Pre-Feasibility Report
3x1000 MW Mundra Expansion Thermal Power Project

PRE FEASIBILITY REPORT

3000 MW (3x1000 MW)
MUNDRA THERMAL POWER PROJECT
DIST. KUTCHH, GUJARAT

Developer:
ADANI POWER LIMITED
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<td>Water Balance Diagram</td>
<td>LII-P.008794-M-00127-001</td>
<td>0</td>
</tr>
</tbody>
</table>
SECTION: 1

EXECUTIVE SUMMARY
1. EXECUTIVE SUMMARY

1.1 Introduction:

Gujarat is a state in the western part of India known locally as Jewel of the Western part of India. The state is bordered by Rajasthan to the north, Maharashtra to the south, Madhya Pradesh to the east, and the Arabian Sea, as well as the Pakistani province of Sindh to the west. Its capital city is Gandhinagar, while its largest city is Ahmedabad.

It has an area of 196,204 km² (75,755 sq mi) with a coastline of 1,600 km (990 mi), most of which lies on the Kathiawar peninsula, and a population of 60,383,628 (2011 census). It is divided in 33 districts. The State has a population density of 308 inhabitants per sq. km. Ranked 9th in population of India. Gujarat had an estimated GSDP (Gross State Domestic Product) of about US$142.38 billion in the 2014-15 fiscal year. The state registered a GSDP growth rate of 8% for the year 2014-2015. Gujarat’s contribution to India’s GDP in the year 2013-14 was 7.31%.

Gujarat has some of the largest business corporations in India. It is one of the major industrial hubs of India. Major agricultural produce of the state includes cotton, groundnuts (peanuts), dates, sugar cane, milk and milk products. Industrial products include cement and petrol. Reliance Industries operates the oil refinery at Jamnagar, which is the world’s largest grass-roots refinery. The world's largest shipbreaking yard is in Gujarat near Bhavnagar at Alang. India’s only Liquid Chemical Port Terminal at Dahej. Gujarat is the only state in India to have a statewide gas grid of 2,200 km. Gujarat records highest decadal agricultural growth rate of 10.97%. As per RBI report, in year 2006–07, 26% out of total bank finance in India was in Gujarat.

The state is rich in calcite, gypsum, manganese, lignite, bauxite, limestone, agate, feldspar, and quartz sand, and successful mining of these minerals is done in their specified areas. Jamnagar is the hub for manufacturing brass parts. Gujarat produces about 98% of India's required amount of soda ash, and gives the country about 78% of its national requirement of salt. It is one of India's most prosperous states, having a per-capita GDP significantly above India's average. Kalol, Khambhat, and Ankleshwar are today known for their oil and natural gas production. Dhuvaran has a thermal power station, which uses coal, oil, and gas. General Motors manufactures its cars at Halol near Vadodara, Tata Motors manufactures the Tata Nano from Sanand near Ahmedabad, and AMW trucks are made near Bhuj. Surat, a city by the Gulf of Kambhat, is a hub of the global diamond trade. In 2003, 92% of the world's diamonds were cut and polished in Surat.

Gujarat is considered as India’s most economically free state. At an investor’s summit entitled “Vibrant Gujarat Global Investor Summit” held in Jan ’15, the state government signed 21000 Memoranda of Understanding for Special Economic Zones worth a total of ₹ 2.5 million crores. Gujarat has the lowest unemployment rate of 1% against the national average of 3.8%.

Gujarat is state with surplus electricity. Gujarat sold surplus power to 12 states: Rajasthan, Tamil Nadu, Uttar Pradesh, Maharashtra, Andhra Pradesh, Delhi, Haryana, Karnataka, Chhattisgarh, Uttarakhand, Madhya Pradesh, and West Bengal. It is estimated by 2017 , Gujarat has a capacity to generate 40,039 MW (double the
projected demand) to meet the requirement of any additional projects due to the rapid industrialization.

For the year 2014-15, Peak demand for Gujarat state was 13,603 MW and could manage to meet 13,499 MW i.e. deficit of 0.8%. Similarly, energy requirement for the same period is 96,235 MU and could manage to meet 96,211 MU without any deficit. Even though Gujarat is power surplus, the state can supply electricity to several other states. With vision of achieving per capita power generation and consumption benchmarks and to match the POWER FOR ALL mission, Government of Gujarat is taking-up a number of strategic steps so that electricity requirement of the other states can be met.

Electricity Act – 2003 has given highest priority to installation of Power Plants, encouraged Private participation in this sector and introduced open access of power transmission. With the above in view, Adani Power Limited (APL) has planned to install 3x1000MW at Siracha Village in continuation to existing 4620MW.

Adani Power Limited (APL) has set up 4620 MW (4x330MW + 5x660MW) of APL in Gujarat State near Siracha Village (Dist. Kutch). The first unit of 330 MW was commissioned in Aug ‘09 and last unit of 660 MW in Mar ‘12. These units are supplying power to Gujarat, Haryana, Tamil Nadu and Bihar.

Further, with the desire to contribute in making other states and the country as power efficient and contributing in nation’s growth, APL has proposed development of Mundra TPP Expansion Project with additional capacity of 3000 MW (3x1000 MW).

Power generated by the Project shall be used to meet the increasing power requirement in the other states of the country.

1.1.1 Company Highlights:

Adani Power Limited is Flagship Company of Adani Group. ADANI Group, is one of the leading business houses of the country with revenue of about US$ 10 billion, employing over 10,000 people and having diverse interests in global trading, development and operation of Ports, IDC terminal, establishment of SEZ, Oil refining, logistics, gas distribution, Power Generation, Power Transmission and Power Trading etc. Adani Port at Mundra promoted by the ADANI Group is operational since 1998.

ADANI Group is manned by experienced and highly qualified professionals including technocrats of repute. The team has demonstrated capabilities in conceptualization and implementation large projects excellent records of establishing benchmarks in the industry. ADANI Group has rich and extensive experience of liaison with government agencies, import, funding etc. With this track record of the organization in tying up finances, flow of funds will not pose any problem for implementation of the proposed project.

Adani Power Ltd (APL), has been formed for development of a number of Power Projects along with its associated dedicated transmission systems. Adani Power Ltd has commissioned India’s first super critical 660MW unit at Mundra on 22nd Dec 2010 and subsequently commissioned 4 (four) units of 660MW at Mundra by 31.03.2012. Presently, the company has total installed generation capacity of 10440 MW, out of which 4620 MW (4x330 MW + 5x660 MW) at Mundra in Gujarat as APL,
Pre-Feasibility Report

3x1000 MW Mundra Expansion Thermal Power Project

3300 MW (5x660 MW) at Tiroda in Maharashtra as APML, 1320 MW (2x660 MW) at Kawai in Rajasthan as APRL and 1200 MW (2x600 MW) at Udupi in Karnataka as UPCL.

Adani Power Limited has established 4620 MW imported coal based power project in Mundra Taluka of Gujarat State. Being first to commission a 660 MW supercritical unit in India, APL is all set to foray into ultra-supercritical unit of 1000 MW.

It is expected that APL will be able to ensure sale of power generated at the proposed expansion of Mundra Thermal Power Plant by operating the station at base load and thus ensuring adequate revenue generation. With the proposal taking shape, the commercial aspects viz. wheeling and banking, arrangement with the grid, possibility of supplying uninterrupted power to the identified consumers, Power Purchase Agreement (PPA) and other commercial and legal aspects with Power Grid Corporation of India Limited (PGCIL)/State Grid Authority shall be firmed up.

In the present study report, the plant location is studied with reference to availability of different inputs and other infrastructure for the station size under consideration. By evaluation of the data, a suitable configuration and layout for the station has been worked out. The study dwells upon other features viz. technical aspects, environmental issues, project implementation and finally the cost involved to implement this project.

1.2 Executive Summary:

1.2.1 Demand Supply Scenario:

For the purpose of power planning and grid management, Gujarat is a part of Western Region. The State of Gujarat is currently having power surplus and is supplying power to other states. Gujarat leads the country in the per capita consumption of electricity. The projected industrialization levels coupled with increase in urbanization and income levels would lead to substantially higher demand for power. The energy units required by 2020 would be nearly two and half times the existing generation.

The state is trying to promote several projects to take care of the ever-increasing demand of power beyond 2014-15 in the country. Even if all the projects now on the drawing board fructify it does not cover the power deficit of the country. There shall, however, be no difficulty in selling the excess power if generated to the power starved states in other regions of the country.

1.2.2 Basic Requirements:

Major considerations for selection of the site for establishing the proposed 3x1000 MW Ultra Super Critical TPS:

- **Fuel Requirement @ 85% PLF:**
  - Coal : 11.5 MMT per annum @ 85%PLF

  It is proposed to use imported Coal sourced from Australia/Indonesia with maximum ash Content of 25 % (worst coal) and Sulphur Content of less than 0.5 % for this Project.
The coal will be received at Mundra West port and will be transported to the Project site by a single stream elevated cross-country conveyor. Mundra west Port with present handling capacity of 60 MTPA is having adequate spare capacity to handle 11.5 MTPA coal requirement of the project.

The coal handling system of the proposed power project will have the rated capacity of 3000 TPH and design capacity 3300TPH with 100% redundancy and suitable crushing, stacking, reclaiming & feeding system will be provided.

Coal storage of 7 days requirement shall be kept in plant.

- LDO/HSD : 22000 KL per annum

The boiler will be designed for cold start-up and initial warm-up using Light Diesel Oil (LDO)/HSD. LDO/HSD will be received to the proposed plant by means of the rail/road tankers from indigenous sources.

### Water Requirement:

- Water : 28720 cum/hr (251.58 MCM per annum) Sea Water including Wet lime based FGD

Sea water will be sourced through the existing sea water reservoir of existing project which is being fed from Intake channel of APSEZL. Intake Channel, is having adequate capacity to meet the 28720 cum/hr requirement of the project. Outfall of approx. 21350 cum/hr will be through existing outfall facility of APSEZL. Necessary augmentation of outfall facility if required will be taken at appropriate time by APSEZL.

### Land Requirement:

The Thermal Project will be built in the approximately 201.5 Hectare (498 acres) of land which includes the plant and its auxiliary infrastructure. Certain infrastructure such as the area for pumping station, water reservoir, etc, is envisaged to be shared with the existing Thermal Power station.

APSEZL has planned SEZ on the Identified project land, which falls under forest area. This land has been applied by APSEZL for industrial/infrastructure purpose. Once necessary clearance is obtained, required land for the expansion project will be allotted to APL.

The plant layout for the proposed station has been developed keeping in view the optimum use of available land, direction of road access, operational ease and financial requirements for the initial development of the Project. **The proposed plot plan is attached as Annexure -1.** Table below provides land usage details for proposed project.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main plant area</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Power block area</td>
<td>80</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Item</td>
<td>Area (acres)</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>b)</td>
<td>Switchyard area</td>
<td>40</td>
</tr>
<tr>
<td>c)</td>
<td>Coal handling area</td>
<td>50</td>
</tr>
<tr>
<td>d)</td>
<td>Cooling tower and CW pump house</td>
<td>70</td>
</tr>
<tr>
<td>e)</td>
<td>Others</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>290</td>
</tr>
<tr>
<td>2</td>
<td>Green belt</td>
<td>208</td>
</tr>
<tr>
<td>3</td>
<td><strong>Total</strong></td>
<td><strong>498</strong></td>
</tr>
</tbody>
</table>

**Technical features** outlining the salient parameters of the main plant and equipment are discussed in the Section-5. The state-of-the-art technology will be deployed for auxiliaries and sub-systems to ensure safe and continuous operation of the units with minimum unscheduled outages.

**Total ash generation** for the project with worst coal is estimated to be approx. 2.875 MTPA. Considering that in our existing units at mundra, we are able to utilise 103 % of total ash generated (Ash is being utilised from ash dyke as well) our efforts will be made to achieve 100% ash utilization from first year itself.

The condenser cooling shall be done by **closed cycle cooling system** and the cooling water will be drawn from existing CW reservoir of APL which is sourcing sea water from existing open channel of APSEZL.

The proposed electrical system will be provided with adequately sized equipment and with generous redundancy to ensure uninterrupted operation of the plant. Electrical equipment and systems are discussed and described in Section - 5.3 of the report.

A 765 KV Switchyard will be provided for evacuation of power with required nos. of outgoing feeders. As Mundra Thermal power plant is well connected with CTU & STU we do not envisage any difficulties in evacuation of power. The exact configuration would be decided after tying up the power evacuation with the purchaser and the receiving substation voltage level.

The proposed station envisages the state-of-the-art Distributed Digital Control & Management 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 systems are described and discussed in adequate detail in Section – 5.4 of the Report.

Civil engineering aspects envisaged are detailed out in Section – 5.5.
To minimize emission of Suspended Particulate Matter (SPM) along with boiler flue gases, Electrostatic Precipitators of high efficiency and adequate size will be provided at exit end of each boiler to bring down SPM emission level fewer than 30 mg/Nm$^3$. Low NOx burners and SCR have been envisaged to reduce the NOx generation and consequent emission within 100 mg/Nm$^3$. Wet lime stone based FGD will be installed to limit the SOx emissions within 100 mg/Nm$^3$. Limestone consumption shall be approx. 7.39 TPH/unit and estimated gypsum generation shall be approx. 11 TPH/unit.

One RCC stack of 275m with three flues is envisaged for the proposed units. Liquid waste from the plant will be properly treated before re-use and/or disposal.

In Section – 8.3 of the report, O&M Philosophy for operation and maintenance is detailed out. The training requirement of O&M persons is also discussed in Section-8.3.5.

The project will be financed in such a way that the capital structure is built up to equity capital 30% and loan capital 70%. The Project Cost with Interest during Construction (IDC) is estimated as Rs. 18,000 Crores. The considerations for Project cost and Tariff Calculation are discussed in brief in Section 9.

Adequate facilities will be developed for execution of the project. The project will be implemented on Engineering, Procurement and Construction (EPC) concept and may be awarded through International Competitive Bidding Process.

The schedule of commissioning of first unit is envisaged as 48 months from the zero date and subsequent unit shall be commissioned within a gap of 6 months thereafter.
SECTION: 2

PROJECT HIGHLIGHTS
2. PROJECT HIGHLIGHTS

<table>
<thead>
<tr>
<th>Owner</th>
<th>Adani Power Limited (APL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Capacity</td>
<td>4620 MW (Existing) + 3000 MW (Proposed)</td>
</tr>
<tr>
<td>Plant Configuration</td>
<td>4x330MW + 5x660 MW (Existing) + 3x1000 MW (Proposed)</td>
</tr>
<tr>
<td>Location</td>
<td>Nearest Village: Siracha; Nearest City: Mundra, 25 Km; Nearest Railway Station: Bhuj, 70 Km from Plant; Nearest Airstrip: Mundra (35 Km); Nearest Airport: Bhuj (71 Km); Nearest Sea Port: Adani Port, Mundra (35 Km)</td>
</tr>
<tr>
<td>Seismological Information</td>
<td>ZONE – V as per IS 1893 : 2002</td>
</tr>
<tr>
<td>Land for the Project</td>
<td>201.5 Hectare (498 acres)</td>
</tr>
<tr>
<td>Source of water</td>
<td>Sea Water nearly 5 kms from the Site</td>
</tr>
<tr>
<td>Water Requirement</td>
<td>251.58 MCM per annum including Wet lime based FGD</td>
</tr>
<tr>
<td>Cooling System</td>
<td>Closed cycle cooling system using Sea water</td>
</tr>
<tr>
<td>Primary Fuel</td>
<td>Imported Coal</td>
</tr>
<tr>
<td>Coal requirement</td>
<td>11.5 million metric tonnes per annum @ 85% % PLF (GCV - 4000 Kcal/Kg, (worst coal) Ash – 25% (Max), Sulphur - (0.5% Max), SHR – 2062.5 Kcal / kwh)</td>
</tr>
<tr>
<td>Support Fuel &amp; Source</td>
<td>LDO//HSD from nearest refinery/oil depots by /Road.</td>
</tr>
<tr>
<td>Support fuel (HSD/ LDO)</td>
<td>22,000 KL per annum @ 85% PLF (1 ml/kwh)</td>
</tr>
<tr>
<td>Steam Turbine Generator</td>
<td>The Steam Turbine will be single shaft, multi-cylinders, tandem compound single reheat, regenerative, condensing unit directly coupled to AC Generator giving a continuous rated output of 1000 MW at generator terminals.</td>
</tr>
<tr>
<td>Steam Generator</td>
<td>Steam Generator will be ultra-supercritical pressure balanced draft furnace, single reheat, radiant, dry bottom type, sliding (variable) pressure operating, suitable for outdoor installation designed for firing pulverized coal as main fuel.</td>
</tr>
<tr>
<td>Station Operation</td>
<td>Base Load</td>
</tr>
<tr>
<td>Philosophy</td>
<td>Base Load</td>
</tr>
</tbody>
</table>
### Pre-Feasibility Report

**3x1000 MW Mundra Expansion Thermal Power Project**

<table>
<thead>
<tr>
<th>Chimney</th>
<th>275 meter high RCC stack with Three flues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Evacuation</td>
<td>By 765 KV system to Gujarat and other utilities depending upon the requirement of the purchaser.</td>
</tr>
<tr>
<td>Total Project Cost including IDC</td>
<td>Rs 18,000 Crores (Approx.)</td>
</tr>
<tr>
<td>Zero Date</td>
<td>Date of financial closure / award of main equipment, whichever is earlier.</td>
</tr>
</tbody>
</table>

**Project Completion Schedule from the Zero date**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit-1</td>
<td>48 months</td>
</tr>
<tr>
<td>Unit-2</td>
<td>54 months</td>
</tr>
<tr>
<td>Unit-3</td>
<td>60 months</td>
</tr>
</tbody>
</table>
SECTION: 3

DEMAND ANALYSIS & JUSTIFICATION
3.0 DEMAND ANALYSIS & JUSTIFICATION:

3.1 Introduction

Power is among the key infrastructure that contributes towards the economic development of any nation. Since liberalization of the Indian economy in the early 1990s, the power sector in India has witnessed significant growth. Installed electricity generation capacity in India stood at about 281 GW in Nov ’15, with a contribution of 69.5% from thermal. In transmission also, the country has made significant progress in the pursuit of making electricity available for all. Considering the positive change in policy matters, the country's growth is expected to follow an upward trend.

However, the peak electricity demand in the country is growing at a rate of 6.31% per annum whereas the average growth in the capacity addition during the last decade has been around 6.0%. Considering GDP growth rates of 8% per annum, the rate of growth of power needs to be more than 10% annually.

Further, the average per capita electricity consumption in India stands at 1010 kWh as compared to the global worldwide per capita consumption of more than 3000 kWh.

Keeping in view the growth of demand and the gap between demand and supply, the government has set a target of power generation capacity of around 2,98,067 MW by the end of 12th plan i.e. by 2017. Capacity addition during 12th plan is estimated at 98,190 MW, out of which the share of coal based power plants will be of the order of 66,600 MW.

With a reheat and regenerative machine of 1000 MW set size and assured availability of sufficient fuel at a competitive price, APL expects to generate power at an attractive price. The profitability can be assured if there is adequate demand for the next 25/30 years and if power can be transmitted to potential buyers or consumers at a reasonable cost. Energy from the proposed station may be evacuated to the state/national (PGCIL) grid through 765kV substations within a reasonable distance from the site.

3.2 The Electricity Act 2003

The Electricity Act - 2003 passed by the Parliament has ushered in sweeping changes in the Power Sector and provides a legal framework for enabling reforms and restructuring of the Power Sector. It has simplified administrative procedure by integrating the Indian Electricity Act, 1950, the Electricity (Supply) Act, 1948 and the Electricity Regulatory Commissions Act, 1998 into a single Act.

The Electricity Act, 2003 is based on the principle of promoting competition, protecting consumers' interests and providing power to all. The salient features of the Act are:-

- Unbundling of Generation & Transmission segments of the Power Sector
- De-licensing of thermal power generation
The Act consolidates the laws relating to generation, transmission, distribution, trading and use of electricity; takes measures that are conducive for the development of the sector including rationalization of electricity tariff, ensuring transparent policies regarding subsidies and addresses environmental concerns, among others.

The Act has ushered a paradigm shift in the power sector. Competition is now possible not just in generation, but also in every facet of the sector including transmission and distribution and private sector investment is now facilitated by greater transparency brought in by the Act.

The Act permits free entry into generation, unless there are overriding safety and environmental concerns. The Act also promises non-discriminatory open access to the transmission system. To this end the Central Electricity Regulatory Commission (CERC) had framed the regulation for the "Open Access in Inter-State Transmission" in January, 2004, which facilitates the bulk sale of energy from generators to the customers. This has introduced the idea of trading in wholesale electricity.

3.2.1 Concept of Independent Power Producers:

The Union Power Ministry is encouraging Independent Power Producers (IPPs) across the country as a means to create additional generating capacity at a faster rate through private sector participation.

Power plants usually sign long-term Power Purchase Agreements (PPAs) with State governments under which they agree to sell power to state-owned distribution utilities at agreed rate for a specified period.

Independent power producers may sign PPA with the state electricity utilities for supply of electricity regularly to the grid or to meet peak loads. IPPs may also sign long-term power purchase agreements with bulk power buyers, committing a certain percentage of their capacity to such agreements. IPPs can also sell the surplus power generated in the open market to licensed power traders who needs the power at that particular time.

The Electricity Act, 2003 recognized the concept of trading as a distinct licensed activity and CERC was identified as the regulator. CERC have issued guidelines for trade licensing, power trading and for setting up power exchanges. CERC have issued power trading licenses to many trading companies and power exchanges have come into being.

To facilitate sale of power to power traders and third parties, the government has established an open access policy in power transmission. Introduced in the Electricity Act, 2003, open access basically refers to the right to transmit power over a system
belonging to a third party. CERC have laid down procedures for open access in distribution. SERC of many states have followed up by laying down of provisions for open access.

With such concerted efforts in all areas, IPP’s are considered a favorable option to meet the power demand.

3.3 National Electricity Policy

The Central government has prepared the National Electricity Policy for development of the power system based on optimal utilization of resources. It is one of the key instruments for providing policy guideline to the Electricity Regulatory Commission (ERC) and to the Central Electricity Authority (CEA) for preparation of the National Electricity Plan. The Policy aims at accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources and energy security issues. The Policy also aims at overcoming the energy and peaking shortages and ensuring the commercial viability of the Electricity Sector, inter alia.

3.4 Perspective of Power Development

3.4.1 Power Development Scenario of 12th Plan (2012-2017):

As per the 5th National Power Plan (2002-2012) prepared by CEA a need based installed capacity of the order of 2,98,067 MW is required by the end of 12th Plan based on demand projections of 17th Electric Power Survey and a system reliability level of Loss of Load Probability (LOLP) less than 1% for the country.

The primary resources for Electric Power Generation are water, fossil fuel (coal, lignite, oil & natural gas) and nuclear energy. They would continue to serve as major resources for electric power generation in the long run, though various forms of renewable source, such as wind, solar, bio-mass, tides etc., will also contribute.

Based on the report of the working group on Power constituted by Planning Commission, a capacity addition of 78,700 MW was targeted in 11th Plan ending in March 2012, comprising 15,627 MW Hydro, 59,693 MW thermal and 3380 MW Nuclear. Out of the total thermal capacity of 59,693 MW, coal/lignite based capacity was expected to be 40,901 MW.

For 12th Plan ending in March 2017, CEA has identified a capacity addition of 98,190 MW comprising of 9,204 MW Hydro, 67,686 MW thermal, 2,800 MW of Nuclear and 18,500 MW of renewable sources. The 12th Plan program is comparatively large so as to provide not only for normal growth during the 12th Plan period, but also to compensate for any short fall in the capacity addition during 11th Plan period.
3.4.2 Present Status of Demand & Availability:

A review of the statistics reveals that during the year 2014-15, the country witnessed an energy shortage to the tune of 3.6 % and peak demand shortage of 4.7%. Notably there is an acute shortage in the certain areas of the country.

The peak demand shortage on all-India basis for this period was nearly 7,002 MW. It may be noted that the peak demand is actually restricted demand and is likely to be much higher.

Keeping the present scenario of shortages in energy and peak demand in view and to maintain a GDP (Gross Domestic Product) growth of 8% to 10%, the Government of India has very prudently set a target of about 2,98,067 MW of power generation capacity by March 2017.

The capacity addition required in next five (5) years will be 98,190 MW. The thermal power generation addition, during this period is estimated to the tune of 67,686 MW. It is estimated that the total funds requirement in the next five (5) years will be approximately Rs. 6,43,831 Crs. This includes the expenditure on infrastructure development in coal mining and coal transportation to the power plant sites, as well as the funds required for setting up plants with transmission and distribution system.

3.5 The Power Scenario in Gujarat

The State of Gujarat falls within Western region as per Central Electricity Authority (CEA). The total installed capacity of Power Utilities as on 31.10.2015 with break-up in Southern region and in Gujarat in particular is as follows:

<table>
<thead>
<tr>
<th>Table 3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal</strong></td>
</tr>
<tr>
<td><strong>Coal</strong></td>
</tr>
<tr>
<td>WESTERN REGION</td>
</tr>
<tr>
<td>GUJARAT STATE</td>
</tr>
</tbody>
</table>

Source: CEA; All figures in MW
RES: Renewable Energy Sources

As per 17th Electric Power Survey of CEA the electric energy requirement in the State of Gujarat during the end year of 11th & 12th Plan periods have been projected as follows:

<table>
<thead>
<tr>
<th>Table 3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan Period</strong></td>
</tr>
<tr>
<td>11th Plan ended year 2011-12</td>
</tr>
<tr>
<td>12th Plan year ending 2016-17</td>
</tr>
</tbody>
</table>
From above, it is apparent that there is substantial requirement of capacity addition to bridge the gap of electricity demand & supply and also to meet the objective of National Electricity Policy of Govt. of India.

Considering the load growth and the schemes for capacity addition taken-up, the gap between the peak demand and availability is not likely to close in the near future.

### 3.6 Choice of Fuel

It is proposed to use imported coal with max Ash Content of 25 (worst coal) and Sulphur Content of less than 0.5% for this Project. The imported coal shall be unloaded at West Port and thereafter will be transported through conveyor system to the proposed site.

### 3.7 Station Configuration

The proposed station is planned for total capacity of 3x1000 MW. While selecting the unit sizes for large utility stations, the major criteria are:

- Plant availability
- Cooling Water availability
- Compatibility of grid to withstand sudden outage of unit
- Operating experience of the set size
- Thermodynamic cycle efficiency and specific input consumption viz. fuel, water etc.
- Specific investment requirement & cost of generation.

Station comprising 1000 MW is recommended in order to take advantage of economy of scale in specific cost, construction and operation of the units, manpower involved, the heat rate achievable and lower specific auxiliary power consumption. With higher set sizes, the capital outlay as well as cost of generation is comparatively less.

For the proposed station, installation of three (3) units of 1000 MW is considered preferable. These units 1000 MW set size have favorable heat rate at high plant load factor and reasonably low operating cost. Several power projects are in service or under implementation with 1000 MW units. As such, availability of skilled operating personnel from other thermal power stations in the country render definite advantage in favor of 1000 MW sets. Further these set sizes are considered appropriate in the light of expansion of both PGCIL and the State Grid to handle the generated power.

In the light of the above, configuration of 3x1000 MW is considered appropriate for the proposed expansion of the station.

### 3.8 Justification of Project:

The state of Gujarat has been on the path of growth in all sectors of the economy. The state government is committed to ensure “Power to All” on round-the-clock basis.
Due to consistent support and growth strategy adopted by the State Government, the large, medium and small scale units are being set up every year. This process of industrialization further boosts the demand for power in the state. Moreover, open access provision of transmission system provided in the Electricity Act, 2003 enables a Power generating station to wheel the generated power to any parts of India.

Before undertaking a large Power Project, the criteria given importance are as follows:

- Unit size and station configuration
- Cost of Energy generated from the station.
- Load demand of the State, region and of the Country.
- Thermodynamic Cycle efficiency and reduced emission.
- Operating experience of similar plants.
- Station availability and Plant Load Factor attainable.
- Project Time frame

The Project proponents have carefully considered all above and decided to expand the existing Adani Power Limited.

The basic requirements for setting up a Coal based Thermal Power Plant are Land, Fuel, Water and Power evacuation facility. The Project Authorities have already taken pre-emptive actions in these areas and their status is as follows:

**Land:**
Approximately 201.5 Hectare (498 acres) land has been identified for the project.

**Water:**
The Water requirement for the Project will be met from Sea Water at a distance of 5Km from the Power Plant site. Application for drawl of water is to be made to Maritime Board., Govt of Gujarat.

**Coal:**
It is proposed to use imported Coal with maximum Ash Content of 25% and Sulphur Content of less than 0.5% for this Project. The imported coal shall be unloaded at West Port and thereafter will be transported through conveyor system to the proposed site.

**Power Evacuation:**
Power shall be supplied at 765kV voltage level.

The "low cost of power" would prove to be the strong point of this project in the merit order rating when compared to other power stations.
SECTION: 4

PROJECT DETAILS
4.0 PROJECT DETAILS

4.1 Accessibility:

The Project site is located near Siracha village in Mundra Taluka of Kutchh District of Gujarat.

The Project site is located adjacent to State Highway SH-6 at a distance of 4 Kms. Distance from National Highway (NH-8A) is 12 kms.

The site is well connected by the National / State Highways, broad gauge rail link and is 25 km away from the Mundra sea port. The nearest airport is Bhuj Airport located at a distance of 55 kms from the project site. The nearest railway station is Adipur/Gandhidham, which is about 65 kms from project site and nearest town is Mundra which is about 20 kms from the project site.

4.2 Land for the Project:

Presently 201.5 Hectare (498 acres) of land has been identified for the project. Broad Breakup of the same is indicated in following table –

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main plant area</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Power block area</td>
<td>80</td>
</tr>
<tr>
<td>b)</td>
<td>Switchyard area</td>
<td>40</td>
</tr>
<tr>
<td>c)</td>
<td>Coal handling area</td>
<td>50</td>
</tr>
<tr>
<td>d)</td>
<td>Cooling tower and CW pump house</td>
<td>70</td>
</tr>
<tr>
<td>e)</td>
<td>Others</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>290</td>
</tr>
<tr>
<td>2</td>
<td>Green belt</td>
<td>208</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>498</td>
</tr>
</tbody>
</table>

Since the site is located nearer to the Coastal area, Highway and railway lines all infrastructural facilities like access road, railhead, clear means of receiving coal, etc. are available nearby the site. Other technical aspects like wind direction, soil characteristics also have been taken into consideration while developing the Plant Layout.

4.3 Fuel Source and Availability:

4.3.1 Source & Type of Fuel:

a) Main Fuel - Coal
The main fuel considered for the project is imported coal with maximum Ash Content of 25% (worst coal) and Sulphur Content of less than 0.5% for this Project. The imported coal shall be unloaded at West Port and thereafter will be transported through conveyor system to the proposed site. Coal storage of 7 days requirement of coal is proposed at the power plant.

The annual requirement of coal is estimated at about 11.5 MMTPA @ 85% PLF for the three (3) units of 1000 MW, considering a gross calorific value of 4000 Kcal/kg at 85% plant load factor and station heat rate of 2062.5 Kcal/Kwh. The coal shall have Ash Content of 25% (Max.) (Worst coal) and Sulphur content < 0.5%.

b) Start-Up Fuel

The boiler will be designed for cold start-up and initial warm-up using Light Diesel Oil (LDO)/HSD. LDO/HSD will be received to the proposed plant by means of the rail/road tankers.

The annual requirement of LDO/HSD for cold start up and load stabilization is estimated to be around 22,000 KL per annum.

4.3.2 Infrastructure & Mode of Transportation:

The Imported coal from Indonesia/SA/Australia shall be unloaded to Mundra West Port and thereafter will be transported through conveyor system to the proposed site.

4.4 Makeup water Availability & Transportation:

4.4.1 Sea Water

The water requirement for the proposed project will be met from the existing Sea water reservoir. Water received from the source shall be further treated in pre-treatment plant and then used for make up to cooling tower. Desalination Plant followed by Pre-treatment plant and then used for service water and feed to DM plant(RO+MB) for power plant purposes. Water requirement for the proposed 3x1000 MW power plant will be in the order of about 251.58 MCM per annum including requirement of Wet lime based Flue Gas Desulphurisation (FGD) plant.

4.4.2 Sweet Water Requirement

The sweet water to cater the plant needs such as feed to DM plant(RO+MB) for power cycle make up, auxiliary cooling water, services, potable water, etc., shall be fed from a Water Treatment Plant (Desalination plant) for the proposed plant.

Indicative water balance is attached as Annexure-1.2.

4.5 Power Evacuation Plan:

It is proposed to sell power generated from the station at 765 KV level to various utilities. A 765 KV Switchyard will be provided for evacuation of power with required
nos. of outgoing feeders. As Mundra Thermal power plant is well connected with CTU & STU we do not envisage any difficulties in evacuation of power. The exact configuration would be decided after tying up the power evacuation with the purchaser and the receiving substation voltage level.

4.6 Environmental Aspects:

In the proposed project water directly from sea will be used in closed circuit after suitable pre-treatment for circulating water system and sweet (Desalinated) water needs will be met. Suitable provisions will be incorporated in the design of buildings, structures and selection of equipment such that there are no adverse effects due to emissions, noise, contamination of soil water and air. A detailed EIA study shall be conducted to assess the impacts and the recommendations will be followed while establishing the project.

Electrostatic Precipitators of high efficiency and adequate size will be provided at exit end of each boiler to bring down SPM emission level fewer than 30 mg/Nm³. Low NOx burners and SCR have been envisaged to reduce the NOx generation and consequent emission within 100 mg/Nm³. Wet lime stone based FGD will be installed to limit the SOx emissions within 100 mg/Nm³. Limestone consumption shall be approx. 7.39 TPH/unit and estimated gypsum generation shall be approx. 11 TPH/unit.

One RCC stack of 275m with three flues is envisaged for the proposed units. Liquid waste from the plant will be properly treated before re-use and/or disposal.

Detailed environmental aspects have been given in Section – 8.0:

4.7 Site Features:

The selected site near Siracha village has the following inherent advantages:-

- Shared Infrastructure with existing plant.
- Availability of suitable and contiguous land.
- Water supply directly from Sea.
- The site is not located in any Eco Sensitive area.
- Power can be evacuated at 765 kV level.
- The site is well connected by port, rail and road for transport of Fuel & Heavy equipment.
- Strategic location with respect to load centres.
SECTION: 5

TECHNICAL FEATURES
5.0 TECHNICAL FEATURES:

The power generating Units will be of ultra-supercritical steam parameters utilizing imported coal.

It is proposed to use sea water as cooling water for condenser. The condenser cooling circuit shall operate on 'closed cycle system'.

The bottom ash will be collected in semi-wet form and fly ash in dry form. Fly Ash shall be extracted in dry form and stored in storage silos for the purpose of utilization. Total fly ash shall be utilized and hence no fly ash disposal system shall be envisaged. Bottom ash shall be collected (in semi-wet mode) in bottom ash storage bin and shall be utilised for various applications & filling of low lying areas (outside the proposed plant) through the trucks.

Switchyard will be located near the power block. The power generated at the plant will be evacuated at 765 kV level to Gujarat state utilities or bulk purchasers through existing and additional 765 kV lines proposed from proposed 765kV Switchyard to Substations of Gujarat & PGCIL system depending upon the requirement of the Purchaser.

Design requirements envisaged in “Central Electricity Authority” (Construction of electrical Plant & electrical lines) Regulations: 2007 shall be complied with.

The plant will be designed in compliance with applicable National and International Codes and Standards such as ASME, AWWA, 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 PLANT PERFORMANCE:

The general technical description is detailed in Section 6.2 for the steam turbine of 1000 MW from each Unit. For tariff calculation, the plant gross heat rate with performance coal, design ambient conditions and cooling water temperature, is considered to be 2062.5 Kcal/kWh on GCV basis and the auxiliary consumption is considered as 7.5 % of the gross power generated. Availability of the plant of similar size and type is above 90%.

The steam parameters will be selected considering the parameters offered by different manufacturers for equipment of similar type and rating, to get the advantage of standard proven design at competitive cost.
5.2 MECHANICAL EQUIPMENT AND SYSTEM:

5.2.1 STEAM GENERATOR AND ACCESSORIES:

Steam Generator
The steam generator units proposed for the station will be ultra-supercritical, once through, outdoor, pulverized coal fired, balanced draft, single reheat, dry bottom type with two pass or tower type arrangement as per manufacturer's standard. For improved efficiency at part loads and flexible operability, boiler capable of sliding pressure operation is favoured. An added advantage in these type of boilers is feature of Boiler circulation pumps which shorten the start-up time and heat loss during start-up period.

The combustion system will be provided for pulverised coal firing with Low NOx type coal burners. The steam generators will be designed for continuous satisfactory operation with the range of coal. The furnace would be conservatively designed for fuel to burn completely and to avoid any slagging in the furnace and excessive fouling in the super heater sections of the boiler. The design flue gas velocities would be carefully selected to minimise erosion of pressure parts and other vital components on account of ash. The steam generators would be designed in accordance with the latest provisions of Indian Boiler Regulations.

Capacity of steam generating units would be so selected as to ensure adequate margin over the requirement of Turbine at 100% MCR in order to cater to auxiliary steam requirement for soot blowing operation, and also for start-up of the adjacent unit, and de-aerating of the steam generating units after prolonged use. The steam generators would be designed to operate with "the HP Heaters out of service" condition (resulting in lower feed water temperature at Economiser inlet) and deliver steam to meet the turbo-generator requirement at base load. Economiser section of the boiler would be non-steaming type with provision for recirculation during start-up, chemical cleaning etc. Super heater section would be divided in convection and radiant zones and designed so as to maintain rated steam temperature at outlet over the range of 60% to 100% MCR load. Main steam de-superheating stations with provision for spraying water tapped off from feed water piping would be provided. Air preheaters, preferably of rotary type would be provided with a set of soot blowers of automatic sequential electrically operated type, arranged for on-load cleaning of the heat transfer surfaces.

Draft system of each boiler would be provided with Forced Draft and Induced Draft Fans with suitable capacity and control arrangement, each independently capable of meeting the requirement at 60% boiler MCR load. The forced draft fans would control total airflow to boiler and the induced draft fans will control furnace draft of the boiler through automatic control loops. The coal will be received to the coal bunkers of about 12 hours storage capacity and the same will be fed to the coal pulverisers utilising gravimetric feeders. The pulverised and conditioned coal will be then distributed to the Low NOx coal burners from each mill for combustion in the furnace of the boiler thro' coal conveying pipes.

LDO/HSD and LDO will be required for start-up, load carrying and flame stabilization at low load. LDO/HSD will be used for cold start-up and for low load operation and flame stabilization.
The complete boiler will be top supported type and would be provided with all supporting steel structures, platforms, galleries, elevator and stairways for easy approach and maintenance of the unit. Adequate weather protection would be provided for instruments and operating personnel.

Necessary lining and insulation along with fixing materials to limit outside surface temperature to a safe level would be provided. Monorails and hoists required for handling heavy equipment, motors, fans etc. would be supplied along with the steam-generating units for ease of maintenance.

**Electrostatic Precipitator**

Each steam-generating unit would be provided with electro-static precipitators. Each precipitator will have two parallel gas paths, any of which can be isolated for maintenance when required, keeping the other path in operation. Each path will have fields in series for collection of fly ash. The ESP will be designed for outlet dust burden not exceeding 30 mg/Nm\(^3\) at 100% MCR.

**5.2.2 Steam Turbine**

The steam turbine would be 3000 rpm, tandem compound, single reheat, regenerative, condensing, horizontally split, three-cylinder machine with extractions for regenerative feed heating. The turbine would be designed for main steam parameters of corresponding to the boiler output of pressure and temperature, before emergency stop valves of HP turbine and reheat steam parameters to IP turbine. The LP turbine will exhaust to condenser. At turbine valve wide open (VWO) condition the turbo-generator set will be able to operate continuously with a throttle steam flow of about 105% turbine MCR condition.

The bypass station will act not only as a protection to the unit during pressure rise resulting from sudden load throw off but also enable operation of the unit at loads lower than the controllable range of load. This will also permit quick, repeated hot starts of the unit on its tripping.

A fully automatic gland sealing system will be provided for the turbine which will have provision for receiving steam from auxiliary steam header during start-up and low load operation. The turbo-generator will be equipped with electro-hydraulic governing system ensuring stable operation under any grid fluctuation and load throw off condition. The turbo-generator will be equipped with turning gear. The unit will also be provided with self-contained lubricating oil system for supplying oil to turbine and generator bearings and also to hydrogen seal oil system of the generator. The lubricating oil will be cooled by Closed Circuit Cooling Water System utilising seawater as cooling medium.

Generator will be connected to its unit step up transformer. The auxiliary power requirement of the unit will be drawn from its unit auxiliary transformer tapped off from the generator bus duct. All auxiliaries like turbine oil purification system, generator seal oil system etc. as well as necessary protective and supervisory system will be provided to ensure trouble-free, safe and efficient operation of the turbo-generator. The unit will be guaranteed to generate required output at generator
terminals continuously. The turbine will be suitable for wet steam washing for which set of auxiliary equipment necessary for the units will be provided.

5.2.3 Condensing Equipment

Double pass surface condenser capable of maintaining the required vacuum while condensing steam at the maximum rating of the turbine will be provided. The condenser will be of divided water box design with rolled steel construction of body and water chamber. Condenser with titanium tubes, tube sheet, baffles plates, etc. is envisaged for sea water application. The condenser will be designed as per HEI code or equivalent. The condensers will have integrated air cooling zone and it should be designed so as to accept full quantity of steam during turbine HP and LP bypass operation without any undue vibration, thermal stress etc. The condenser axis will be at right angle to the turbo-generator axis.

Necessary controls for Oxygen content of condensate leaving the condenser hot well will be provided. The condensate temperature will not be less than the saturation temperature corresponding to condenser back pressure. The water boxes will be protected by a suitable protection system. The maximum heat load of the condenser will correspond to turbine operating with valves wide open condition at 105% TMCR steam flow.

Vacuum pumps will be provided to maintain the vacuum in the condenser by expelling the non-condensable gases. One vacuum pump would operate during normal plant operation and during start-up, both the units may be operated such that the desired vacuum can be pulled within a short time.

5.2.4 In-plant coal handling, transportation and bunker feeding system:

The coal handling system for the power plant will be normally operational for two shifts a day with provision for third shift operation also. It is considered to have a 12 hrs Storage capacity in the bunkers.

Imported coal will be used for the plant. The coal to the power plant will be received from port through 6.7km long high speed conveyor system. From coal silo (located at plant end) coal will be conveyed to the boiler bunker through crusher house and a number of coal transfer houses. Provision shall be kept for stacking crushed coal in stock yards from where coal will be reclaimed as and when required in coal bunkers.

The sub systems of the In-Plant Coal Handling Plant are:

- Coal Silo
- Crushing & Screening System
- Coal stacking & Reclaiming
- Belt Conveyors
- Metal Detectors
- Magnetic Separators
The coal of size (-) 100mm shall be made available at coal silo (located at plant end). The combination of conveyors shall feed uncrushed coal to screen. The higher size coal particle (more than 25mm) will be fed to crusher and smaller particle (less than 25mm) will be fed to belt feeder for feeding to conveyor. The bigger coal particle will be crushed to -25mm by the ring granulator type crusher.

Conveyor will feed crushed coal to bunker through V-Plough tripper for storage purpose. Metal detector, coal supply unit, electronic belt conveyor shall be provided at strategic locations. Dust suppression (Dry Fog Type) system shall be provided at the discharge end of all conveyors excepting crusher house at bunker bay while dust extraction system shall be provided at vibrating screen and bunker bay. Manual/Electric hoist at various buildings shall be provided for maintenance purpose. All belt conveyors shall be provided with fire resistance and its speed shall be limited to 3.5m/sec.

2x100% coal crushing and conveying streams from coal silo shall be provided up to bunker feeding system.

5.2.5 Fuel Oil Handling System:

The fuel oil handling system with consist of unloading area, HSD/LDO unloading pumps, two HSD/LDO tank, HSD/LDO forwarding pumps. Fuel oil pump house will also be constructed for accommodating fuel oil unloading & forwarding pumps.

5.2.6 Ash Handling System:

Ash formed due to combustion of coal in the pulverised coal steam generator will be collected partly as bottom ash in bottom ash hopper and partly as fly ash in the fly ash hoppers. The major sub systems are as under:

Bottom Ash Handling System

Submerged scrapper chain conveyor system shall be provided to extract and convey the bottom ash (in semi-wet mode) from bottom ash hopper to bottom ash storage bin located within the boiler area. Disposal of bottom ash from the bottom ash storage bin shall be done through trucks. Two (2) nos. (1W+1S) scraper chain conveyors shall be provided per unit. One (1) nos. bottom ash storage bin shall be provided per unit.

Flushing apparatus system shall be provided to extract and convey the economizer ash in lean slurry form to submerged scraper chain conveyor for onward conveying
(along with bottom ash) to bottom ash storage bin. Removal of Bottom ash and economizer ash shall be done on a continuous basis. Suitable gates shall be provided beneath the bottom ash hopper to isolate the scraper chain conveyor from the boiler furnace in case of any exigency.

One (1) Settling tank and surge tank (common for 03 units) shall be provided for recirculation of overflow water from scraper chain conveyer and decanted water from bottom ash storage bin.

Overflow water from scraper conveyer and decanted water from BA storage bin shall be collected in a Drain sump and then pumped to Settling tank. Overflow from Settling tank will be collected in surge tank for reuse in ash handling system.

**Fly Ash Handling System:**

The fly ash handling system will extract fly ash pneumatically under vacuum from electro static precipitator (ESP) and Air Preheater hoppers, store fly ash in intermediate surge hoppers. From surge hoppers fly ash will be conveyed pneumatically under pressure to ash storage silos.

Three ash silos of 24 hour storage of fly ash shall be provided. One boiler unit will be provided with one pneumatic conveying system for handling of fly ash collected in the fly ash hoppers. Fly ash from the ESP and APH hoppers of each unit shall be removed in 5.0 hours per shift of 8 hours.

The fly ash handling system will include vacuum pumps, aeration blowers and heaters, intermediate surge hopper, air compressors and dryers, fly ash transmitter, all valves, piping, supports, platforms, access stairs and ladders, all control & instrumentation, electrical equipment, power and control cable and cabling etc. The bends with wear resistant linings will be provided for fly ash conveying pipelines.

**5.2.6.2 Ash Disposal**

It is expected that approximately 2.875 MMT/annum total ash will be generated when utilising worst coal of maximum 25 % ash. The fly ash generated from the proposed units shall be utilized fully as per MoEF guidelines. Cement industries around the proposed plant area shall also be identified for utilization of fly ash. Fly ash from the silos shall be loaded in to ash/cement bulkers and sent to cement industries. Fly ash shall also be utilised in Brick industries in making fly-ash bricks, in construction of roads and flyovers etc. Considering 100% fly ash utilization, no fly ash disposal system is considered.

Bottom ash shall also be utilised fully for filling of low lying areas (outside the proposed plant) and other applications in semi-wet mode through trucks.

**5.2.7 Plant Water System**

**5.2.7.1 Water drawl**

For drawl of sea water for the proposed project, existing sea water reservoir shall be used and another intake pump house shall be constructed to cater plant water requirement.
5.2.7.2 Makeup Water System

Sea water is considered as the source of water for the station. The consumptive water requirement of the proposed 3x1000 MW station is estimated at around 28720 m3/hr (251.58 MCM per annum including wet lime based FGD system). The requirement of plant water will be met by drawl of water through an intake structure with pump house to be constructed in the intake reservoir. Re-circulating cooling water system using wet evaporative induced Draft cooling towers will be deployed for the proposed station. It will be used for the condenser and auxiliary equipment cooling in a closed cooling water circuit. The choice of cooling water system is guided predominantly by the GOI guidelines on use of sea water for cooling purposes.

The total raw water requirement of 28720m3/hr considers semi-wet disposal of bottom ash, heat cycle make-up, make-up to cooling towers, wet lime based FGD and other consumptive requirements like potable water, different varieties of process and service water etc. It is proposed to utilise blow down from the cooling tower in ash handling and intermittent quenching of water drained from boiler. The break down is furnished in the Water Balance Diagram.

Sea water at the plant end will be received in water reservoir, which will have an overall storage capacity of about seven (07-10) days’ water requirement of the Plant. Sea water will thereafter, be pumped to the Raw water pre-treatment plant and Ash handling plant by 4X33.3% capacity Raw water pumps. Separate pump house shall be designed and constructed for FGD water requirement.

For the proposed units, five (05) clariflocculators units each having rated capacity of about 5000 m3/hr is considered for pre-treatment (PT) plant for CW system. Further two (2) nos. clariflocculators / tube settlers each having rated capacity of about 2500 m3/hr (or 2X2500 m3/hr) is considered for PT plant of Desalination/DM system/ Plant cycle make-up. Normally both the clariflocculators will be running at full load condition. However, when one clariflocculator is under maintenance, the second clariflocculator will run on overload condition to meet the desired clarified water requirement. Lime, alum, ferric chloride and other coagulant will be dosed in the clariflocculators to accelerate the coagulation.

Clarified water from PTCW will be used as make-up for the Circulating water system directly. From PTDM plant (2X2500 m3/hr) water will be stored in a twin chamber RCC reservoir having a storage capacity of about 4-hours of Desalination plant feed water requirement. From the Clarified water reservoir water will be pumped to Desalination plant.

Desalinated water will meet the requirement of Potable water, of Air Conditioning and ventilation plant, service water for washing, cleaning and other housekeeping needs, Cooling and sealing water of AHP, CHP service water, Feed to Brackish water RO + MB unit etc. Service water will be met by three (3) nos. of Service water pumps (2W +1S) each having 50% capacity to meet the requirement of both units.

Feed water to meet the requirement of DM plant will be met by 3x50% feed water pumps.
2x100% potable feed water pumps shall be provided to meet potable water requirement.

Cooling water in circulation is estimated at 116275 m³/hr per unit including the requirement of auxiliary cooling circuit (secondary circuit) and considering temperature rise across cooling tower as 9.0 degree C.

The makeup water requirement for cooling circuit at full load is estimated at 23459 m³/hr for 03 units. The cooling tower blow down is expected to be about 17790 m³/hr. Blow down water qty shall sent to plant outfall through CMB. Regeneration effluent from DM plant will be neutralised before discharge to Central Monitoring Basin (CMB). The water from CMB after suitable treatment will be recycled for use in Ash water sump, CHP dust suppression, and plant outfall.

5.2.7.3 Desalination plant, Demineralisation Plant & Heat Cycle Make-up System:

Water consumption is calculated by considering 1% of cycle make up and DM plant is designed by assuming average 3% make-up for the heat cycle and accounting for three hours regeneration time, demineralising chains, of 3X120 m³/hr capacity addition to existing DM plant have been envisaged for the proposed units. DM plant will supply heat cycle make-up, the make-up requirement for primary water circuit in heat exchangers for the auxiliary cooling system of boiler, turbine generator and other common auxiliaries.

Clarified water will be pumped to the Desalination plant. Appx. 21 MLD (by considering 3% cycle make up) product water capacity desalination plant will be installed. Clarified water will be first filtered through dual media filters installed within the Desal plant. Filtered water will subsequently be passed through Ultrafiltration if required and, Reverse Osmosis units, degassifier towers. Desalinated water will be used as a service water, potable water and Feed to BWRO+MB unit

DM plant for demineralisation.

In the DM plant, the water will be feed to secondary RO (BWRO) installed within the DM plant building. Product water of BWRO will be feed filtered water subsequently be passed through, Reverse Osmosis units, degassifier towers and to mixed bed exchangers.

The demineralised water will be stored in DM water storage tanks. Acid and alkali unloading, storage and feeding system will be installed for the DM plant resin regeneration. DM water will be stored in DM water storage tanks of about 3 x 3000 m³ capacity.

DM water from the storage tanks will be transferred to unit condensate storage tanks by four (4) nos. DM transfer pumps (3W +1S) each having 100% capacity to meet the requirement of one unit.

There will be one common DMCCW circuit for each unit - TG auxiliaries, BOP auxiliaries and SG auxiliaries each. DMCCW system will have 2x100% capacity DMCCW pumps, 2x100% capacity Plate type Heat Exchangers, 2x100% filters and one expansion tank.
5.2.7.4 Circulating and Auxiliary Cooling Water System

The plant CW system will include the CW and auxiliary CW pumping system & induced draft cooling towers (IDCT).

It is proposed to provide single circulating water pump house in the plant for three (03) units with six (06) numbers of pumps in pump house, two (2) for each unit. CW shall be supplied to each condenser through CW piping which shall have concrete encasement from outside. All valves / butterfly valves, RE joints and other fittings shall be suitable for sea water application.

There are certain station auxiliaries which may have to be cooled by clarified water. In such case, however, it will be ensured that the clarified water is cooled and recycled through close cycle cooling using IDCT of CW system.

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 main & auxiliary CW pumps and suitably treated prior to discharge.

5.2.7.5 Closed Cycle Cooling Water System

Closed circuit cooling water system would be adopted for steam generator and turbine generator and common auxiliaries like air compressors, ash handling plant equipment etc. 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 makeup system. For the secondary side, cooling water would be tapped from CW inlet to condenser and discharged into the discharge duct downstream of the condenser.

For each unit, 2x100% auxiliary cooling water pumps for primary circuit as well as 2x100% pumps for secondary circuit will be provided for supply of auxiliary cooling water to 2X100% Plate Heat Exchangers (PHE). DM water which will be used for cooling the equipment in closed cycle shall be cooled in PHE's. The secondary auxiliary cooling water pumps will be located in ACW pump house near to ACW pump house near the respective units. These pumps will take suction from the CW sump and return back to the CW outlet line from the condenser for rejecting heat to main IDCT. However, alternative arrangement of booster pumps with suction from CW pump discharge shall also be acceptable.

5.2.7.6 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 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 4X33% capacity mixed bed trains, consisting of service vessels for each unit. The resins to be used would be strong acid cation and strong base 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 feed system for preparing, measuring and dosing the required chemicals.

5.2.7.7 Service Water & Potable Water System

Drinking water requirement for the plant will be met from the output of desalination plant receiving stock from fresh water system after proper filtration and treatment. Potable water thus generated shall be stored in a potable water tank of capacity 100 M³.

There will be 2x100% drinking water pumps, which will supply drinking water to various facility area overhead tanks. Plant service water requirement will be met from the Overhead Service water tank and 3x50% Service water pumps, which will supply service water to various facility areas.

5.2.8 Waste water Treatment Plant:

The liquid waste shall be collected and treated/recycled generally as per the following way:

The waste water from neutralization pits of condensate-polishing plant, DM plant shall be collected in the respective neutralization pits and neutralized before pumping to the central monitoring basin before final disposal.

Cooling tower blow down water and RO reject water shall also be collected in CMB before discharge.

The oily waste from main plant area shall be treated using oil water separator and the treated water shall be led to the tube settler provided for service water waste for further treatment. Similarly separate system shall be provided for oily water in fuel oil unloading and storage area. From CMB water will be pumped to outfall channel for discharge to sea.

Rain Water

Rainfall runoff from the coal pile will contain mainly suspended solids. This runoff will be routed to the settling basin for retention and settling of suspended solids, and the clear water from there may be used for dust suppression system.

The rain water is collected in the storm water drain running all around the project. Rain water harvesting pit is connected to the storm water drain.

Excess rain water will flow to common collection pit from where water can be pumped for use in the ash handling system.

Miscellaneous

The plant sanitary waste will be treated in the sewage treatment plant.
5.2.9 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.

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 and DM plant. The system will be complete with piping, hydrants, valves, instrumentation, hoses, nozzles, hose boxes/stations etc.

Automatic high velocity water spray system for all 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 & 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 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 66 deg C and below consisting of QB detectors, deluge valves, nozzles, piping, instrumentation, etc.

Automatic sprinkler or water spray system shall be provided for Auxiliary boiler, store and hydrogen generation plant.

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.
Existing above fire water pump house & storage tank will meet the requirement for additional 3x1000 MW units. Following equipment will be additional required for next phase fire protection & detection system. Additional Hydrant booster pumps, Addition Spray booster pumps required. All piping & detection system are designed for next Phase.

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

5.2.10 Plant Air & Instrument Air System:

For instrument/service air requirement of main plant and auxiliaries, air compressors having a required capacity and a discharge pressure of 8 bar (g) with Air Drying Plants of same capacity will be provided. For the complete plant, five (05) numbers (3W+1 Hot Standby + 1 maintenance Standby) of Instrument air compressors will be provided. These compressors will be oil-free screw type provided with all accessories such as suction filters, inter-coolers, after coolers etc.

The air-drying plants will be capable of achieving a dew point of (-) 40 deg. C at atmospheric pressure. Individual air receiver will be provided near each air compressor and further unit air receivers will be provided near main plant of each unit.

5.2.11 Air Conditioning System:

Inside design conditions of 24.1 degree C dry bulb temperature and relative humidity not exceeding 60% 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, and Steam & Water Analysis Rooms, Conference Room, Shift Charge Engineer’s Room (if applicable), Relay Rooms. A centralised chilled water system is envisaged for air-conditioning the above areas. This system will consist of three (3) nos. (2 nos. two working + 1 no. one standby) screw chilling units. This system also consists of 2 x 60% capacity chilled water pumps, 2 x 60% capacity condenser cooling water pumps, 2 x 60% capacity induced draft FRP cooling towers, adequate number of air-handling units for circulating the conditioned air through air-distribution 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
Any other area, which contains control and instrumentation equipment requiring Space Conditioning or otherwise required to be air conditioned.

A central water cooled chilled water type air conditioning plant will be provided for air conditioning of central Control Room and its associated area.

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

5.2.12 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.

For Ventilation of Station building, forced ventilation system is envisaged. 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 40 degree 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 other 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 20 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.

5.2.13 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-336, P22, P91 shall be used.

5.2.14 Chemical Feed System:

Although high purity water will be used as heat cycle makeup, 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 makeup system.
Normally All Volatile Treatment (AVT) chemistry is adopted for Once through ultr-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 Chemical Feed System shall consist of independent systems of Low Pressure (LP) 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.

5.2.15 Condenser On-load Tube Cleaning System:

Two (2) nos. 2x100% Condenser On Load Tube Cleaning System complete with ball recirculation units, pumps, drive motors, ball collectors, debris filter etc. and appurtenances matching the requirements of the Condenser.

5.2.16 Hydrogen Generation Plant:

Existing hydrogen generation plant shall cater the requirements of new 3x1000 MW units. Or hydrogen cylinder will be purchased to cater hydrogen gas requirement.

5.2.17 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 with an ambient temperature of 47°C and wind velocity of 3.4 m/s.

Steam turbine and also, BFP drive turbine shall have spray insulation to maintain differential expansion of turbine within permissible limits apart from conserving heat.

5.2.18 Cranes & Hoists:

Two (2) no. of EOT cranes of adequate capacities will be provided in the turbine hall for erection and maintenance of turbo-generators and their auxiliaries except generator stator. The main hook capacity of each crane will be 6% over and above the heaviest component / equipment (including lifting beam and slings etc.) to be handled in TG hall.
CW pump house, ACW pumps, Air Compressors, Workshop and other Facility requiring frequent handling of heavy loads will also be provided with EOT cranes of suitable capacity. For handling other heavy equipment weighing 600 kg and above, electrical / manual cranes and hoists of appropriate type and rating will be provided.

5.2.19 Chimney:

One (1) no chimney with 3 flues, of 275 m with RCC construction is envisaged for 3x1000 MW Units to comply with environmental regulations. The chimney will be concrete shell type, MS flues with top one third SS liner to cater to three (03) units of 1000 MW. The chimney will be provided with lightning arrestors and aviation warning lights. System design will include on-line Opacity / Suspended Particulate matter monitoring system, SO\textsubscript{2} and NO\textsubscript{x} monitoring system, CO monitoring and Flue Gas Oxygen analysers etc. The Chimney will be provided with rack & pinion type elevator to facilitate maintenance.

5.2.20 Elevators:

One (1) goods-cum-passenger elevator of about 3000 kg carrying capacity will be provided for each of the steam generating units. One (1) number passenger elevator will be provided at the entrance of the power house building for movement of personnel.

5.2.21 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/m\textsuperscript{2} zinc coating. Suitable allowance on thickness will be provided for the surfaces, which can not be protected by application of painting. All buried piping will be provided with bitumen paint based coating and wrapping. Cathodic protection system shall be provided for all underground structures wherever it will be felt necessary.

All equipment, buildings, structures etc exposed to atmosphere shall be painted to suit marine climate and protect against salt / saline water carry over from sea with the blowing wind.

5.2.22 Workshop & Laboratory:

The power plant is already 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 already established for the station. This has necessary equipment and facilities to test and analyse steam, water, oil, coal etc. required to ensure satisfactory operation and maintenance of the station.
5.3 ELECTRICAL SYSTEMS & EQUIPMENT:

5.3.1 General Description

The generation voltage shall be above 27 kV or as per Manufacturer's standard. The generator would be connected to the switchyard through a step-up Generator Transformer. Power will be evacuated through 3 single CKT 765 KV lines.

For start-up power of project, Start-up power will be availed at 400 KV / 220 KV level from the 4620 MW Mundra power plant with suitable arrangement. Two nos. suitable sized station transformers will be installed in between Generator and generator transformer by taking Tap-off from IPBD. Voltage levels i.e.11KV, 6.6 kV and 415V are adopted for feeding the plant auxiliaries.

General Principles of Design Concept

The design concept of the electrical system as a whole is based on the requirements for the safe and reliable performance of steam turbine generator set and the interconnected electrical system with provision for easy maintenance and overhauling.

The design principles and standards delineated herein are generally in compliance with latest IEC/IS Standards and the Code of Practice already established in the country.

Indian Electricity Rules wherever applicable have also been complied with Design ambient temperature for Electrical Equipment is considered as 50°C.

Auxiliary Power System

Auxiliaries of the Power plant range from large capacity motors to small fractional horsepower motors. The motors shall be connected to power supply as per following design criteria:

Below 0.2 kW 240V, 1 Phase, 50 Hz.
From 0.2 kW to 200 kW: 415V, 3 Phase, 50 Hz solidly grounded system
Above 200 Kw to 2000 KW 6.6kV,3 Phase, 50 Hz resistance grounded system
Above 2000 KW 11 KV, 3 Phase, 50 Hz resistance grounded system

Continuous duty 415 V motors rated 110 KW and above will be controlled by breakers. 415 V Motors rated less than 110 KW will be controlled by fuse and contactors. HT Motors will be controlled by either Vacuum Circuit Breakers or Vacuum Contactors. HT motors of Coal handling system will be controlled by fuse and vacuum contractors considering frequent starting.

System Neutral Grounding
Generator Neutral Grounding: Through Neutral Grounding Transformer.
765/400/200 KV System Grounding: Effective/ solid grounding.
11 KV & 6.6 KV System Grounding: Resistance grounding
415 V System Grounding: Effective/ solid grounding

5.3.2 Rating of Major Equipment

Generator

The generator coupled with steam turbine will have the following salient technical features:
Type : Synchronous generator
Rated capacity : 1176 MVA, 1000 MW
Stator cooling : By Hydrogen / water
Rotor cooling : By Hydrogen
Rated power factor : 0.85 lag
Rated Terminal Voltage: 27 kV or manufacturer's standard
Insulation class : F (Temperature rise limited to class 'B')
Rated Frequency : 50 Hz
Frequency variation range: -5% to +3%
No. of phase : 3
Rated Speed : 3000 rpm

Generator shall conform to IEC-34. Latest CEA guidelines for supercritical thermal power plants.

Short circuit ratio shall not be less than 0.5.

Generator shall be capable of operating continuously on an unbalanced system in such a way that, with none of the phase currents exceeding the rated current, the ratio of the negative-sequence component of current (I2) to the rated current (In) does not exceed the values specified in IEC 60034-1 and under fault conditions shall be capable of operation with the product (I2/In)² and time (t) not exceeding the values in IEC 60034-1.

The withstand capability of generator for 3 phase short circuit at the generator terminals when operating at rated MVA and p.f. with 5% over voltage will be for a period of not less than 3 seconds.

The generator shall be capable of delivering at least two thirds of the rated output with one gas cooler out of service.

Line charging capability (MVAR) of generator will be not be less than 40% rated MVA at zero PF leading.

The generator winding will be star connected and all the six leads of the generator phase and neutral side will be brought out of the stator frame for connection to bus duct.

The neutral of the generator will be earthed through distribution transformer and secondary resistor to limit the ground fault current to above 10 amps.
Surge diverters and protective capacitors will be provided near Generator to protect the insulation of the generators from surges, both from steepness of wave front and magnitude of surge level.

The generator will be provided with static excitation system consisting of Dual channel Digital AVR with Auto as well as Manual control.

The excitation system will have fast response time to meet the system requirement. The AVR (Automatic Voltage Regulator) shall maintain steady generator terminal voltage under variable load conditions and for parallel operation with the grid. Ceiling voltage for exciter will be > 150%.

AVR response time will be short so that it can control generator during system disturbances requiring rapid changes in excitation to maintain the system dynamic stability margins. The excitation response time shall be < 0.5 sec and response ratio shall be >2.

Excitation system will be provided with power system stabiliser for achieving dynamic stability under varying operating conditions.

The excitation system will have in-built protective as well as limiting devices so as to safeguard the generator and excitation system against all possible faults, troubles and mal-operation, if any.

The static thyristor excitation system will be equipped with features such as cross current compensation, volt/frequency ratio controller, slip stabilisation, rotor angle limiter, stator and rotor current limiter, follow-up circuits, field suppression gear.

The generator will be provided with seal oil system, Hydrogen cooling system, stator water cooling system (if applicable) and CO2 system for purging of hydrogen and fire protection system.

**Generator Transformer**

The generator transformer will be designed to deliver the total output of the generating unit into the system and will have the following salient technical features.

- **Type**: Oil filled, outdoor type
- **Voltage ratio**: 765 KV/Sqrt3 kV /27 kV (Generator Voltage)
- **Frequency**: 50 Hz
- **Vector group**: YNd11
- **Percentage impedance**: 14.5% approx.
- **Capacity**: 3 X 410 MVA
- **Cooling**: ODAF 100 % capacity)
- **Taps type**: On Load tap changer
- **Taps range**: +10 % to –10 % in steps of 1.25%

HV side shall be solidly grounded.

**Other Transformers, Bus duct and switchgear:**
• Unit Transformer and Unit Auxiliary Transformer: 50 MVA, 27/11.5 KV and 25 MVA, 11/6.9 KV respectively.
• Station Transformer- Three winding 100/50/50 MVA, 27/11.5/ 11.5 KV
• Auxiliary Transformers-11 or 6.6 KV/ 0.433 KV Dry type
• Bus ducts:
  Generator Bus duct- Isolated Phase Busduct (IPBD)
  11KV & 6.6 kV Bus duct- Segregated Phase Busduct (SPBD)
  LT Bus duct- Non Segregated Phase Busduct (NSPBD)
• 1 KV and 6.6 kV Vacuum Switchgear
• Motor Control Centre and Power Control Centre

Equipment for Hazardous Areas

Electrical equipment such as motors, push button stations, lighting fixtures, junction boxes etc. located in hazardous areas will be provided with increased safety or flameproof type enclosures as per relevant standards and area classification requirements.

5.3.3 Protective System

For protection of equipment against abnormal system conditions, adequate protective devices will be installed in the respective switchgears and/or control and relay panels.

A group of such protective devices may be necessary to protect the equipment under different abnormal conditions arising in the system. Each equipment shall be provided with a unit as well as backup protection.

Besides this, protection against lightning surges will be provided with lightning arresters at suitable locations for outdoor equipment over and above the shielding wires and lightning masts.

In any case, proper discrimination and selectivity shall be provided so as to isolate only the faulty elements, keeping the healthy part of the system in service. The protective relays shall be of numerical type.

The major electrical equipment will be provided as a minimum with the protections as listed below:

765kV Switchyard Protection

• Line Protection- Duplicate Distance Protection, non-switched schemeAuto reclose relay
• Fault Locator
• Backup over current and earth fault protection
• Redundant Bus bar Differential Protection

In addition to above, Lockout relays, trip circuit supervision relays, Local breaker backup Protection will be provided.

**Generator Protection**
- Differential protection - generator winding
- Over voltage protection
- Stator earth fault protection
- Reverse power protection
- Negative phase sequence current protection
- Field failure protection
- Rotor earth fault protection
- Generator overload protection
- Overall differential protection for generator and generator transformer
- Generator under frequency protection
- Local breaker back-up protection
- Diode failure relay.
- Backup Impedance Protection
- Low forward Power protection
- Pole slipping protection
- Winding temperature protection
- Standby stator earth fault protection
- Loss of field protection
- VT fuse failure protection
- Inter turn fault protection

**Generator Transformer**
- Transformer Differential protection
- HV restricted earth fault protection
- HV backup overcurrent protection
- HV backup earth fault protection
• Buchholz protection
• Oil/winding temperature protection
• Over fluxing protection
• Pressure Relief Valve
• LBB protection
• Oil surge protection

**LT transformers**

• Over current protection (IDMTL & instantaneous)
• Earth fault Protection
• LV side Backup Earth fault protection
• Buchholtz protection
• Oil/winding temperature protection

**Unit Transformers**

• Differential protection
• Restricted Earth Fault protection for LV winding
• Over current protection on HV side & LV side
• Backup Earth fault protection
• Buchholtz protection
• Oil/winding temperature protection
• Pressure Relief valve
• OLTC surge relay protection.

**Station Transformers**

• Differential protection
• Restricted Earth Fault protection for HV & LV winding
• Over current and earth fault protection
• Backup Earth fault protection for HV & LV side
• Buchholtz protection
• Oil/winding temperature protection
• Pressure Relief valve
• OLTC surge relay protection.

11KV & 6.6 kV Motors

• Multifunction Numerical motor protection relay having flexibility to accommodate following protections:
  • Differential protection (for motors rated 1000 kW and above)
  • Thermal overload protection
  • Instantaneous overcurrent and definite time - overcurrent protection
  • Earth fault protection
  • Single phase and phase unbalance protection
  • R.T.Ds. for winding/bearing temperature protection (for motors rated 1000 kW and above)
  • Locked rotor Protection

5.3.4 Grounding and Lightning Protection

The plant grounding system will be designed as per the requirements of IEEE-80/IEEE 665/IS-3043. The earth mat of the station will be designed such that the total ground impedance does not exceed 1.0 ohm. The plant grounding will utilise Mild Steel Rods. Equipment grounding conductor will be of galvanised steel flats/GI wire.

Each large structure and building complex will have a ground loop around its perimeter. The ground loops around each structure will be connected to the ground grid.

The fence within the ground grid will be bonded to the plant ground system. The power plant ground grid shall be tied together with the switchyard ground grid.

The grounding system will be connected to all metallic equipment, electrical as well as non-electrical (except underground pipelines), located at the plant site. All these shall be connected at two distinct points. This shall include all structures, buildings, towers, etc.

The chimney and powerhouse building will be equipped with lightning protection. Lightning protection conductors located on the top of the structures will be connected to the ground loop surrounding the structures with down comers as per the provisions contained in the latest issues of Indian Electricity Rules and IS 2309.

5.3.5 765 kV Switchyard
Power evacuation shall be through 765 KV Switchyard. All the Generators shall be connected to 765 kV Switchyard through Generator Transformer. The switchyard will be provided with the feeders as described earlier. The switchyard will be of outdoor air insulated or indoor Gas Insulated type.

The switchyard will be provided with necessary current transformer, capacitor voltage transformers, surge arrestors, protective relays etc.

The control, monitoring and operation of the switchyard will be through SAS (Substation Automation System) in the Switchyard Control Room. Sequential Event Recorder (SER), which is a part of SAS will be provided with analog and digital signals. These signals as a minimum will contain status of all protective relays, lock out relay and breaker auxiliary contacts. These signals will be hardwired to SER cabinet.

The salient technical features of the switchyard are as follows:

The switchyard shall be designed considering the following parameters.

- Nominal System Voltage : 765 KV
- Highest System Voltage : 800 KV
- Rated frequency : 50Hz
- No. of Pole : 03
- Design ambient temperature : 50° C
- Lightning impulse withstand voltage : 2100 KVP
- Switching impulse withstand voltage : 1550KVP
- Power frequency withstand voltage : 830KV
- Short time current and duration : 50KA for 1 sec.
- Dynamic rating : 125KVP
- Corona extinction voltage : 320KV
- Phase to phase clearances : 7600 mm (min.)
- Phase to earth clearances : 4900 mm (min.)
- Live part to Ground : 15000mm (min.)
- Section clearance : 10300mm (min.)
- Creepage distance : 31mm/KV
- System neutral earthing : Effectively earthed

The salient technical features of major switchyard equipments are as follows:

**Circuit Breaker**

- Type / Application : SF6 Gas Puffer type, electrically trip free, outdoor type
- Number of pole : 3 nos., single pole
Nominal / highest system voltage: -765/800KV
Rated Current: Corresponding to rated Voltage
Operation duty: 0-0.3 Sec-CO-3 min-CO
First pole to clear factor: 1.3
Total break time (Max.): 45 msec.
Max. allowable switching overvoltage under any switching conditioning: Not more than 2.3 p.u.
Type of operating mechanism: Spring Operated
No. of trip coils per pole: 2 nos.

**Disconnected**

Type / Application: Knee break type.
Mounting: Horizontal, Upright
No. of phases: 3
Nominal / highest system voltage: 765/800 KV
Rated Current: Corresponding to rated Voltage
Type of operating mechanism: Motor operated
Operating mechanism voltage: 3 Phase 415V / 1 Phase 240V
Control Supply: 220V DC

**Current Transformer**

Type / Application: Oil filled, outdoor type, hermetically sealed
Nominal / highest system voltage: 765/800 KV
Type of insulation: Oil immersed Class A
Accuracy Class for tariff metering: 0.2S
Accuracy Class for other metering: 0.5
Accuracy class for protection: 5P20/PS

**Voltage Transformer**

Type / Application: Oil filled, outdoor type, hermetically sealed
Nominal / highest system voltage : 765/800 KV  
Type of insulation : Oil immersed Class A  
Capacitance : 8800 / 4400 pf  
Accuracy Class for tariff metering : 0.2  
Accuracy Class for other metering : 0.5  
Accuracy class for protection : 3P

**Lightning Arrestor**

Type : Outdoor type  
Nominal / highest system voltage : 765/800 KV  
Rated arrester voltage : 624KV  
Nominal discharge current : 20 kA of 8/20 microsecond wave  
Minimum discharge capability : 8KJ/KV  
Long duration discharge : 3 & 4  
Pressure relief class : A

Sub Station Automation (SAS) System

The SAS shall comprise full station and bay Control, monitoring and communication functions and shall provide all functions required for the safe and reliable operation of the Substation. SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence. The SAS shall conform to IEC 61850 standards. The SAS layout shall be structured in station level and bay level.

All the systems comprising the SAS shall be state-of-the-art, based on latest industry standards, suitable for operation under electrical conditions present in the EHV substations, follow the latest engineering practice, ensure long term compatibility requirements and continuity of equipment supply and safety of the operating staff.

The guaranteed annual system availability shall be not less than 99.9 percent. To ensure availability, adequate redundancy in system design shall be provided at hardware and software level. Required redundancy shall also be provided at CPU, Power supplies, communication channels, network and nodes

Control aspects

a) The entire station shall be controlled and supervised from HMI. Clear control priorities shall prevent the operation of a single equipment which can be initiated at the same time from more than one of the various control levels. The priority shall always be on the lowest enabled control level.
b) Generator transformer breaker will be synchronized from Generator control/relay panel located in the Main plant control room. Further for emergency tripping of these breakers, hard wired facilities shall be provided in Main plant control room.

c) Tie circuit breaker in Generator transformer diameter shall be controlled from both Generator control panel and SAS / BCU for same diameter. Selection for Tie circuit breaker control shall be provided in the Relay panel of the feeder.

d) For Circuit breakers, Local operation shall be carried out from CB operating box, for which Local/remote selector switch located in the CB operating box shall be selected in local. This operation is envisaged only for maintenance and testing of circuit breaker.

e) For Isolators, Local operation shall be carried out from Isolator operating box, for which Local/remote selector switch located in the Isolator operating box shall be selected in local. This operation is envisaged only for maintenance and testing of Isolator.

5.3.6 Balance electrical systems - These shall cover:

- Power and Control Cables
- Illumination System
- Normal A.C. Lighting of the Plant
- Emergency AC Lighting
- Emergency DC Lighting
- Plant Communication
- Station DC System
- Uninterruptible Power Supply System
- Emergency DG Set
- Cable Installation System
- Miscellaneous Motors

5.4 CONTROL & INSTRUMENTATION SYSTEMS

5.4.1 Design Philosophy:

Objective

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.

Design Philosophy
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 Monitoring and Information System (DDCMIS) also referred as Distributed Control System (DCS) of internationally launched latest proven technology.

The state of the art control and instrumentation system will relieve the operator from continuous surveillance, minimize operator interventions and will take pre planned actions required in case of process drift or if unsafe trends or conditions develop in any regime of operation. The system will 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 DDCMIS will provide a comprehensive integrated control and monitoring system to operate, control and monitor the Steam Generator & auxiliaries, Steam Turbine-Generator & auxiliaries and power cycle equipment and auxiliaries including PLC based Balance Of Plant (BOP) systems with a hierarchically and functionally distributed structure.

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.

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 monitor, keyboard/Mouse and also through Large Video Screen (LVS).

The main plant including Steam Generator and its auxiliaries, Steam Turbine Generator and its auxiliaries and power cycle equipment’s and auxiliaries etc. will be controlled and monitored through DDCMIS.

DDCMIS will include the modulating controls of the plant including Co-ordinated Master control, Steam Generator modulating controls, Turbine governing and other Turbine modulating controls, and modulating controls for power cycle equipment’s.

All open loop control functions for the main plant including Steam Generator and the Steam Turbine Generator and their auxiliaries along with power cycle equipment and systems will be implemented in the DDCMIS so that centralized drive operation for the main plant and auxiliaries is possible. DDCMIS will also include sequential start up, shutdown of the plant including Steam Generator, Turbine Generator and power cycle Equipment and Systems.

The control functions will be backed up by protection, interlocks and safety functions. This would cause pre-planned 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 Coal handling, Ash handling, DM Plant, Fuel oil unloading and transfer, Condensate polishing unit, Flue Gas Desulphurisation, etc. will be controlled and monitored through the dedicated operator interface units in the central control room. These packages will have independent and stand-alone PLCs in hot redundant configuration, while the remaining BOP plant packages will have non redundant PLC based systems. All the PLC based packages will be integrated by Ethernet at CCR. Additionally, all the BOP package systems will be provided with LED HMI Operator Interface Units (OIU) with printer in the Local control room. & also connected with dedicated Operator Interface Units (OIU) placed in Main Control Room for monitoring of BOP packages.

Operation and Monitoring of Plant Electrical and downstream System will be performed through DDCMIS. Additionally, DDCMIS will have a redundant Software link with SCADA System for monitoring of switchyard system.

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 diagnostic of fault and remedial action.

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

### 5.4.2 Major Control & Instrumentation System

The major components of Control and Instrumentation system of the unit will comprise of the following:

- Distributed Digital Control Monitoring and Information System (DDCMIS) with plant wide data Highway.
- Steam Generator Control and Protection System configured within the DDCMIS or as per Manufacturer’s standard design interfacing with the DDCMIS.
- Steam Turbine Generator Control and Protection System configured within the DDCMIS or as per STG Manufacturer’s standard design interfacing with the DDCMIS.
- Turbine Supervisory Instrumentation system for STG.
- Vibration monitoring & Analysis system for major plant auxiliaries.
- Operation, monitoring and control of electrical systems.
- Master and Slave Clock System.
- Central Control Room, Unit Control Desk
- Measuring Instruments & flow elements.
- Steam and Water Analysis System (SWAS) and chemical dosing system.
- BOP packaged control system.
- Continuous Emission monitoring instruments and all flue gas analyzers.
- Uninterruptible Power Supply and Distribution.
- Final Control Elements.
- Instrumentation & special cables.
- Maintenance and Calibration Instruments.
- Plant Performance Calculations System.
- Instruments Air Supply
- Erection Hardware and Special tools and tackles.
- Plant Closed Circuit Television System (CCTV).
- Performance Analysis Diagnosis & Optimization System (PADOS)

### 5.4.3 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.

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 Distributed Control System.

An Open Architecture based DDCMIS with Global Database and intelligent distributed configuration has been envisaged for the plant. Necessary interfaces between DDCMIS of all the units of the plant will be provided. It will be capable of handshaking with any third party system with standard protocol. The primary objective will be centralized monitoring, presentation & report of data for information and analysis of the entire plant. The main Data Highway will be high-speed dual redundant type with a bus speed of minimum 100 MB/Sec or higher. Communication link (Software/Hardware) will be provided for DDCMIS.

### 5.4.4 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).
- Steam Temperature
- Auxiliary pressure reducing and de-superheating station (APRDS) Control System.
• Mill / Pulveriser Control System
• Coal Feeder Control System
• Steam Generator Auxiliaries Controls
• Soot blower Control System
• Electromatic Relief Valve control, Furnace Temperature Probe control and other miscellaneous control.
• Air Heater Leakage Control System and Fire Detection System.
• Acoustic steam leak detection 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 protection system, implemented through TMR/Redundant controllers will accept plant protection input signals in a 2-o-o-3 (Two Out of Three), 1-o-o-2 (One Out of Two) or 1-o-o-1 (One out of One) selection configuration, depending on the measurement loop installation constraints and criticality requirements.

The boiler protection philosophy to be implemented is based on the respective required regulations. Alternatively, if proprietary Steam Generator control system by manufacturer is 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.

5.4.5 Steam Turbine Generator (STG) Control System:

The STG control and governing system is configured as a TMR/Redundant Control system, which allows for bump less control transfer from the one to the other channels in the event of a channel failure.

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, but particularly during start-up. The STG control system will typically include the following functional groups:

• Digital Electro hydraulic Governing Control System (DEHC)
• Automatic Turbine Run-Up System (ATRS)
• Automatic Turbine Testing System (ATT)
• Turbine Stress Evaluator (TSE)
• Turbine Protection System (TPS)
- Turbo-supervisory Instrumentation (TSI)
- HP, LP Bypass Control System
- Generator Auxiliaries Control System

The turbine 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 shall be hardwired.

The system will be a fully electronic, fail safe multi-channel system. The protection system, implemented through redundant controllers will accept plant protection input signals in a 2-out-of-3, 1-out-of-2 selection configuration, depending on the measurement loop installation constraints and criticality requirements.

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-out-of-3 voting signal which trips the turbine directly.

The turbine protection philosophy to be implemented is based on the respective required regulations. Alternatively, if proprietary STG control system by manufacturer is 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.

5.4.6 BOP Package Control System:

Balance of plant packages shall be PLC/DCS based and these shall be integrated by Ethernet at the Central control room for centralised operation, control and monitoring. Additional operator interface unit with printer shall also be provided in the local control room for each of these plant packages. These packages include:

- Coal handling plant
- Ash handling plant
- Water treatment including DM plant
- Fuel oil unloading and transfer
- Air Compressors
- HVAC
- Fire detection and protection systems.
- Condenser on line tube cleaning system.
- Vibration monitoring system.
- Condensate polishing system.
- Waste water treatment plant (ETP,STP)

Information from other stand-alone systems shall be made available to DDCMIS of each unit through hardwired signal exchange, if required. The control, interlock, protection and start/stop operation for the Off Site package like DM Water Plant, Coal Handling Plant, Ash Handling Plant, Condensate polishing unit, Fuel oil unloading and storage will have dual redundant PLC based control system. For non-critical BOP packages non-redundant PLC based system is envisaged. The entire PLC based package systems will be integrated by Ethernet at the central control room. Dedicated BOP OIU's in the CCR will be provided for monitoring of these packages.

For redundant PLC based BOP packages, redundant CPU, memory, power supply and communication modules will be provided. For all the BOP packages OIU at the local control room will be provided along with printer for alarm monitoring.

5.4.7 Turbine Supervisory Instrumentation System & Vibration Monitoring System:

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.

PC based vibration monitoring system 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 including analysis of the Generator Overhang for data acquisition and predictive maintenance of machinery/equipment. The vibration monitoring system will be provided with necessary interfaces with DDCMIS for centralized monitoring purpose.

5.4.8 Vibration Monitoring & Analysis System for Major Plant Auxiliaries:

The Vibration Monitoring & Analysis System will be provided for all critical equipment including ID Fans, FD Fans, PA Fans, CEP, Boiler Feed Pumps, 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 & Analysis system will be provided with necessary interfaces with DDCMIS for centralized monitoring purpose.

5.4.9 Central Control Room:

One common Central Control Room and electronic equipment room is envisaged for all units of the plant. The control room will be designed keeping in mind the ergonomics and overall aesthetics of the operating floor of the plant.

5.4.10 Central Control Room Equipment:
The Central Control room will accommodate the following equipment.

a. Unit Control Desk (UCD) and printers in the central control room.

b. DDCMIS system cabinets and electrical relay cabinets and other systems panels (as required) in the Control Equipment room.

c. Shift charge Engineer’s monitor with key board and printers in Shift Charge Engineer’s room.

d. System Maintenance Engineer’s monitor with key board along with the printer in System Maintenance engineer’s equipment room.

e. Uninterrupted Power Supply System (UPS) in UPS room.

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

g. Large Video Screens for respective units.

h. Furnace Flame T.V

i. Alarm Annunciator

5.4.11 Unit Control Desks/

Unit Control Desk:

The unit control desk (UCD) will house OIUs, including Monitor, Keyboard, and Mouse. The UCD will also house Telephone Hand set for communications. The unit, functional group or drive level control and operation of all main plant equipment including non-synchronising breakers of 415V, 6.6 KV and 11 KV system will be done from the Operator interface units (OIUs).

5.4.12 Master & Slave Clock System:

Master and Slave Clock System in redundant configuration would be provided in order to maintain uniform timing throughout for the various plant facilities and also for time synchronization between various digital systems including DDCMIS, and other PLC Based Systems for all units of the plant.

The system will include two master clocks in 100% redundant configuration (one working and the other stand by) 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.
5.4.13 Plant 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.

5.4.14 Steam 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 Specific Conductivity, Cation Conductivity, pH, Hydrazine, Dissolved Oxygen, Silica, Sodium and Phosphate will be provided.

SWAS will consist of Sample Conditioning Panel (Wet Panel) and Analyzers Panel (Dry Panel) located in air-conditioned SWAS room.

Various steam samples with primary coolers and water samples would be routed to a centralised place and cooled to the required temperature before entering analysers / cells. Sample Conditioning Panel will contain sample filtering, secondary sample cooling and temperature control, pressure reduction and control, flow rate control, necessary instruments required for sample conditioning and monitoring. Primary sample coolers and high-pressure reduction units will be located in field. Provision of grab samples will be provided in Sample Conditioning Panel.

The analysers shall be located in a separate Dry panel near the sampling rack in an air-conditioned environment. The Analyzer Panel will consist of process analyzers, monitors and annunciators. Analyzer panel will have alarms for local annunciation with provision for repeat alarms in Central Control Room. The signal from the analyzers will be hooked up with Plant main DDCMIS.

Both the sample rack and analysers are located in a central place with the analyser panel section partitioned for air-conditioning. The SWAS room will be suitably located in the Main Plant Building.

5.4.15 Continuous 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 analyser Instruments:

a) Oxides of Nitrogen NOx
b) Sulphur Dioxide SO2,
c) Carbon Monoxide CO
d) Stack Opacity Monitor.
E) H2O

CEMS will be complete with flue gas sample extraction and conditioning and analysing system. Hardwired connection be provided to hook up the Emission Monitoring System to the Plant DDCMIS.
5.4.16 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.

5.4.17 Field Measuring Instruments:

All field transmitters are envisaged to be smart type having 4-20 mA DC signal output with 100:1 turndown ratio and with superimposed digital signal conforming to HART. Portable digital calibrator/HART communicator is envisaged for on line calibration of the transmitters. Accuracy of process transmitters is envisaged as 0.035%.

All temperature elements (RTD/Thermocouple) will be duplex type. Thermocouple will be mineral insulated type.

Measurement of steam flow, 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. Aerofoil / Ventury type sensors will be used for Combustion Air flow measurements. Orifice Plate will be used for all other flow measurements.

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.

5.4.18 Smart Transmitter Maintenance Station:

Dedicated standalone PC based Smart Transmitter Maintenance Station (STMS) also called HART maintenance station, 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.

5.4.19 Uninterrupted Power Supply (UPS) & Distribution:

An uninterrupted power supply (UPS) system would be provided to cater to single phase, 50 Hz, 2 wire power supply requirements of instrumentation and control systems viz. man-machine interface equipment, analysers, instruments mounted on the unit control panel and other independent systems. For all system cabinets and operation hardware 24 V DC battery systems shall be envisaged. Any other voltages required shall be derived from the UPS source.

UPS system in redundant configuration will comprise of 2x100% redundant inverters of IGBT based, 2x100% redundant chargers, one battery set, static switches, bypass transformer and voltage stabiliser, manual bypass switches and AC distribution board etc.
One maintenance free Lead–Acid / Nickel Cadmium type battery set will be provided. The battery will be rated for a minimum period of one hour considering design margin of 15% and aging factor of 1.25. Each battery charger will be completely automatic and self-regulating type with quick boost and trickle charging capability. Boost charging unit will be rated such that the completely discharged battery can be fully charged in 10 hours.

A stand by AC Power Source with bypass transformer and static voltage stabiliser unit with manual bypass switch will be provided as a back up to the inverters. Status monitoring facility of the UPS will be provided in the DDCMIS by hardwire connectivity.

5.4.20 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 will be operated by electric/hydraulic actuating mechanisms. Control valves will have wide range of controllability, less noise and have adequate fail-safe feature.

Smart Positioners will be provided for pneumatically operated final control elements to interface with the DDCMIS. Each final control element will be provided with Smart positioners, 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.

5.4.21 Instrument & Special Cables:

Individual / pair shielded and overall shielded twisted pair colour coded copper cables would be used for analog signals and overall shielded cables would be used for digital signals. All these cables are armoured. All the insulation including overall sheath would be FRLS quality. 1.5 sq. mm copper control cables shall be used for binary signals, and 2.5 sq. mm copper control cable would be used for cabling for services like field solenoid valve to the control system. 1.0 sq. mm instrument cables shall be used for analogue signals. Compensating cables will be provided for connecting the thermocouple inputs to the measurement system of DDCMIS. 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 / twisted pair cable.

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, CRTs, LVS, printers and operator stations and other related equipment.
5.4.22 Maintenance & Calibration Instrument: (Instrument Laboratory)

One set of Maintenance and Calibration Equipment for instrumentation and control systems, common for all 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.

5.4.23 Instruments Air Supply

I&C Systems will be supplied with adequate Instrument air supply from compressor, Air dryer Assembly. Moisture and oil free Instrument air at 6 Kg/cm² and minus (-) 40°C dew point will be used.

5.4.24 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.

5.5 CIVIL WORKS:

5.5.1 Soil Properties and Load Bearing Capabilities:

Detailed Soil Investigation studies would be conducted at site and kind of foundation would be decided in the due course based on local soil strata.

Seismic Considerations

The power station is located under Zone- V as per IS: 1893 (part-I):2002 Analysis and design of structures to resist the seismic forces will be carried out as per the provisions of IS: 1893. The applicable importance factor of 1.50 will be considered during detailed engineering.

Wind Loading

The applicable design wind pressure will be computed during design of buildings and structures as per IS:875-18:802 for the zone in which the proposed power station is located. Design wind speed to be considered as 50 m/sec. The applicable design wind pressure, appropriate coefficients for variation with heights and shape of structures will be considered.
5.5.2 Power House Building Superstructure:

The main power plant building comprising TG bay (A-B bay) and the adjacent electrical & deaerator bay (B-C bay) will be of steel framed construction up to the roof level. The floor slabs at intermediate levels will be of RCC and supported on steel beams & columns. The TG bay roof (A-B bay) and side cladding will be provided with 0.5 mm pre-colour coated PVF-2 galvalum high strength single skin metallic cladding. The deaerator bay (B-C bay) will have side cladding of brickwork (cement plastered with architectural finishes); B-row and C-row duly painted. Floor slabs and roof covering of B-C bay will be of cast in situ RCC construction. A-B bay will be equipped with EOT cranes. B, C, D raw wall will be of bricks.

Roof will be provided with suitable drainage arrangement through rainwater down corners. doors, windows and rolling shutters will be provided.

All structural components will be shop welded while the field connections will be made with high-tensile bolts or welding as determined in design stage. The transverse frames will be of framed type. In the longitudinal direction, these transverse frames will be braced to resist horizontal forces.

5.5.3 Special Foundation Requirements for Rotating Equipment:

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 a static analysis, a dynamic analysis will be performed to determine the fundamental frequencies of the foundation system. To preclude resonance, the fundamental frequency of the foundation will be 25 percent away from the operational frequency of the equipment. The dynamic behaviour of the foundation will meet the requirements of IS: 2974 (Part I to IV) -Code of Practice for Design and Construction of Machine Foundations.

All rotating equipment will be provided with foundation isolated with adjacent foundations. The vibration isolation foundation system will be provided for, Turbine driven Boiler feed pumps, and Coal crushers.

The vibration isolation system will be capable of vibration isolation not less than 95%.

If minor equipment are to be supported on building structures, floors etc. suitable vibration isolation will be provided.

Civil foundations will be designed to take into consideration soil bearing capacity and ground water table. Generally raft/spread foundations will be considered.

The minimum grades of concrete will be in accordance with appropriate class of exposure as per IS - 456 - 2000. Concrete grade for various works will be –

- M35 for decks of spring supported machine foundations and substructure.
- M30 Mechanical Foundation chimney shell and substructure of spring supported machine foundation.
• M25 structural RCC work in foundations and superstructures, water retaining structures and chimney raft foundation.

• M20 Grade slab & other miscellaneous items

M10 : Sub-grade filling, mud-mat etc (depending upon the aggressiveness of foundation soil)

IS:875 code is referred to for considering all the required provisions. Brickwork in cement mortar 1:4/1:6 will be used for plant buildings as applicable. Ductile detailing of RCC structures will be as per IS: 13920.

Foundations of all major equipment with vibrating load such as fans (ID, FD, PA, coal mills and coal crusher etc. will be spring supported deck type with supporting framed structure of RCC. Equipment foundation will be separated from adjoining part of building and other foundations joints at floor/slab will be suitably sealed.

All building will be provided with 1500 mm wide and 150 mm thick plain cement concrete paving around on the outside. The plinth protection will be laid over prepared sub-base and base.

Steel doors, windows, rolling shutters will be provided with glazing as required. The roads in the plant area will be of adequate thickness and width as per requirement of different areas. It is proposed to have water-bound macadam roads during construction stage and the same will be finished with asphalt surfacing during completion stage. Adequate plant roads/curverts, grading and drainage will be provided. All roads will be designed & provided as per applicable IRC standards.

5.5.4 Structural Steel Works:

Structural works will be designed for dead-load plus adequate live-load plus worse of wind load and earthquake load with importance factor of 1.5 and seismic load as per IS 1893:2005 as applicable for zone-III.

Bunker bay will comprise of structural steel framework supporting the coal bunkers, feeder floor and tripper floor. The structural frame will be designed as a fixed joint frame in the transverse direction and braced frame in the longitudinal direction. 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 raft/spread foundations. Tripper bay and conveyor galleries will be provided with colour coated sheet cladding.

Stairs, platforms and galleries will be of minimum 900 mm width complete with handrails, toe-plate and curbing as required. Stair treads will be of 250 mm with 150/190 mm height between successive treads.

RCC foundations for Turbo-generators, Boiler feed pumps, (as required) ID/FD/PA fans, coal mills and coal crushers will be provided with vibration isolation systems.
supporting the top RCC deck to support the machine/equipment.

5.5.5 Water Retaining Structures:

RCC Water retaining structures will be leak proof and designed as un-cracked section. The design will conform to IS:3370. In all liquid retaining structures, PVC water bar will be provided at each construction/expansion joint.

RCC foundations of boiler columns and other miscellaneous equipment will be included. RCC grade slab covering the boiler area will be provided for Grade slab foundations will be provided for ESP columns, duct supports and miscellaneous minor equipment. ESP control room electrical room will be of flat RCC roof construction with brick walled construction.

5.5.6 Civil Works for Plant Water System:

1. Cooling Tower

Induced draft cooling tower for each unit to handle 116275 cu.m/hr water with leak proof underground basin and separation of whole basin in two parts by means of partition wall, internal platform arrangement, hot water duct system and CW channel etc. Suitable draining and pumping arrangement from the drain box outside is provided for sludge disposal. Cooling Tower will be RCC framed structure as per the requirement of BS:4485-1996 Part I to IV.

2. Pre-treatment plant & overhead tanks for potable water/ service water

Pre-treatment plant consists of required capacity clariflocculator along with Aerator, Filtered water reservoir, firewater sump, and pump houses, sludge deposition tanks etc. The design and construction of all these structure shall be based on IS:3370 part I to IV along with the provision of specified leak proof arrangement of structures.

5.5.7 Civil Works for Coal Handling Area:

Crusher House and Stacker Reclaimer will be constructed. Conveyors galleries, supporting trestles and transfer houses will be of fabricated structural steel work. All components will be of welded fabrication with bolted/welded joints for erection and assembly in the field. Intermediate floors and roof in transfer houses will be of reinforced concrete supported on structural steel framing. Crusher foundation with vibration isolation spring system for isolating the crusher house building will be of RCC frame. Conveyor tunnels will be of concrete box section with provision of appropriate water proofing arrangement.

5.5.8 Civil Works for Ash Handling Plant:

The Ash collector & store system will be of RCC construction with RCC columns and beams. The ash hopper will be compartmentalized lined with abrasion resistant liners. Provision for suitable steel inserts will be made for installation of the pipes, valves etc. The facilities will have the provision for travelling crane of adequate capacity and lift. The blower/compressor room will be separate RCC construction in flat roof.
construction located close to ESPs to accommodate the blowers/ compressors with its auxiliaries.

Pipe rack for conveying the ash and water pipes to silos will be of structural steel framed construction having its columns mounted on the RCC foundations. Foundation for collection tank, pipe rust structures and foundation for conveying system to silos and provision of installing composed air system will be provided.

5.5.9 Civil works for Waste Water Management:

As a part of waste water system management, adequately sized settling sump, oil water separator; settling pond; waste treatment plant sumps will be provided in RCC construction lined inside with suitable materials. Plant drainage system will be designed as per the area drainage pattern. The surface run off the power plant area and also the process water taken out buildings are taken to natural drainage system through a designed storm water drains through open drains, pipes.

Plant rainwater drainage will be connected to the nearby existing natural drainage system.
For the main power plant building one no. with sufficient capacity of sewage treatment plant will be located in the vicinity and for other miscellaneous buildings indigenous septic tank and soak pit will be provided.

All the waste water from powerhouse building, boiler building chemical house etc. are taken to a common medium basin where water is separated from oil and other chemical in WWTP and necessary civil work like Lamellar clarifier, dry and wet sand pit etc. will be constructed as per IS:456 - 2002 and IS:3370 part I to IV.

5.5.10 Civil works for Switchyard:

Civil work for switchyard will consists of tower foundations, equipment foundations, foundations for lighting mass towers, control room building and cable trenches, roads drains and link fencing.

5.5.11 Civil works for Chimney:

One (1) no. Three-flue RCC chimney having flues of steel with insulation (insulated outside the flue) will be provided. The height of the chimney as per CPCB will be 275 M. The chimney will be fitted with 500 kg capacity elevator, staircase inside the windshield of RCC slip form construction. Chimney will be fitted with pollution measuring apparatus & warning lights at top.

Chimney will be provided with lightning arrester, aviation warning lights as per statutory requirement. The outside of the chimney shell will be painted with acid resistant cement paint. The top of the chimney shell will be painted with alternate red and white bands conforming to Aviation safety Standard requirement.
SECTION: 6

PROJECT IMPLEMENTATION
6.0 PROJECT IMPLEMENTION

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.

The Project is proposed to be executed under Multiple EPC Contracts.

6.1 Project Implementation Schedule:

The first Unit of 3x1000 MW project is proposed to go in to commercial operation in 48 months from "Zero date" and for subsequent unit with a gap of 6 months. ‘Zero date’ is date of award of main plant equipment / Financial closure.

6.2 Project Management:

The major phases of the project during its implementation are classified under the following heads:

1) Planning & Contract Packaging
2) Design, Engineering, Tendering & Contract award
3) Manufacturing, Inspection and Expediting Phase
4) Transportation/ Handling of Equipment
5) Construction/Erection and Testing/Commissioning
6) Operation & Maintenance and Manpower Training & Placement.

The Project will be managed by the Project Company under the overall direction and control of its Director. Full-time project management responsibility shall vest in the Vice President of the Project Company. The Project Company's site establishment shall be headed by a Construction Manager who shall be responsible for all site works.

6.3 Planning Phase:

6.3.1 Contract Packaging

The Company intends to implement the project through a Multiple EPC (Engineering, Procurement & Construction) Contract. The EPC contract will cover complete mechanical, electrical, instrumentation and associated civil works including site development and approach roads but excluding colony.

APL shall carry out pre-EPC preparatory works such as carrying out feasibility studies for construction water, construction power and arranging the same upto single point of plant boundary, carrying out soil investigation etc. APL shall develop its own site office & necessary facilities for proper monitoring & execution of project in scheduled time.
Indicative scope of the packages envisaged is as below:

**EPC Package:**

EPC Package 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, HT/LT Switchgear also like Coal Handling System, Ash Handling System, DM Plant, CW/ACW System including Cooling Tower, Fire Protection System, Instrument & Process air system, Cranes & hoist, 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, civil works for off-shore structures, etc.

EPC Contractor will establish a comprehensive reporting structure, which broadly includes:

- Management Reports – Progress Reports Daily and Monthly including Three month look ahead Planning, 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 APL through separate contractors / suppliers. This will include procurement of standard tools, mobile equipment, fire tender and construction of residential colony.

**6.3.2 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 EPC Contractors and Implementation Consultant. The date of Notice-to-Proceed of the EPC contract will be the zero date of the Master Network.

**6.3.3 Engineering Consultant:**

The Engineering Consultant would undertake the various tasks related to the engineering, design. 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 EPC Contractors would be reviewed and checked/ approved by the 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

6.4 Tendering, Contracts & Engineering Phase:

6.4.1 Engineering, Planning, Monitoring & Control:

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 accordingly 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 Company Project Coordinators to evaluate the work actually performed vis-à-vis detailed schedules Milestones on a predefined frequency. Corrective action will be identified and the plans updated.

6.4.2 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 would be finalized and monitored vigorously.

When the EPC Contract is awarded, detailed programme in the form of networks is tied up with the EPC contractor to clearly indicate the owner's obligation and the EPC Contractor's responsibilities. The owner's inputs in terms of land availability, construction power/water availability, civil fronts etc. while that of the EPC contractor's in terms of drawing submission, manufacture, supply, transportation, erection and commissioning is clearly brought out in the program. Monthly progress reports including S curve are generated for monitoring & tracking purposes.

6.5 Manufacturing, Inspection & Expediting Phase:

6.5.1 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.
6.5.2 Quality Assurance:

An independent Quality Assurance Group for ensuring the quality during the project engineering, procurement and manufacturing, as well as during material storage is organized in the Corporate Office. Contractor would be asked to 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 the contract the QA dept. shall discusses with the prospective EPC contractors and finalize mutually acceptable inspection programme and detailed quality plans. In the post-contract stage, the inspection reports generated by the inspectors are reviewed to evaluate the quality status with respect to the specified levels and necessary coordination of all actions necessary to ensure the achievement of the required quality levels.

The quality plans after discussions and finalization with the Contractor will form a part of the contract.

6.6 Transportation / Handling of Equipment:

The proposed Site is at a distance of 3 Km from National Highway no 8A which is well connected with State Highway. The site is well connected by the National / State Highways, broad gauge rail link and is 25 km away from the Mundra sea port. The nearest airport is Bhuj Airport located at a distance of 55 kms from the project site. The nearest railway station is Adipur/Gandhidham, which is about 65 kms from project site and nearest town is Mundra which is about 20 kms from the project site. There are many heavy equipment to be transported to site, suitable road till site from National / State Highways as well as from nearest railway station, already developed.

The list of main equipment, which fall in the heavy category are Generator Stator, Generator Rotor and Generator Transformers, Deareator, HP Heater and Ceiling Girder.

Route survey will be conducted by the EPC contractor for planning and implementation of transportation of all major equipment/materials.

6.7 Construction & Commissioning Phase:

6.7.1 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 EPC Contract, L-2 networks would be finalized, keeping in view the interface events required to be realized. Based on the L-2 network the Execution Group would initiates securing of required drawings in sequence for continuous progress of works at site.
6.7.2 Project Review Team Meeting:

A project review team headed by Director 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 or a predefined frequency. The meetings will review both pre-award and post-award progress of EPC contract in line to the project Milestone of their package.

Interface problems among engineering, contracts and site affecting project execution are also reviewed and appropriate decisions taken to expedite the release of drawings, materials and such other requirements.

Budgetary review will also be carried out during this meeting and shortfall, if any, will be identified and responsibility would be fixed to ensure correction.
SECTION: 7

ENVIRONMENTAL ASPECTS
7.0 ENVIRONMENTAL ASPECTS

7.1 Environmental Aspects:

In the proposed project, water from Sea will be used in closed cycle circulating water system, wet lime based FGD system and sweet water needs will be met from RO system. Electrostatic precipitators of high efficiency and stack height as per CPCB norms etc. will limit the emission levels. As such, no undue problem is envisaged from installation of the power plant at said location from environmental aspect.

7.1.1 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 – 7.1

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of Pollution</th>
<th>Source of Pollution</th>
</tr>
</thead>
</table>
| 1.      | Air Pollution    | o Dust particulates from fly ash in flue gas  
|         |                  | o Sulphur dioxide in flue gas  
|         |                  | o Nitrogen oxides in flue gas  
|         |                  | o Coal dust particles during storage/ handling of coal  
|         |                  | o Dust in the ash disposal area |
| 2.      | Water & Sewage Pollution | o Waste water from water treatment (WT) plant  
|         |                  | o Steam generator blow down  
|         |                  | o Cooling tower blow down  
|         |                  | o Plant drains  
|         |                  | o Waste water from coal pile area run off |
| 3.      | Noise Pollution  | o Steam turbine generator  
|         |                  | o Other rotating equipment  
|         |                  | o Combustion induced noises  
|         |                  | o Flow induced noises  
|         |                  | o Steam 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 waste water:
• Low NOx burners along with Selective Catalytic Reactor (SCR) have been envisaged to reduce the NOx generation and consequent emission.

• High efficiency Electrostatic Precipitators has been envisaged to limit the particulate emissions to 30 mg/Nm3.

• One no. 275 mtr. height three-flue chimney is 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 makeup water requirement for the plant.

• The Plant will be designed to treat all waste water that generated from plant. The waste water will be discharged as per the prevailing environment norms.

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

• Adequate drift elimination system shall be provided on cooling towers to avoid the saline drift to the nearby areas.

7.1.2 Pollution Monitoring and Control Measures:

There are no ecologically sensitive or archaeologically important monuments in the area. Ministry of Environment and Forest (MoEF), have laid down procedures for environmental clearance for industrial projects including thermal power stations. The notification requires industry to carry out EIA study, in accordance with MoEF guidelines to determine the impact of new industry on the existing environment in respect of atmospheric and liquid pollutants and resultant air and water quality in the area to ensure their quality well within the prescribed limits. Separate EIA study would be carried out for the proposed project covering aforesaid issues.

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 waste water qualities within the acceptable limits specified by the Gujarat State Pollution Control Board and the Ministry of Environmental & Forests (MoEF).

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 discharge gases are maintained within the permissible limit. The main stack will be provided with portable monitors to periodically monitor the PM, CO, NOx and SO2 constituents in the flue gas on continuous basis.

The plant waste water will be periodically analyzed on a weekly basis so that the waste water is maintained within the permissible levels of the pollution control board regulations.
The pollution control measures proposed to be adopted for the project are summarized as follows:

### 7.1.2.1 Air Pollution:

High efficiency Electrostatic Precipitators (ESP) will be installed to control the emission of ash particles. The precipitators would be designed to limit the particulate emission to less than 30 mg/Nm³.

In order to meet the guidelines of State Pollution Control Board for SO₂ emission, wet lime based FGD along with one (1) no. three-flue 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 at Coal stockyard. Further in order to arrest the coal dust generation, all conveyors will be provided with enclosed galleries. 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. Green belt will be developed all around the plant periphery as per the norm laid down by MoEF to minimize dust nuisance outside the plant boundary.

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 30 mg/Nm³ to trap the dust in the bunkers.

Plant equipment design and operation will ensure SO₂ 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 NOx emissions from the SG 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 along with SCR will limit NOx below 100 mg/Nm³.

### 7.1.2.2 Ash Disposal:

#### Utilization

Fly ash generated from the proposed power plant will be commercially utilized, to the extent possible, in one or more of the following industries: (i) cement, (ii) brick, (iii) fly
ash. (iv) road making and paving, (v) agriculture, (vi) back filling and (vii) any other industry that is technically feasible. Apart from these uses, fly ash can be used for the construction of ash-pond dyke, reclamation of low-lying areas and such agricultural applications as soil conditioner and fertilizer.

The following strategies will be adopted to ensure full fly ash utilization in brick and cement block manufacturing:

I. Fly ash will be supplied free of charge at the silos to brick and cement block factories.
II. Basic technology, as well as initial expert advice for using fly ash in making bricks and cement blocks, will be provided to local brick and cement block makers free of charge.
III. Seminars and workshops will be organized at the expense of APL to create market awareness for fly ash bricks and cement blocks in large cities.
IV. The Gujarat state government will be requested to provide certain financial incentives, in line with those provided by some other states, to brick and cement block makers, and to ensure the use of fly ash building materials in public works projects to the fullest possible extent.
V. As the major constraint in spreading the adoption of fly ash building materials is the unreliability of fly ash supply to widely dispersed brick and cement block industries, the state government can be requested to provide valuable assistance by creating depots near large consumption centres under its auspices.

Bottom ash will also be utilized fully for construction of bunds in the nearby areas and around the plant area as a protection against water ingress, low lying filling area etc.

7.1.2.3 Noise Pollution:

Several noise suppression and attenuation features shall be designed into the plant for the protection of personnel at all normally accessible locations within the plant boundary, both inside and outside the different buildings, and for the protection of the inhabitants living in the vicinity of the power plant.

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 at a distance of 1 metre 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. Also, all measures will be taken to limit the noise levels at the plant boundary with in the stipulated limits.

To achieve the noise limitations around the equipment, the main measures taken shall be as follows:

- Each feed water pump sets shall be covered by a separate enclosure,
Each coal crusher shall be covered by a separate hood, Small units like condensate and vacuum pumps, shall be designed so as to limit noise emission, Bypass valve, the de-superheater and the relevant piping shall be covered with acoustic insulation. To achieve the noise limitations in the control room, the control equipment such as computers and its accessories (such as printers) and the air conditioning system shall be designed so as to limit noise emission. During maintenance/inspection works, the personnel will wear ear protections.

To achieve the far field noise limitations, the following main measures shall be taken, as appropriate for that purpose:

- Steam vent pipes shall be fitted with silencers,
- The steam generator thermal insulation shall be designed to limit noise emission,
- The steam generator draught fans, the electrostatic precipitators and the air heaters shall be designed to limit noise emission,
- The main transformers shall be designed to limit noise emission.

An Environmental Impact Assessment Study shall be carried out to access the noise level limits to be kept at the proposed plant boundary considering the back ground noise level.

7.1.2.4 Water Pollution:

Sea water is required for makeup to the closed cycle re-circulation system of condenser cooling. It is proposed to utilise the power plant waste water for plant reuse to achieve minimum discharge concept. It is envisaged to utilize cooling water blow down for ash handling purposes and treated waste water from various sources for gardening. Rest of the treated waste water treated and cooling tower blowdown will be sent to sea water outfall.

Streams of waste water emanating from the power station sources during operational phase will be treated individually based on the waste water quality. The treated waste water will be recycled for plant use and for green belt development. Therefore, there will be no impact on the ground water resources.

The major waste water generated from the plant like DM Plant discharge will be treated in a waste water treatment plant and recycled. Blow down water and treated water from CMB will be sent back to sea via outfall channel. The coal pile area run off 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 shall be discharged 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 run-off is directed on the ground by sheet flow, to well defined drainage paths leading to the ditches.

Treated effluent will be discharged to the sea through sea water outfall facility.

7.1.2.5 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 dyke through the existing infrastructure.

7.1.2.6 Afforestation and Green Belt Development:

The landscaping and ground cover system meant to enhance the appearance of selected areas, enhance soil and slope stabilization of the land of the power plant, and assist in reducing the noise level and fugitive dust generated by the plant.

Extensive afforestation at plant area is planned along with a green belt development program in line with MoEF guideline which would not only act as lung space in the area but would also improve aesthetics and will be continued in all available space. As per the stipulations of MoEF, green belt will be provided all around the power plant boundary by planting trees and the total green area including landscaping area will be 1/3rd of the plant area.

7.1.2.7 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 be displayed at appropriate points/locations.

7.1.2.8 Rehabilitation:
Identified land does not has any habitants hence project does not envisage any rehabilitation.

7.1.3 Rapid Environment Impact Assessment (REIA) Studies:

Environment Impact Assessment (EIA) studies will be carried out and base line data will be collected. 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.

7.1.4 Post Project Environmental Management Plan:

Air Environment:

The major source of air pollution is from combustion of coal, which results in release of SO₂, NOx and PM.

Prediction for SPM is made taking into consideration the design efficiency of the ESP. 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 PM, SO₂, 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. Wet lime FGD is to be installed to meet requirement of SOₓ emission norms.

SCR to be installed (if reqd.) for meeting the NOx emission norms.

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 neighbourhood is predicted to be negligible.

The turbine & generators will be provided with acoustic enclosures and housed in buildings that would considerably reduce the transmission of noise to the outside environment.

Noise levels will be periodically monitored and any corrective action taken.

**Water Environment:**

The common waste water treatment plant, which receives discharges from neutralization pit of DM Plant, clarified waste water from Oil Water Separator, etc will be designed to enable maximum re-use/recycling. The treated waste water will be utilised for plant consumptive requirements and for green belt development. Cooling tower blow down, RO reject and treated waste water will be discharged into the sea through sea water outfall.

7.1.5 **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 needs 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 would 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 and adequate care would be taken while designing the same.

Fuel oils (LDO/HSD) will be used in small quantity for initial start-up. Chlorine and other chemicals are used in the makeup water treatment & DM Plant. The hazards associated with the use of these materials would be taken careful consideration and due precaution would be taken for its 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:

- Recognising 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 makeup 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 that the emergency plans 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 firefighting 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 both 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.
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.
SECTION: 8

SYSTEM DESIGN AND O&M PHILOSOPHY
8.0 SYSTEM DESIGN AND O&M PHILOSOPHY:

8.1 Overall Requirement:

The station will be designed to operate primarily as a base load station. Design of the plant will provide for the following:

- Capability of rapid unloading from full load to no-load conditions in the minimum possible time to minimize turbine cooling.
- Capability to achieve full load within the shortest possible time after synchronization, subsequent to an overnight shutdown (8 hours).
- The main plant, auxiliaries and associated systems & controls will be designed to permit house load operation, without shutting down the Unit in the event of sudden loss of load demand due to tripping of transmission lines or other grid disturbances.
- 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:

- 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.
- Use of only proven design concepts and conservative designs.
- Strict implementation of quality assurance norms during design, manufacture as well as installation and commissioning stage.
- 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. In this regard, CEA regulations for construction of electrical plant & electrical lines shall be complied without any exception.
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:

- Low auxiliary power consumption.
- Low makeup water consumption.
- No oil support above 30% MCR operation with any combination of mills.
- 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 makeup water production and makeup 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 Data Acquisition System (DAS). 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 Monitoring Group of Corporate Office and monthly O&M review meetings.

8.3 Operation & Maintenance Philosophy:

In order to ensure a high level of performance of the power station, the operation and maintenance of the power station would be entrusted to experienced O&M Contractor.

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, the proposed O&M Contractor would also be consulted during the review of package vendors, plant design features, operational and maintenance features of plant systems and equipment.

8.3.1 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 would aim at maximising the availability of the generating Units while ensuring minimum maintenance cost and safety of plant & personnel. The system would cover organizational structures, preventive maintenance schedules, detailed work specifications covering all maintenance jobs, permit-to-work system, long term maintenance planning, safety aspects etc.
8.3.2 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.
- Development of indigenous sources/in-house capability for imported spare parts.
- Development of more than one source wherever applicable.

8.3.3 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.

8.3.4 O&M Training:

An experienced O&M contractor will be placed at an early stage to introduce the best system and operational management and practices. O&M contractor 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.

8.3.5 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.

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.

8.3.6 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:

Employees required for 3x1000 MW Units in addition to existing O&M staff is estimated to be around 250 nos. excluding contract labour.

8.4.2 In-Plant Facilities:

The following facilities already exist in this station:

i. Administrative Building and technical office
ii. Construction offices and stores (at construction stage only)
iii. Time and security offices
iv. First Aid and fire fighting station
v. Canteen and welfare centre
vi. Toilets and change rooms
vii. Car parks and cycle/ scooter stands
viii. 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:

Township/Residential colony is not part of this proposal.
SECTION: 9

PROJECT COST ESTIMATES AND FINANCIAL ANALYSIS
9 PROJECT COST ESTIMATES AND FINANCIAL ANALYSIS:

In this section project cost estimate has been worked out and fixed cost as well as variable cost of generation has been computed for the proposed project in order to assess overall financial viability of the project. For this purpose, a comprehensive financial model has been set up based on CERC guideline, representing a complete simulation of the Project with regard to technical and financial aspects.

9.1 Basis of Project Cost

The project cost estimate has been worked out on the following basis:

9.1.1 Assumptions for Hard Cost Input

The followings are key assumptions made while estimation of project cost.

- Total three (3) Units of 1000 MW capacity with 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 from the cost of similar kind of projects with ultra-super critical steam conditions.
- The cost of balance of plant equipment, auxiliaries and services has been estimated from in-house data for similar items of other ongoing domestic projects.
- The cost of general civil and architectural works of the plant has been estimated based on similar works of other ongoing domestic projects.
- Contingency @ 5.0% has been considered on the cost estimate for EPC and Non EPC works.
- Capital Investment for external coal transportation arrangement upto 1st in plant Junction Tower for Project has not been considered in the cost estimate.

9.1.2 Assumptions for Soft Cost Input

The major assumptions made to compute the soft cost are as follows:

- Financing - Debt: Equity - The project is considered to be financed by domestic equity and rupee term loan with 70:30 Debt Equity Ratio. The rate of interest of debt is considered as 11.50 %. No financing cost for Equity has been considered.
- Interest During Construction (IDC) - has been included in the Project Cost based on the phasing of the expenditure upto COD of 3rd Unit.
- Working Capital - The rate of interest on working capital loan is assumed to be 11.50% p.a.
• Taxes and Duties - Taxes and Duties as per prevailing law.
• Exchange Rate – As applicable.

9.2 Project Cost

On the basis of assumptions discussed above, the estimated costs of the project amount to Rs. 18,000 Crores. The summary of break-up of the project cost is indicated in Table 9.1 below.

Table – 9.1
Project Cost Break Up

<table>
<thead>
<tr>
<th>Particular</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Hard Cost</td>
<td>13100</td>
</tr>
<tr>
<td>Preliminary &amp; Pre-operative Expenditure</td>
<td>610</td>
</tr>
<tr>
<td>Financing Charges</td>
<td>120</td>
</tr>
<tr>
<td>Interest During Construction Period</td>
<td>2780</td>
</tr>
<tr>
<td>Contingency</td>
<td>870</td>
</tr>
<tr>
<td>Margin Money for WC</td>
<td>520</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>18000</strong></td>
</tr>
</tbody>
</table>

(all figure in Rs. Crores)

The Project cost is estimated at Rs. 18,000 Crores & is proposed to be finance with debt & equity in ratio of 70:30.

The proposed components of financing are:

<table>
<thead>
<tr>
<th>Particular</th>
<th>Rs Crores</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Contribution – Equity</td>
<td>5400</td>
<td>30</td>
</tr>
<tr>
<td>Debt Finance</td>
<td>12,600</td>
<td>70</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18,000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

9.3 Phasing of Expenditure
Date of Financial Closure has been considered as Zero Date. The quarterly expenditure for the Project cost including IDC has been spread for the Project Schedule of 60 months from Zero Date, considering the completion schedule of 48 months for the first Unit and within a gap of 6 months for subsequent units.

### 9.4 Cost of Generation & Tariff Calculation

The estimate for the cost of generation for the project has been arrived on the basis of following technical inputs and financial inputs.

#### 9.4.1 Technical Input Assumptions

Basic data for the purpose of estimation of operational expenses are as follows:

- Plant gross capacity - 3x1000 MW.
- Plant Load Factor (PLF) - 85%
- Station Heat Rate - 2062.5 Kcal/kWh
- Plant Auxiliary power consumption -@ 7.5% including FGD & SCR.
- The gross calorific value (GCV) of design coal - 4354 Kcal/Kg

#### 9.4.2 Financial Input Assumptions

The following are the financial assumption in Tariff calculation:

**Debt Structure**

The repayment period of the proposed loan structure has been shown in the Table-9.2 below. No moratorium period has been considered.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>RTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Rate</td>
<td>%</td>
<td>11.50%</td>
</tr>
<tr>
<td>Repayment Period</td>
<td>Years</td>
<td>20</td>
</tr>
<tr>
<td>Repayment Mode</td>
<td>Instalments</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

**Return on Equity**

ROE has been considered as 15.5% (as per CERC Norms).

**Working Capital**

Working Capital covers the following:

- Coal costs for 1 months
- Secondary fuel cost for 2 months
- O&M expenses for 1 month
- Maintenance spares, 20% of O&M expense

**O&M Expenses**

Annual fixed operation and maintenance cost has been considered as Rs. 1.87 million per MW of generation as first year of operation and escalated at the rate of 6.24% per annum as per CERC norms.

**Fuel Cost**

Imported coal is considered for the plant. Coal cost is considered as Rs. 3817 per Ton including the transportation cost. The escalation rate of 3% per annum is considered on the coal cost. Secondary fuel cost is considered as Rs. 34000 per KL with an escalation of 3% per annum.

**Depreciation**

5.28% using straight line method for first 12 years and 2.05% for balance 13 years as per CERC norms. The economic plant life has been taken as 25 years for depreciation calculation as per CERC norms.

**Taxes & Duties**

Taxes and duties shall be as applicable.

**9.4.3 Tariff Calculation**

In accordance with CERC guidelines
SECTION: 10

PERMITS AND CLEARANCES
10.0 PERMITS AND CLEARANCES

Certain permits and clearances are required to be obtained by APL from different Government and Statutory Agencies at various stages of development phase of the project. These are classified into two broad categories known as statutory and non-statutory clearances. The list of clearances/permits required for the project and their status is as under:

Table 10.1
Statutory Permits and Clearances

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Authority</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Registration of the Company</td>
<td>Not Required</td>
<td>Adani Power Ltd (APL) is already registered</td>
</tr>
<tr>
<td>2</td>
<td>Water availability</td>
<td>Maritime Board</td>
<td>Sea water required for 3x1000 MW will be 251.58 MCM. NOC for the same is to be obtained.</td>
</tr>
<tr>
<td>3</td>
<td>NOC for setting of Facility - Pollution clearance (Water &amp; Air)</td>
<td>State Pollution Control Board</td>
<td>APL will do the needful once the EIA Report is ready.</td>
</tr>
<tr>
<td>4</td>
<td>Environmental and Forest Clearance</td>
<td>Ministry of Environment &amp; Forests (MOEF), GoI</td>
<td>APL will apply for Environmental Clearance.</td>
</tr>
<tr>
<td>5</td>
<td>Forest clearance</td>
<td>State Forest Dept. / MOEF, GoI.</td>
<td>Land has been applied by APSEZ for Industrial/Infrastructure use.</td>
</tr>
<tr>
<td>6</td>
<td>Civil aviation clearance for Chimney height</td>
<td>Airport Authority of India</td>
<td>Once location of chimney is finalised, APL will apply for clearance.</td>
</tr>
<tr>
<td>7</td>
<td>Coastal Regulatory Zone clearance</td>
<td>Ministry of Environment &amp; Forests (MOEF), GoI</td>
<td>APL shall apply for it later</td>
</tr>
<tr>
<td>8</td>
<td>Rehabilitation and Resettlement of displaced families by land acquisition</td>
<td>State Govt.</td>
<td>As no PAF, R&amp;R is not Envisaged</td>
</tr>
</tbody>
</table>
## Table 10.2

### Non-Statutory Permits and Clearances

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Description</th>
<th>Authority</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land availability</td>
<td>Within notified industrial area</td>
<td>201.5 Hectare (498 acres) of land has been identified for the project. The acquisition process is in progress.</td>
</tr>
<tr>
<td>2</td>
<td>Fuel Linkage</td>
<td>Blended Coal</td>
<td>Imported Coal shall be used for this Project.</td>
</tr>
<tr>
<td>3</td>
<td>Transportation of fuel</td>
<td>Indian Railways Transport Agency</td>
<td>APL shall transport imported coal though dedicated conveyor from Mundra west port.</td>
</tr>
<tr>
<td>4</td>
<td>Clearance from Archaeological</td>
<td>Not Required</td>
<td>Not required, as no archaeological / religious monument / site is located in the close vicinity.</td>
</tr>
<tr>
<td></td>
<td>department</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Import Licences &amp; Formalities</td>
<td>Controller of Import Authorities</td>
<td>Will be applied after selection of EPC contractor.</td>
</tr>
</tbody>
</table>
# ANNEXURES

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Plant General Layout</td>
<td>LII-P.008794-G-00110-001</td>
<td>0</td>
</tr>
<tr>
<td>1.2</td>
<td>Water Balance Diagram</td>
<td>LII-P.008794-M-00127-001</td>
<td>0</td>
</tr>
</tbody>
</table>