – 20% of O&M Expenses
• Receivables at NAPAF– 2 Months
• O&M expenses for 30 days

O&M Expenses
Annual fixed operation and maintenance cost has been considered as Rs. 17.30 lakhs per MW for base year i.e. on year of NTP (FY 2017-18) and escalated at the rate of 6.3 % per annum thereafter as per CERC norms (average of year on year increase from FY 2014-2015 to FY 2018-2019).

Fuel Cost
− Landed Cost of imported coal is considered as Rs.4500/MT as on FY 2015-16 with escalation of 2%.
− Secondary fuel (HSD) cost is considered as Rs. 50000/kL as on FY 2017-18 with escalation of 2% per annum.
− Landed Cost of Limestone is considered as Rs. 2800/MT as on FY 2017-18 with escalation of 2% per annum.

Depreciation
Depreciation is calculated as per CERC norms in straight line method. The economic life of the Project has been considered as 25 years. Below are the considerations of depreciation:
− Salvage Value: 10%
− Depreciation of Land purchased: 0%
− Depreciation of Land under lease: Not applicable for this Project as no lease land is considered.
− Depreciation for Plant & Machinery: 5.28 % for first 12 years and 2.05% for the remaining life of the Project.
− Depreciation for Building & Civil Works: 3.34 % for first 12 years and 3.84% for the remaining life of the Project.

All assets except land has been depreciated based on straight-line method.

Corporate Tax
• Corporate Tax rate- 28.33%
• MAT rate - 20.96%

The general assumptions and inputs has been given in Annexure – 3 (Table – 1) and attached with this Report.

11.3.3 Tariff
In accordance with CERC Tariff Regulation, two-part tariff comprising of Energy Charge per kWh and Capacity Charge per kWh is calculated year on year basis. For tariff calculation, the economic plant life has been considered as 25 years reckoning Project COD.

The Energy Charge and Capacity Charge for the proposed project worked out in the financial model as per the following.

Variable Charge
The Variable Charge covers the following items:

- Primary Fuel Cost
- Secondary Fuel Cost
- Cost of Limestone

**Fixed Charge**

The Fixed Charge covers the following items:

- Return on Equity (Pre-Tax basis)
- Interest on Term Loan
- Depreciation
- Interest on working capital
- O&M expenses &
- Compensation Allowance

**Levelized Tariff**

The levelized Tariff calculated assuming discounting factor of 13.1% is given below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>First Full Year (2022-23) Tariff (Rs. per KWh)</th>
<th>Levellized Tariff (Rs. per KWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Energy Charges</td>
<td>2.39</td>
<td>2.69</td>
</tr>
<tr>
<td>2.</td>
<td>Capacity Charges</td>
<td>2.22</td>
<td>2.10</td>
</tr>
<tr>
<td>3.</td>
<td>Total Tariff</td>
<td>4.61</td>
<td>4.79</td>
</tr>
</tbody>
</table>

The year wise tariff calculations at NAPAF of 85% are indicated in Annexure – 3 (Table 2) placed at the end of this section.