MAHARASHTRA STATE POWER GENERATION CO. LTD.

DETAILED PROJECT REPORT

FOR

BHUSAWAL T.P.S. UNIT – 6: 1X660 MW PROJECT

CONSULTANT

PROCON ENGINEERS

(DIV. OF NIMOTO CONSULTING ENGINEERS PVT. LTD.)

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1.0 INTRODUCTION AND EXECUTIVE SUMMARY

1.1 INTRODUCTION

The basic objective of the planned development in power sector in the country is to outpace the rapid rise in power demand with reasonable level of reliability to ensure faster economic growth. The most important primary resources for electric power generation are fossil fuels, water and nuclear energy. Rapid industrialization induced by the on-going liberalization of the country's economic policy, continued stress on rural electrification with larger use of electric pumps for irrigation purposes and increase in electricity utilisation for transportation and household purposes have all contributed to rise in the growth rate for demand of power.

Government of India has planned a mission POWER TO ALL BY 2012. Growth in Economy and population has resulted in rise in the growth rate for demand of power.

65% of total power generated in the State of Maharashtra is fossil fuel based thermal power. Present power shortage in Maharashtra State is to the tune of 4800 MW. Maharashtra State Power Generation Company Limited (MAHAGENCO) has planned a massive capacity addition to cater for increase in demand. Also Independent Power Producers (IPPs) have planned for their own power projects. The opening of this sector to private entrepreneur has also encouraged Independent Power Procedure (IPPS) to establish Power Generating Stations.

Although several new power projects have been identified with a view to bridge the gap between the demand and supply, only a few could be taken up so far due constraints like difficulty in acquisition of land required for the project, non availability of inputs like coal, water etc.

In order to reduce the duration for setting up the new power station, MAHAGENCO have planned the expansion of existing power station. Accordingly MAHAGENCO has proposed to augment the power generating capacity of Bhusawal Thermal Power Station where 1x62.5 MW &2x210 MW units are in operation and 2x500 MW units are under erection.

With the advancement in technology and increasing confidence in power generating units utilising supercritical steam parameters in the country, MAHAGENCO has now proposed to set up 1x660 MW unit as a replacement of old 62.5 MW unit (de-rated as 58 MW). Thus the net capacity addition from this project will be 602 MW (660-58). The project is proposed with supercritical technology. MAHAGENCO has already adopted supercritical technology for 3x660 MW Koradi Expansion Project which at present is under execution stage.

MAHAGENCO has decided to obtain a Detailed Project Report (DPR) prepared for the proposed **BHUSAWAL T.P.S. UNIT – 6: 1X660 MW PROJECT**.

Under the present report the feasibility of setting up the station is assessed considering following:

1.1.1 Availability of Inputs

(a) Land
(b) Coal
(c) Water
(d) Power Evacuation

For the main power block, 660 MW set is favoured in view of:

(a) Superior thermal efficiency
(b) Less specific initial investment requirement
(c) Commendable performance record of the above sets abroad

(d) With less emission, the technology is environment-friendly.

MAHAGENCO have appointed **Procon Engineers (Procon)** as Owner's Consultant for the proposed Bhusawal T.P.S. Unit - 6: 1X660 MW Project and has also asked Procon to prepare a Detailed Project Report (DPR) for the same along with other services.

1.2 EXECUTIVE SUMMARY

It is observed from 16TH & 17TH Electric Power Survey (EPS), published by the Ministry of Power, Government of India, that the energy demand / supply position for Maharashtra at the end of the 12th Plan requires substantial capacity addition particularly in Thermal sector. This scenario highlights the need for measures to bridge the gap between the demand and supply. In order to induct more base-load stability of the state grid a station with 660 MW nominal capacity has been proposed for implementation during the 12th Plan Period. In Section-II of the report, the justification of the project is discussed.

The proposed 1x660 MW unit shall be constructed in 108.07 Ha of land being acquired by MAHAGENCO. For the proposed 1x660 MW station, 22 MM^3 / Annum of raw water and 3.18 MMT / Annum of coal will be required for operation, considering 330 days running of plant per annum. The site is selected on the basis of:

(a) Availability of required land near the existing Bhusawal TPS of MAHAGENCO.

(b) Availability of required quantity of water from Ozerkheda Reservoir (Hatnur dam water will be pumped upto Ozerkheda).

(c) Availability of good infrastructural facility including road and rail connection

MAHAGENCO have received approval from Government of Maharashtra for setting up the station. Necessary infrastructure is available at Bhusawal. In Section-III of the report, the basic requirements for a Thermal Power Station have been discussed.

The plot FGL varies between 210 RL - 213 RL which is above the highest flood level (198.20 RL) of the area as per the Plot Plan No. DG/253-NOW-5001 Rev.-0 In Section-IV of the report, the features of the identified plot are discussed.

In Section-V of the report, the technical features of the 660 MW set size outlining the design parameters of main plant and equipment are discussed. A reheat steam cycle with regenerative feed heating arrangement with Supercritical steam parameters has been proposed.

Raw Water supply to plant is planned from Ozerkheda Reservoir (Hatnur dam water will be pumped upto Ozerkheda Reservoir).

Re-circulating cooling water system with Natural Draft Cooling Tower has been proposed for the station.

Coal with 3731 Kcal/kg calorific value is planned for use for the station. However, for design purpose, calorific value of 3500 Kcal/kg of worst coal is considered. On the basis of this, the coal requirement per day works out to be 9640 tons. Since Wagon Tippler capacity shall be 25 Tips / hr (Design), 20 Tips / hr (Rated) i.e. 1200 Tons per hour unloading capacity, a 1200 TPH Capacity double stream coal conveying system is proposed considering about eight hours running of CHP. The advantage of higher capacity is interconnection to existing plant, if required, can be done & more time will be available for maintenance of new CHP. With 25 Tips/hr of wagon tipplers, the unloading time of full rake as per Railways requirement can be achieved.

In accordance with the notification no So 763 dtd 14.09.00 of Ministry of Environment and Forest (MoE&F), the system shall be provided for collection

of dry ash in ash silos. This dry ash shall be issued to end users on first come first serve basis. Efforts shall be made for 100% utilization of ash. However, to meet the eventualities in immediate future, it is proposed to provide high concentrated ash slurry disposal system. For this purpose, Ash dump area of 85 Hectors utilized for existing units, will be utilized for proposed 1 x 660 MW Bhusawal TPS Project.

Other auxiliaries and accessories shall ensure safe and continuous operation of the unit with minimum unscheduled outage. In Section-VI of the report, the auxiliary systems are discussed.

The electric Generator would be 3-phase, 50 Hz, hydrogen-cooled, 3000 rpm machine with static or brushless excitation system and would generate power at 21 kV at 0.85 power factor. This may vary as per manufacturer's standard. The electrical system proposed would be equipped with adequately sized equipment and with adequate redundancy to ensure uninterrupted operation. In Section-VII of the report, the electrical equipment and systems are discussed.

The proposed station envisages the state-of-the-art Distributed Digital Control System (DCS) 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. In Section-VIII of the report, instrumentation and control philosophy of the proposed station is dealt in adequate details.

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

Details of plant buildings, civil engineering aspects and the relevant layout within the identified plot are furnished in Section-IX of this report.

To minimise emission of Suspended Particulate Matter (SPM) along with boiler flue gases, Electrostatic Precipitators of adequate size will be provided at the exit of Boiler to bring down SPM emission level under 45 mg/Nm^3 (max). 275 Mtr high Stack is envisaged for the proposed unit. Liquid effluents from the plant will be properly treated before re-use. A detailed scheme for the proposed unit has been provided in Section-X covering the entire environmental aspects.

The station location is at a reasonable distance from localities, and necessary facilities would have to be developed for execution of the project. As per the prevailing trend, the project would be implemented on Engineering, Procurement & Construction (EPC) mode with the performance guarantees, timeframe and the penalty clauses well defined. As such, the EPC contractors will arrange all the construction equipments. Project authority would provide clear site, clearances, construction power and construction water to the EPC contractor. In Section-XI of the report, the construction facilities have been discussed.

In Section-XII of the report, O&M staff requirement for operating and maintaining the plant is discussed. It is assumed that some of the functions during annual maintenance would be off loaded by giving on contract basis. A total manpower requirement of 426 persons has been envisaged for the proposed station. This may undergo revision as per project authority's own model of manpower deployment. The training requirements of O&M personnel are also discussed under this chapter.

In Section-XIII of the report, employee facilities and residential township requirement are outlined.

The project is proposed to be implemented by reputed, experienced and financially sound EPC contractor to ensure timely completion. Project

authority has engaged the services of an Owners' engineer for preparation of specification, review of design and drawings by EPC contractor. Project co-ordination and monitoring and assurance of construction quality shall be overviewed by Owner's project team. Some of the works namely land grading, construction of road to the site, boundary wall, etc. would also be undertaken by the EPC contractor. The project is planned to be implemented and handed over for commercial operation within a timeframe of 51 months from the date of LOA for BTG package which is considered as zero date. The project execution, monitoring and control, project schedule, have been discussed under Section-XIV of the report.

Based on available quotes and in-house data, the project cost estimate has been worked out. A total capital outlay of Rs. 4548 crores (without Mega Power Project Status) would be involved. The details are furnished in Section-XV of the report.

1.3 PROJECT AT A GLANCE

1.3.1 General

(a)	Owner of the Project	:	Maharashtra State Power Generation Company Limited (MSPGCL) or MAHAGENCO
(b)	Project Authority at site	:	Chief General Manager (Project)
(c)	Project	:	1x660 MW at Bhusawal Thermal Power Station.
(d)	Selected Location	:	Bhusawal in Jalgaon District in Maharashtra. Latitude – 21.02 N Longitude – 75.51 E
(e)	Nearest Major Towns	:	Bhusawal & Jalgaon
(f)	Seismic Zone	:	Zone III
(g)	Access by Road	:	Adjacent to National Highway 6

	(h)	Access by Rail	: Existing Railway siding facility for Bhusawal TPS shall be augmented as per the requirement.
	(i)	Access by Air	: Aurangabad Airport.
1.3.2	Preliminary Project Particulars		:
	(a)	Main Fuel	: Coal from Machhakata coal mines, Orissa.
	(b)	Fuel Transportation	: By rail in rake loads of BOX-N wagons.
	(c)	Water	: A total of 22 MM^3 / Annum of raw water is required for the proposed station.
	(d)	Land for Plant proper	: 108.07 Hector of land shall be acquired for new plant.
	(e)	Land for Ash Disposal	: Ash shall be dumped in the existing ash bund.
	(f)	Land for Township Land for Corridors	: Shall be accommodated in existing colony by constructing additional buildings. Transmission corridor shall be arranged by MAHATRANSCO. Corridor for ash pipe lines & raw water supply lines shall be arranged by MAHAGENCO
	(g)	Layout Features	: One 660 MW unit can be accommodated within the available space
	(h)	Land Development	: The entire station will be laid at average level of 213 m RL which is above the highest flood level (HFL) of the area.
1.3.3	Technical Features		:
	(a)	Power Generating Unit	: One unit of 660 MW Turbine Generator set fed by steam with supercritical steam parameters from coal fired PF Steam

Generator.

(b) Cooling System : Semi-open re-circulating condenser cooling system with wet-type Natural Draft Cooling Tower.

(c) Coal Handling System : Coal handling facility, which comprises of Wagon Tipplers, crushers, stacker-cum-reclaimer in the coal yard and double stream conveying system with capacity of 1200 TPH (Rated) of each stream.

(d) Ash Disposal System : Dry extraction and disposal with provision for high concentration slurry disposal for fly ash and wet disposal for bottom ash is considered.

(e) Power Evacuation : At 400 KV level.

(f) Environmental Aspects : A 275 m high Stack as per MoEF guidelines and an adequately designed electrostatic precipitator with more than 99.89 % efficiency are envisaged. Waste water quality to be maintained as per MoEF notification. Most of the wastewater and ash water would be recycled back to the system after treatment for use in less priority areas.

(g) Rehabilitation Requirement : Nil

1.3.4 Other Facilities :

Township : Within the existing township

1.3.5 Mode of Implementation and Project Cost :

(a) Mode of Implementation : Through two (02) nos. EPC (Engineering, Procurement and Construction) contracts. (BTG with associated civil works and BOP with associated civil works)

Project Time Frame: Fifty-one (51) months from zero date i.e. the date of 'Letter of Award' for BTG package to commercial operation.

(b) Project Cost : Present day cost including interest during construction, Rs.4548 Crores (without Mega Power Project status).

1.3.6 Tariff :

First Year Tariff : Rs 3.25 per kWh

Levelised Tariff : Rs.3.27 per kWh

2.0 NEED FOR THE PROJECT

2.1 INTRODUCTION

The National Electricity Policy notified by the Govt. of India lays down the following major objectives:

(a) Every house shall have Access to Electricity within next 5 years.

(b) Demand shall have to be fully met by 2012. Energy and peaking shortages to be overcome and adequate spinning reserve (at least 5%) to be ensured.

(c) Per capita electricity consumption over 1000 units by 2012 to be ensured.

(d) Minimum consumption of 1 unit per household per day as a merit good by year 2012.

Capacity addition in 11th (2007-12) plan period has to fulfill the above said aims and objectives.

Sector	Hydro	Thermal				Nuclear	R.E.S (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	27065.00	44977.00	4046.12	602.61	49625.73	0.00	2701.12	79391.85
Private	1233.00	8056.38	6307.50	597.14	14961.02	0.00	12819.99	29014.01
Central	8565.40	31165.00	6702.23	0.00	37867.23	4560.00	0.00	50992.63
Total	36863.40	84198.38	17055.85	1199.75	102453.98	4560.00	15521.11	159398.49

TABLE I: INSTALLED CAPACITY OF ALL REGIONS OF INDIA AS ON 31.3.2010

Table I gives the actual Installed Capacity of all India as on 31.3.2010

Note:

(i) Installed capacity of states is provisional and it is being reconciled.

(ii) Installed capacity does not include benefits from projects in Bhutan.

(iii) R.E.S. includes :-SHP – 2604.92 MW, Wind – 10647.45 MW, B.P. & B.G. – 2167.73 MW, U&I & Solar – 101.01 MW]

The restricted Cumulative Annual Growth Rate (CAGR) in Electrical Energy Consumption (EEC) as recorded in the country for 9th & 10th plan ranges between 3% and 5%. The growth rate of EEC as forecast in the 17th Electric Power Survey (EPS) is about 10% for the period till the end of 11th plan.

The present scenario has thus forced Govt. of India to lay special emphasis on accelerated rate of capacity addition and also maintaining cost of energy within reasonable limit.

The proposed project of 660 MW coal based Bhusawal TPS Project in Jalgaon District, Maharashtra fits in well in the present demand-supply scenario.

2.2 ALL INDIA POWER SCENARIO

Table II shows the "Actual Supply Position" of energy and peak demand of the country from 2002-03 to 2009-10 as on date 31.03.2010.

Year	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Avail-ability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
2002-03	81492	71547	9945	12.2	545983	497890	48093	8.8
2003-04	84574	75066	9508	11.2	559264	519398	39866	7.1
2004-05	87906	77652	10254	11.7	591373	548115	43258	7.3

Year	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Avail-ability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
2005-06	93255	81792	11463	12.3	631757	578819	52938	8.4
2006-07	100715	86818	13897	13.8	690587	624495	66092	9.6
2007-08	108866	90793	18073	16.6	739345	666007	73338	9.9
2008-09	109809	96685	13124	12	774324	689021	85303	11
2009-10	118,472	102,725	15,748	13.3	830,300	746,493	83,807	10.1

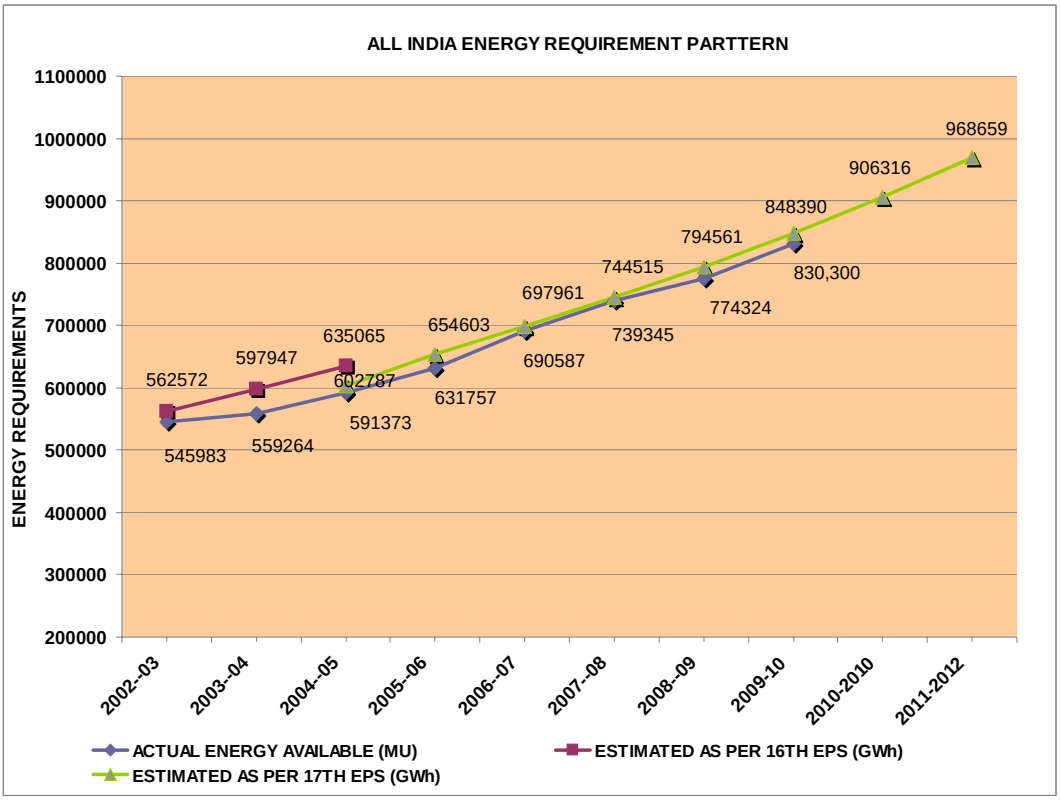
Source: CEA database

TABLE II: ACTUAL POWER SUPPLY POSITION OF ALL REGIONS AS ON 31.3.2010

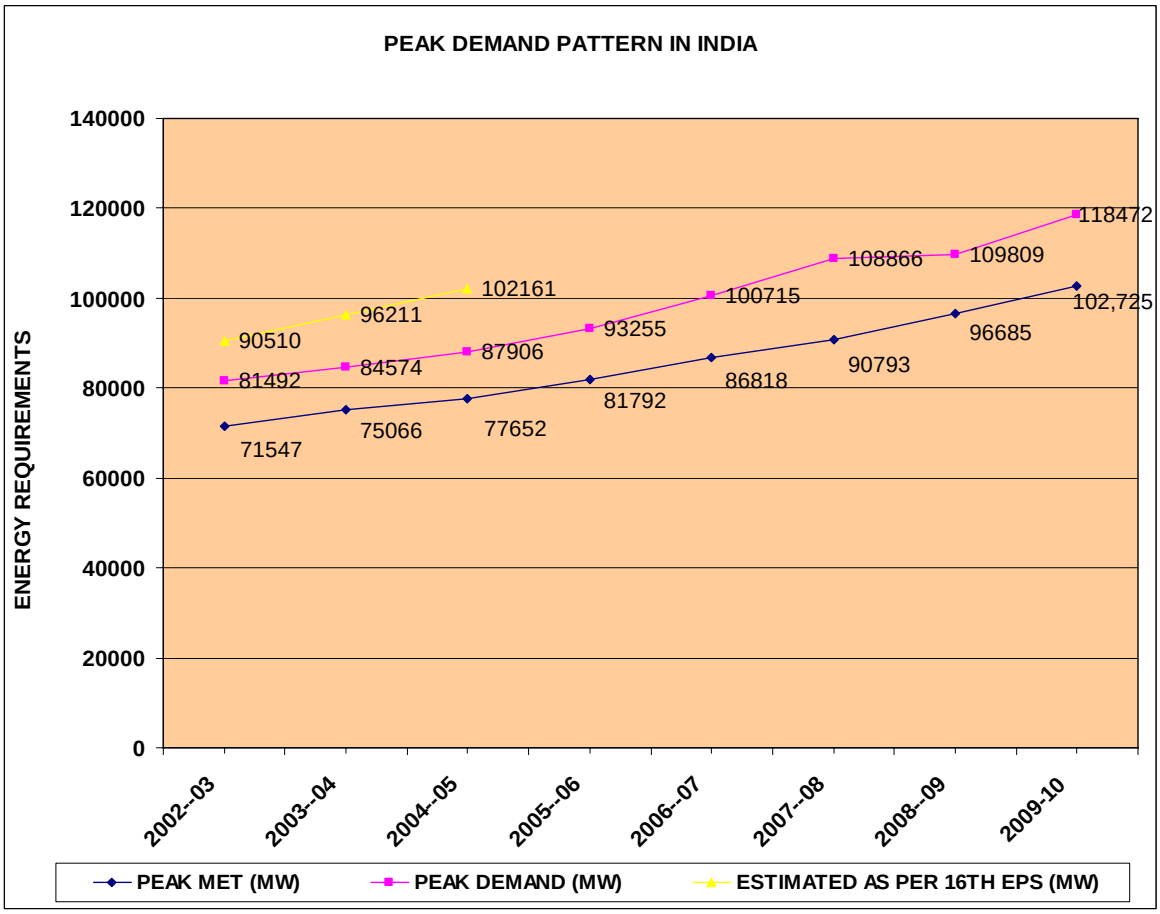
The peak demand shortage on all-India basis for the period of 2009-10 is around 15748 MW. **It may be noted that the peak demand as mentioned is only restricted demand and the unrestricted demand is likely to be higher.**

All India Regionwise Power scenario for 2009-10 is as per enclosed **ANNEXURE I.**

According to 17th EPS, estimated energy requirement (in GWh) and peak demand (in MW) works out to 968,659 GWh and 152,746 MW respectively for the year 2011-12.



GRAPH I: ALL INDIA ENERGY REQUIREMENT PATTERN



GRAPH II: PEAK DEMAND PATTERN IN INDIA

Graph I & II represents All-India energy requirement & Peak Demand figures both as per the 16th & 17th EPS as follows:

(a) Actual for the years 2002-2003 to 2009-10.
(b) Estimated for years 2002-2003 to 2004-05 as per 16th EPS.
(c) Estimated for the years 2004-05 to 2011-12 as per 17th EPS.

From the graphs it is noted that there is continuous increase in shortfall of energy & Peak Demand. This is attributable to lack of capacity additions during this period.

2.3 POWER SCENARIO OF WESTERN REGION

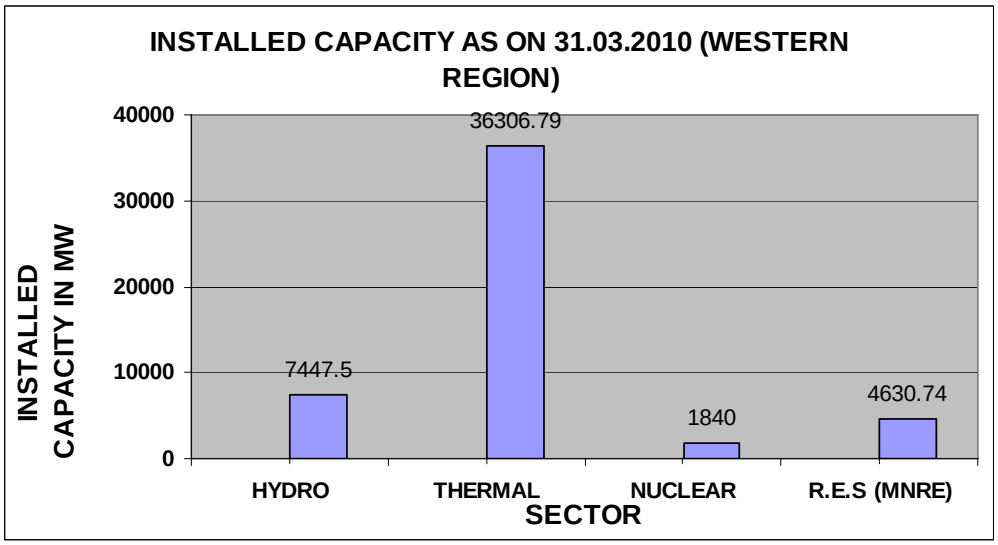
For the purpose of power planning and operation of regional grid the western region consists of the following states:

(a) Gujarat
(b) Madhya Pradesh
(c) Chhattisgarh
(d) Maharashtra
(e) Goa
(f) Dadra & Nagar Haveli (UT)
(g) Daman & Diu (UT)

All three sectors namely Central, State & Private contribute to the power generation capability in the region. There are two nuclear stations in the region, one at Tarapur in Maharashtra and the other at Kakrapara in Gujarat. Power Grid Corporation of India Limited (PGCIL), the central sector constructs, operates and maintains transmission and transformation facilities for inter-state and inter-region transfer of power. The power generating capability in the region is predominantly thermal.

The details of the installed capacity of Power Utilities in Western Region as on 31.03.2010 are as per enclosed **ANNEXURE II**.

Graph III below indicate installed capacity of Western region as on 31.03.2010

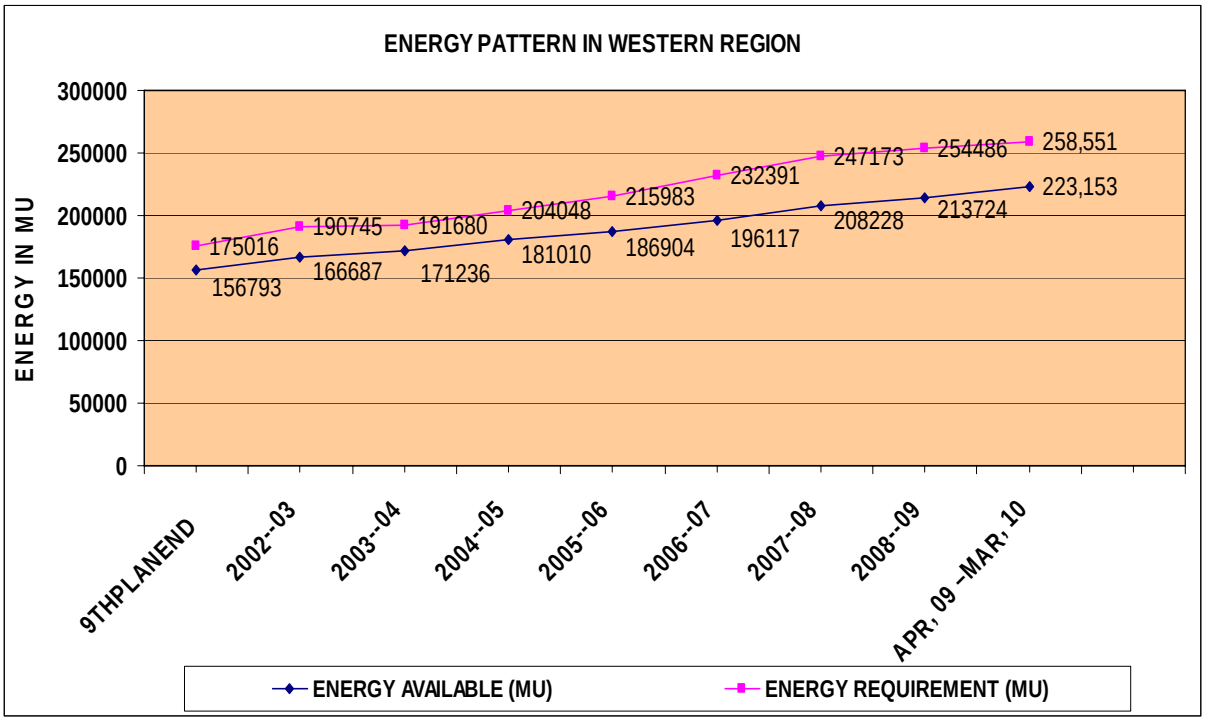


GRAPH III: INSTALLED CAPACITY AS ON 31.03.2010 (WESTERN REGION)

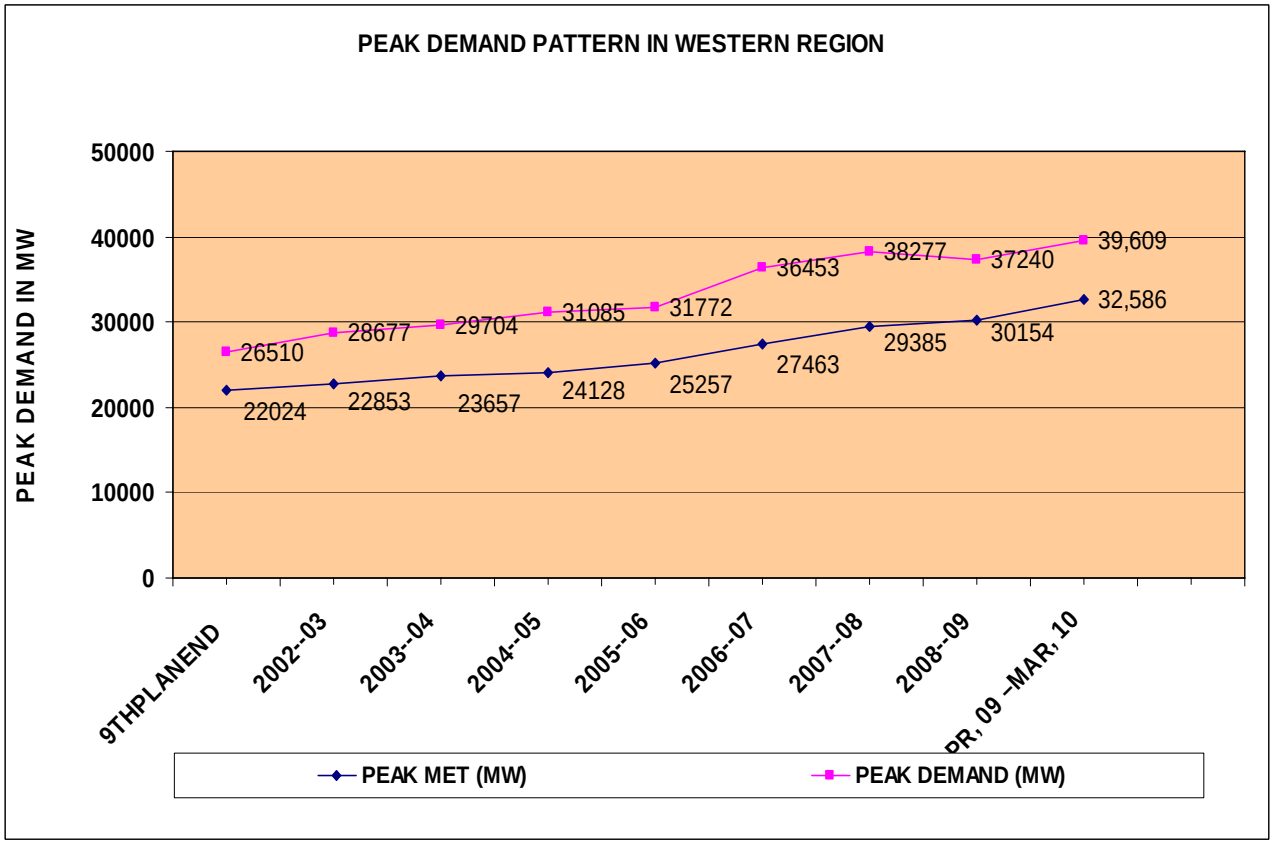
2.4 ACTUAL POWER SUPPLY POSITION OF WESTERN REGION FROM 2002-03 TO 2009-10 IS AS UNDER:

Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Avail-ability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
9TH PLAN END	26510	22024	4486	16.9	175016	156793	18223	10.4
2002-03	28677	22853	5824	20.3	190745	166687	24058	12.6
2003-04	29704	23657	6047	20.4	191680	171236	20444	10.7
2004-05	31085	24128	6957	22.4	204048	181010	23038	11.3
2005-06	31772	25257	6515	20.5	215983	186904	29079	13.5
2006-07	36453	27463	8990	24.7	232391	196117	36274	15.6
2007-08	38277	29385	8892	23.2	247173	208228	38945	15.8
2008-09	37240	30154	7086	19.0	254486	213724	40762	16.0
APR, 09 –MAR, 10	39,609	32,586	7,024	17.7	258,551	223,153	35,398	13.7

TABLE III: ACTUAL POWER SUPPLY POSITION IN WESTERN REGION



GRAPH IV: ENERGY PATTERN IN WESTERN REGION



GRAPH V: PEAK DEMAND PATTERN IN WESTERN REGION

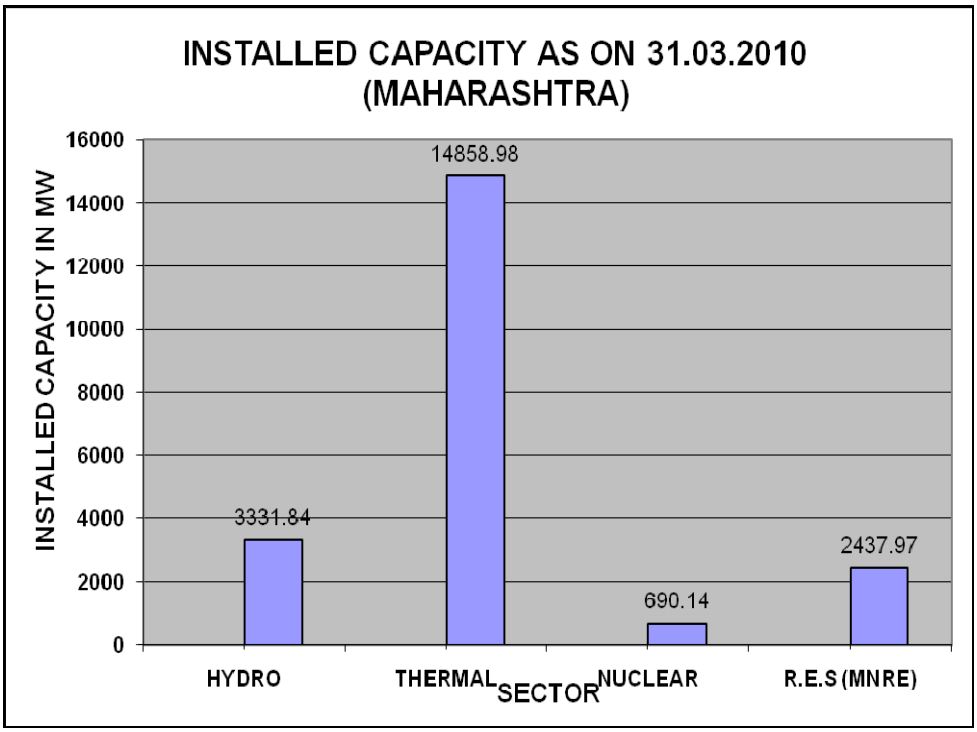
2.5 POWER SCENARIO OF MAHARASHTRA

The details of the installed capacity of Maharashtra as on 31.03.2010 are furnished below:

Sector	Hydro	Thermal				Nuclear	R.E.S (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	2884.84	7300.00	852.00	0.00	8152.00	0.00	233.72	11270.56
Private	447.00	1900.00	180.00	0.00	2080.00	0.00	2204.25	4731.25
Central	0.00	2003.05	2623.93	0.00	4626.98	690.14	0.00	5317.12
Total	3331.84	11203.05	3715.93	0.00	14858.98	690.14	2437.97	21318.93

SOURCE: CEA

TABLE IV: INSTALLED CAPACITY IN MAHARASHTRA



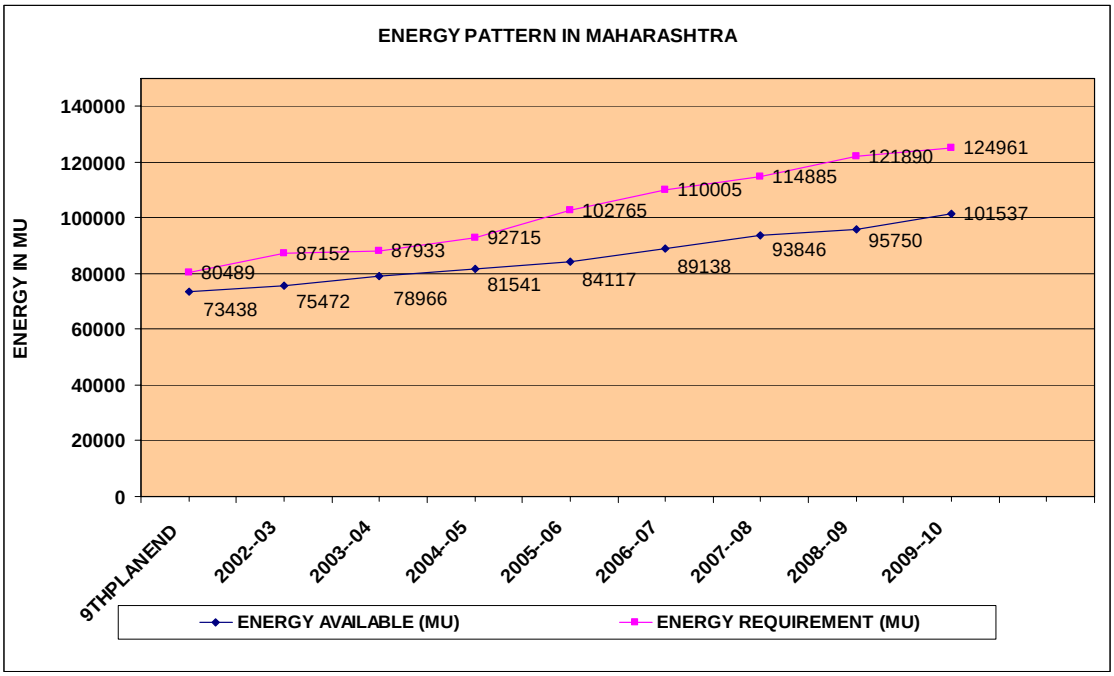
GRAPH VI: INSTALLED CAPACITY OF MAHARASHTRA

2.6 ACTUAL POWER SUPPLY POSITION OF MAHARASHTRA FROM 2002-03 TO 2009-10 IS AS UNDER:

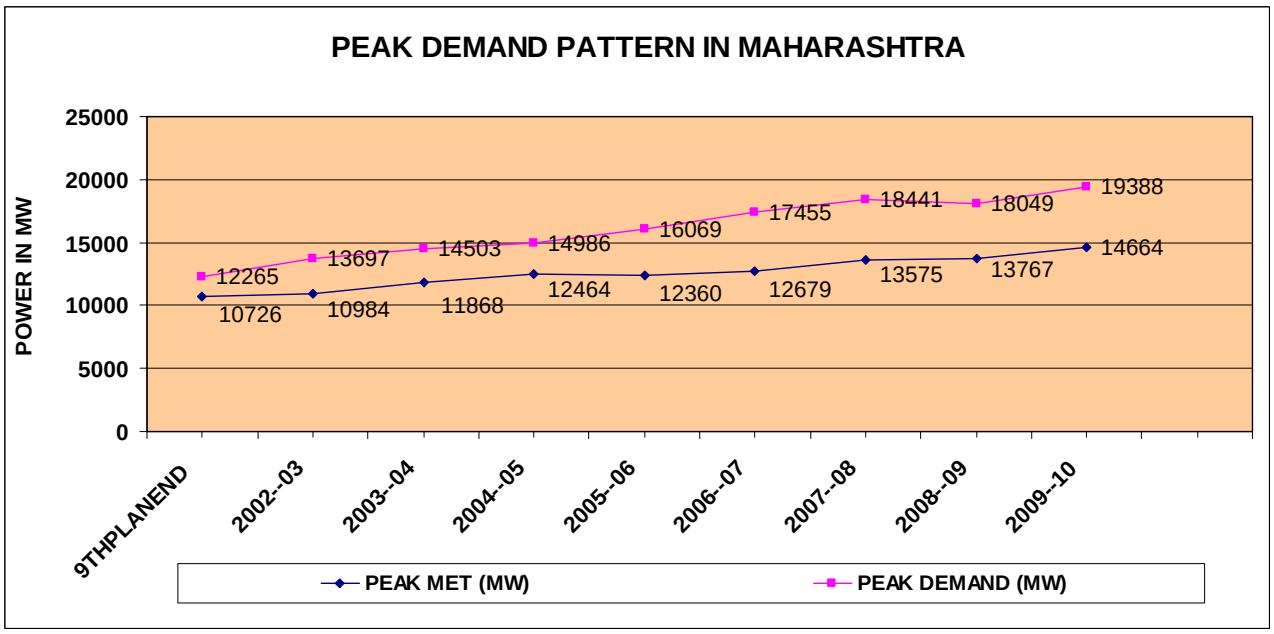
Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Avail-ability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
9TH PLAN END	12265	10726	1539	12.5	80489	73438	7051	8.8
2002-03	13697	10984	2713	19.8	87152	75472	11680	13.4
2003-04	14503	11868	2635	18.2	87933	78966	8967	10.2
2004-05	14986	12464	2522	16.8	92715	81541	11174	12.1
2005-06	16069	12360	3709	23.1	102765	84117	18648	18.1
2006-07	17455	12679	4776	27.4	110005	89138	20867	19.0
2007-08	18441	13575	4866	26.4	114885	93846	21039	18.3
2008-09	18049	13767	4282	23.7	121890	95750	26140	21.4
2009-10	19388	14664	4724	24.4	124961	101537	23424	18.7

TABLE V: ACTUAL POWER SUPPLY POSITION OF MAHARASHTRA

As per 17th EPS report Graphs VII & VIII give the energy requirement and the peak demand both actual (up to 2009-10) and estimated values (from 2002-03 to 2009-10) for the State of Maharashtra.



GRAPH VII: ENERGY PATTERN IN MAHARASHTRA



GRAPH VIII: PEAK DEMAND PATTERN IN MAHARASHTRA

It can be seen from the above graphs, that there is a deficit of 23424 Mus in energy supply & 4724 MW in Peak demand in the year 2009-10.

2.7 JUSTIFICATION OF THE PROJECT

2.7.1 The long term forecast as per 17th EPS for all states is as per Table VI:

STATE	ELECTRICAL ENERGY REQUIREMENT (GWH)			PEAK ELECTRIC LOAD (MW)		
	2011 -2012	2016 -2017	2021-2022	2011 -2012	2016 -2017	2021-2022
Delhi	36292.545	52762.386	73481.328	6092.409	8728.832	12069.050
Haryana	38417.069	54304.879	73838.162	6839.158	9375.160	12557.464
Himachal Pradesh	9503.908	13135.520	17657.400	1611.109	2194.159	2906.958
Jammu & Kashmir	11202.446	15271.949	21282.743	2062.737	2789.568	3856.642
Punjab	60488.861	82571.657	107342.309	11000.469	14441.277	18351.770
Rajasthan	48915.759	67767.236	92376.811	8482.079	11404.490	15100.779
Uttar Pradesh	79267.680	110664.947	150157.415	13947.013	19622.530	26833.528
Uttarnanchal	8444.717	11667.894	16191.306	1533.337	2085.410	2849.272
Chandigarh	2308.347	3366.693	4440.158	419.542	602.307	782.095

STATE	ELECTRICAL ENERGY REQUIREMENT (GWH)			PEAK ELECTRIC LOAD (MW)		
	2011 -2012	2016 -2017	2021-2022	2011 -2012	2016 -2017	2021-2022
Sub Total (NR)	294841.333	411513.161	556767.632	48136.901	66582.928	89912.790
Goa	4582.911	6879.880	9082.496	721.306	1082.827	1429.498
Gujarat	85445.226	119083.096	156841.512	14373.742	19670.034	25446.677
Chhattisgarh	21784.878	33076.392	45115.620	3565.388	5374.867	7279.413
Madhya Pradesh	49338.498	70444.570	98986.680	8461.912	11772.241	16128.817
Maharashtra	**125661.409**	**167226.739**	**219910.417**	**21953.740**	**28347.752**	**35944.127**
D. & N. Haveli	5041.957	8204.128	12242.813	777.792	1265.600	1888.623
Daman & Diu	3004.817	4890.242	7842.185	552.088	857.119	1323.701
Sub Total (WR)	294859.697	409805.046	550021.724	47108.381	64348.650	84778.064
Andhra Pradesh	89032.490	132118.210	175590.124	14721.210	21845.290	28215.843
Karnataka	53539.620	79995.770	107470.552	8826.000	13092.380	17463.812
Kerala	19229.540	26331.640	36134.030	3528.050	4573.790	5916.364
Tamil Nadu	87221.910	134754.730	182825.156	14224.060	21975.660	29814.931
Pondicherry	4419.430	6867.800	9639.046	682.500	1060.600	1488.566
Sub Total (SR)	253442.990	380068.150	511658.908	40367.135	60432.580	80484.967
Bihar	19904.770	32857.080	58248.405	3607.000	5598.220	9567.426
Jharkhand	23408.480	36274.000	51741.061	4296.130	6604.000	9129.079
Orissa	27149.150	39095.650	63098.108	4459.000	6330.460	10074.098
West Bengal	41019.893	60228.010	84498.993	7406.850	10742.720	15071.881
Sikkim	320.000	486.930	629.382	83.000	119.540	150.465
Sub Total (ER)	111802.293	168941.670	258215.949	19088.442	28400.908	42711.602
Assam	7584.620	13052.660	24433.491	1443.000	2292.350	3984.588
Manipur	931.890	1359.680	2336.809	203.000	269.940	444.598
Meghalaya	2101.000	2777.700	4015.131	428.290	542.030	751.391
Nagaland	698.000	1040.070	1505.358	152.000	222.340	318.821
Tripura	1229.000	1761.080	3180.264	282.000	386.610	666.135
Arunachal Pradesh	385.520	557.380	762.307	116.000	147.970	189.177
Mizoram	398.481	594.690	763.662	115.249	161.750	196.033
Sub Total (NER)	13328.511	21143.260	36997.022	2536.610	3759.804	6179.947

STATE	ELECTRICAL ENERGY REQUIREMENT (GWH)			PEAK ELECTRIC LOAD (MW)		
	2011 -2012	2016 -2017	2021-2022	2011 -2012	2016 -2017	2021-2022
Andman & Nicobar	343.590	536.570	779.450	76.910	118.940	131.660
Lakshadweep	40.130	58.190	67.548	11.450	16.610	19.277
Total (All India)	968658.543	1392066.048	1914508.233	152746.097	218208.593	298253.241

TABLE VI: LONG TERM FORECAST OF ALL STATES

It can be seen from the above that Peak demand at Maharashtra state shall be 28347.752 MW up to 2016-17. Similarly Maharashtra energy requirement shall be 167226.739 MW (in 2016-17).

Considering the above Peak energy & Peak demand deficit MAHAGENCO has planned massive capacity additional plan.

2.7.2 Capacity Addition Programme By MAHAGENCO

2.7.2.1 As a part of power capacity addition during the 10th Five Year Plan, following projects have been already taken up for implementation and these units are already synchronized,

(a) New parli Thermal Project 250MW Unit No. 6 - put into commercial operation with effect from 01st Nov. 07.

(b) Paras T.P.S. Expn. Project 250 MW Unit No. 3 - put into commercial operation with effect from 31st Mar. 08.

2.7.2.2 Following Phase-I Projects of MAHAGENCO will also be commissioned during 11th Five Year Plan.

SR. NO.	NAME OF THE PROJECT	CAPACITY IN MW	ZERO DATE	SCHEDULED DATE OF COD
(a)	New Parli TPS Expn. U-7	1 x 250	31.08.2006	Commissioned in Dec. 2009
(b)	Paras TPS Expn. U-4	1 x 250	31.08.2006	Commissioned in Jan. 2010
(c)	Khaperkheda TPS Expn. U-5	1 x 500	23.01.2007	Dec 2010
(d)	Bhusawal TPS Expn. U-4 & U-5	2 x 500	23.01.2007	Unit-4: Feb. 2011 Unit-5: May 2011

2.7.2.3 2 x 500 MW Chandrapur TPS Expn. Project is already approved by GOM and will be commissioned during 12th Five year Plan in Phase-II Projects. The implementation schedule is as indicated below:

SR. NO.	NAME OF THE PROJECT	CAPACITY IN MW	ZERO DATE	SCHEDULED DATE OF COD
(a)	Chandrapur TPS Expn. U-8	1 x 500	09.02.2009	Jul. 2012
(b)	Chandrapur TPS Expn. U-9	1 x 500	09.02.2009	Oct. 2012

2.7.2.4 3 x 600 MW units at Koradi (2 units of 660 MW as expansion project under Phase-II & one unit of 660 MW will be added as replacement against 4 old units of 120 MW which have outlived and need replacement) has been approved by cabinet on 17.07.2008. The commissioning schedule of there units is as follows:

SR. NO.	NAME OF THE PROJECT	CAPACITY IN MW	ZERO DATE	SCHEDULED DATE OF COD
(a)	Koradi TPS Repl. Unit-8	1 x 660	23.09.09	Dec. 2013
(b)	Koradi TPS Expn. Unit-9	1 x 660	23.09.09	Jun. 2014
(c)	Koradi TPS Expn. Unit-10	1 x 660	23.09.09	Dec. 2014

2.7.2.5 The replacement Project

Earlier 3 x 250 MW replacements Projects at Parli, Paras & Bhusawal have been approved by GOM. Subsequently, it was decided to propose 1x660 MW unit at Bhusawal instead of 1x250 unit at Paras & 1x250 Mw unit at Bhusawal. The commissioning Schedule of these projects is as under,

SR. NO.	NAME OF THE PROJECT	CAPACITY IN MW	ZERO DATE	SCHEDULED DATE OF COD
(a)	Parli Replacement Unit-8	1 x 250	20.01.2009	Jul. 2012
(b)	Paras Replacement Unit	1 x 250	In place of these 2 x 250 MW Units, **one unit of 1 x 660 MW is proposed at Bhusawal** as Replacement Unit. **Zero Date – March'2011** **Schedule date of COD – June'2015**	
(c)	Bhusawal Replacement Unit	1 x 250		

2.7.3 Power Projects Considered For Development in future:

SR. NO.	NAME OF THE PROJECT	CAPACITY IN MW	ANTICIPATED COD	PRESENT STATUS
(a)	Dondaicha TPS Project, Unit-1 & Unit-2	2 x 660	Jan. 2015 Jul. 2015	Approved by the Mahagenco Board. Approval of GOM is awaited.
(b)	Dondaicha TPS Project, Unit-3, U-4 & U-5	3 x 660	Jul. 2015 Jan. 2016 Jul. 2016	Approved by the Mahagenco Board. Approval of GOM is awaited.
(c)	Gas Based Combined cycle Power Project at GTPS, Uran Block-1 &2	814 406	Sept. 2010 Dec. 2012	Approved by the Mahagenco Board. (Subject to linkage of adequate quantity of gas at affordable price on long term basis).

2.8 UNIT SIZE SELECTION

For selecting the unit size and station configuration for the proposed 660 MW Thermal Power Station, the important criteria are as follows:

(a) Cost of energy generated from the station.

(b) Steady load requirement.

(c) Thermodynamic cycle efficiency.

(d) Operating experience of set size.

(e) Station availability

(f) Plant load factor attainable

(g) Specific investment requirement

(h) Project timeframe and manpower requirement

The unit size of 660 MW is endowed with the following merits:

(a) Availability of technology.

(b) High thermodynamic efficiency.

(c) Lower station heat rate ensures lower coal consumption.

(d) Load variation capability, if required.

(e) Capability of grid to tolerate any outage.

3.0 BASIC REQUIREMENTS

3.1 INTRODUCTION

The basic requirements for setting up and operating a coal fired extension power station of 1x660 MW capacity are:

(a) Availability of adequate land suitable for setting up the station by utilizing the existing infrastructure to the extent possible.

(b) Assured availability of sufficient water of appropriate quality on year-round basis.

(c) Confirmed supply of adequate fuel with effective transportation system to ensure the least delivered cost of fuel at the plant end.

(d) Possibility of power evacuation to the grid at appropriate voltage level(s).

(e) Availability of construction water and power, availability of construction manpower.

(f) Road and rail access, connectivity from airport, seaport etc.

(g) Availability of other infrastructural requirements.

This Section discusses the requirements vis-à-vis the availability within the stipulated time frame of the above features at the proposed site for the coal based power station.

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3.2 LAND

The land requirement for the coal based Thermal Power Project can broadly be classified under the following major heads:

(a) Main Plant Area

(b) Ash Dump / Management Complex

(c) Residential Township

(d) Other land area requirements for infrastructure facilities such as rail access, ash disposal pipe route, evacuation corridor, environmental requirements etc.

108.07 Ha of land is available for installation of 1 x 660 MW capacity conventional coal based Thermal Power Station with Supercritical steam parameters. This is based on the site features and land configuration, space required for Cooling Tower, coal receipt by railways, Coal Handling facility, Fuel Oil System, 400 KV Switchyard (By MAHATRANSCO), Water Treatment facility, mandatory space provision for FGD, Green belt as per MPCB / MoEF norms etc.

The above land will be excluding the land required for disposal of ash generated from the proposed power station. Ash disposal shall be in existing ash bund. For this purpose, Ash dump area admeasuring 85 hectors, utilised for existing units, will be utilised for proposed unit 1x 660 MW.

It is expected that the plant personnel will be suitably accommodated by constructing additional buildings in existing residential colony.

Additional land required for rail access, road access, ash disposal pipe routing, power evacuation corridor etc. also shall be arranged by

MAHAGENCO & MAHATRANSCO. About 8.02 Ha additional land is being acquired for this purpose.

The site has following merits:

(a) 108.07 Ha Land is already acquired.

(b) Land is partially developed and above flood level.

(c) Site is suitable from coal transportation logistics. The plot is located close to existing Bhusawal TPS where Broad Gauge Railway Facility is already available.

(d) Environment clearance can be easily obtained, as the site is not located in an environmentally fragile area. Not being near an airport, construction of tall Chimney will not create any flight hazard.

(e) Ready availability of required infrastructure like construction facilities viz. construction power, construction water.

(f) Access road and rail connections exist.

(g) Power will be evacuated at 400 KV level to MAHATRANSCO sub-station to be located within the available area of TPS via 400 KV line.

(h) Township facility is available, which will be expanded suitably.

(i) The site is well connected to coal mines, Mumbai Port and Aurangabad Airport, by railways and National Highway.

(j) Being located near Bhusawal, it will ensure easy availability of skilled / unskilled manpower and other civic amenities.

(k) Assured year-round availability of water from Ozerkheda Reservoir (Hatnur dam water will be pumped upto Ozerkheda).

(l) The Contour Plan & Vicinity Map of the area is as per **ANNEXURE III**. The site location map of the area is as per **EXHIBIT I**; this indicates availability of land for the power plant (108.07 Ha). The incoming railway line route to the plant site is also indicated. It may be seen that the land available is suitable and generally adequate for the station with all the auxiliaries and accessories.

3.3 WATER REQUIREMENT & AVAILABILITY

In a conventional fossil fuel-fired Thermal Power Station, water is used to meet the following basic requirements:

(a) To meet cooling requirement for Steam Condenser which acts as a heat sink for the thermodynamic cycle and other auxiliary cooling such as, Bearing / Lube Oil Coolers, Compressors, Generator Stator etc.

(b) To meet the heat cycle make-up and other process requirements.

(c) For miscellaneous services viz.

(i) Fire fighting

(ii) General services viz. A/C and ventilation, floor washing etc.

(iii) Sealing and cooling water for equipment of Ash Handling and Coal Handling System.

(iv) Dust extraction and dust suppression in coal yard

(v) Potable use in the plant and housing complex

(vi) Transport media for ash in case of wet disposal of ash

(vii) Horticulture and a forestation

For meeting the requirements of power cycle make up, cooling circuit and for potable use, water from Ozerkheda Reservoir (Hatnur dam water will be pumped upto Ozerkheda) shall be utilized.

The water coming from Ozerkheda Reservoir shall be stored in a twin chamber Raw Water Reservoir. One Day storage of Raw Water is planned in Raw Water Reservoir for the proposed 1x660 MW TPS. A raw water pump house shall be constructed for raw water supply for treatment and subsequent uses.

Initially about 19.5 MM^3/Annum of water shall be required. This is based on the consideration of cycle of concentration of 5 in the cooling water system and utilization of Cooling Tower blow down as Service Water Requirement, Ash Handling Plant, Coal Handling Plant, Horticultural etc.

After few years, it is expected that some of the ash water of Bottom Ash system will be recovered from the Ash Pond and shall be recycled to the Ash Handling Plant. In such a situation the raw water requirement is expected to reduce. The total estimation of water requirement is given in **ANNEXURE VI.**

The Raw Water Analysis is furnished in **ANNEXURE V**.

A route survey for water line for transport of water shall be separately carried out by another agency to decide the best engineering solution of routing the pipelines and requirement of land acquisition and/or right of way.

3.4 FUEL REQUIREMENT, AVAILABILITY & TRANSPORTATION

3.4.1 Main Fuel (Coal)

The proposed Thermal Power Station of MAHAGENCO shall utilize Grade E/F domestic coal. Coal would be sourced from Machhakata coal mines in Orissa. The gross calorific value (GCV) has been considered as 3731 Kcal/Kg. However, for design purpose worst coal with calorific value of 3500 Kcal/Kg is considered. The estimated coal requirement is as follows:

(a)	Station Heat Rate for 660 MW set	:	2130 Kcal/kWh
(b)	Assumed Gross Calorific Value of Coal (Worst Coal)	:	3500 Kcal/kg
(c)	Daily Coal Requirement @ MCR	:	9640 Tons
(d)	Annual Coal Requirement	:	@ 3.18 MMT
(e)	Railway traffic involved (Rake load of 58 wagons i.e. 3500 MT/Rake)	:	2.57 rake load / day (Average)

The Analysis of Coal is given in **ANNEXURE VII** enclosed. This may be reviewed when the planning for the Beneficiation Plant is completed and the actual analysis are available.

Coal will be moved in BOX-N wagons, preferably owned by the Railways. Kolkata-Mumbai electrified rail route (BG) of S.E. Central Railway passes close by. The coal rakes shall be moved up to Bhusawal on the Kolkata-Mumbai main line.

3.4.2 Auxiliary Fuel

Auxiliary liquid fuel, viz. LDO will be required for cold start-up and HFO will be required for flame stabilization at lower load. Oil requirement shall be met

through existing tanks by Transfer Pumps. Analysis of LDO and HFO are given in **ANNEXURE VIII** and **ANNEXURE IX** respectively.

3.5 POWER EVACUATION

The power evacuation from new 1x660 MW unit will be through a dedicated 400 KV switchyard of MAHATRANSCO located in front of main plant STG Building

3.6 OTHER INFRASTRUCTURAL FACILITIES

Availability of a few other infrastructure facilities is essential for timely implementation of the project in a compact construction schedule. The facilities, which are considered essential during early stage of construction, are:

(a) Access roads.

(b) Construction water and treated potable water.

(c) Construction power.

(d) Housing facility for the construction staff with water supply, electricity, community facilities viz. market, school, health care, entertainment facilities etc.

(e) Ancillary or small-scale industries to feed the new plant at project stage.

(f) Local availability of skilled and unskilled manpower

(g) Telecommunication facility etc.

(h) NH – 6 Highway is near to the site

(i) The railway line is already available for existing Power Station.

The nearest airport at Aurangabad is at a distance of 150 Km. The port facility at Mumbai may be utilized for sea transportation of heavy equipment. Communication facilities viz. telephone, facsimile, internet, etc. and other facilities already available in the existing plant will have to be suitably extended for timely implementation of the project.

Amenities like market, hospital, schools, college, small-scale industries to support construction of the plant are available in Bhusawal & Jalgaon cities. The local villages can also be of assistances for workforce to be deployed at the initial stage. To accommodate a large workforce during construction of the project, it is envisaged that some housing facilities viz. temporary labour hutments may be developed along with necessary civic amenities. The facilities in the township will also be suitably mobilized for the expansion project.

4.0 SITE FEATURES

4.1 INTRODUCTION

The State of Maharashtra has embarked on faster development of different industries. This has led to increasing demand for electrical power. But the state is presently witnessing large deficits in power supply, which need to be catered by base load station. Accordingly coal based thermal power generation has received top priority because power thus generated will first of all help the industrial and agricultural development in the state strengthening its economy and any surplus power can be easily sold to the neighboring power starved states in the western and northern regions.

In order to meet the continued power and energy demand in the state, MAHAGENCO proposes to augment the power generating capacity by setting up 1x660 MW Thermal Power Project at Bhusawal in Jalgaon District. After commissioning of this proposed TPS, aging 62.5 MW unit shall be dismantled.

The site is already well connected by railway line and transportation of coal is not likely to pose any problem and hence indigenous coal is selected as the main fuel. The estimated annual coal requirement is about 3.18 MMT for the proposed 1x660 MW Bhusawal TPS Replacement Project.

MAHAGENCO & Gujarat State Electricity Corporation Limited (GSECL) jointly have been allotted Machhakata coal blocks in Mahanandi Coal Fields Ltd. in Orissa for Captive mining. Captive coal company MahaGuj is registered and it is proposed to develop these coal blocks to cater to the requirements of MAHAGENCO's Projects which includes proposed project of 1x660 at Bhusawal.

The favorable and unfavorable features of the project location in the light of associated basic requirements are discussed hereinafter.

4.2 FEATURES OF THE IDENTIFIED SITE

4.2.1 Land Features –The details of available land are as under

(a) Availability of Land:

(i) Plant Location : Village Pimpari Sekam
(ii) Name of Taluka : Bhusawal
(iii) Name of District : Jalagaon (Maharashtra State)

(b) Total area of Land already acquired (Hectare):

	Land acquisition	Land Required in Ha.	Land acquired in Hectare				
			Govt. Land	Pvt. Land	Forest Land	Other	Total acquired as % of required
(i)	Main Plant	108.07	4.06	104.01	Nil	Nil	100%
(ii)	Ash disposal	Nil	Nil	Nil	Nil	Nil	Nil
(iii)	Colony	Nil	Nil	Nil	Nil	Nil	Nil
(iv)	MGR, Railway siding, road. Pipe line etc.	8.02	Nil	Nil	Nil	Nil	0%
(v)	Total	116.09	4.06	104.01	Nil	Nil	93.10%

4.2.2 Water Resource

The present water requirement for Bhusawal TPS is 45 MM^3 / Year for the existing units and the units under construction i.e. 2x500 MW units. The estimated water requirement for proposed 1x660MW unit is around 19.5 MM^3

/ Year (Considering ash pond recovery and ETP water). Thus, total water requirement will be around 64.5 MM³/year.

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Presently, availability of water is @ 58.09 MM³ / year which includes water from Hatnur dam (46.09 Mm³/year) and Sudgaon Bandhara (12.00 Mm³/year). For the balance 7 MM³/year water requirement, the Water Resources department vide letter no. 2254 dated 31.10.2009 is requested to accord approval for allotment of 7 Mm³/year water, from the Ozerkheda Reservoir under construction.

4.2.3 Fuel Resource

MAHAGENCO & GSECL are jointly developing coal block at Machhakata, Orissa allotted by Ministry of Coal in which MAHAGENCO's share shall be 60% of the coal reserves. Coal requirement of 1x660 MW Bhusawal Project shall be catered through this share.

Raw coal size shall be (-) 300 mm and shall be predominantly of 'E'/'F' grade. However, beneficiated coal size shall be limited to (-) 100 mm. The mine development plan of the captive mines and the implementation schedule of Coal Beneficiation Plant shall match the project commissioning schedule. It is understood that the production from the mine shall gradually pick up and the rise in production should also meet the increase in coal requirement with the commissioning of the unit.

Coal from the above mines shall be transported in coal rakes of BOX-N wagons of Indian Railway and unloaded at plant site by two number of wagon tipplers.

An independent coal unloading, crushing and storage facility has been proposed to cater to the requirement of the proposed unit.

A railway spur shall be taken from the existing rail line coming to the plant and an independent marshalling yard has been proposed in the power

station. The new railway system shall be installed in time so that it can also be utilized for the movement of construction material/equipment.

4.2.4 Power Evacuation

The power generated at the extension station shall be distributed in the State of Maharashtra through 400 KV system of MAHATRANSCO who shall install a dedicated 400 KV switchyard in the powerhouse area.

4.2.5 Environmental Consideration

The plant shall be located more than 500 m away from highway no. NH-6. Green belts have been planned on all sides to minimise impact of wind blown pollution to the surrounding areas. Villages adjoining the ash disposal area would also be protected by green belt buffer. The plant water system is designed for maximum usage of waste water to attain ‘zero discharge’.

Chimney of adequate height (275 m) is considered to maintain ground level concentration of SPM, NO_x, SO_x etc. within acceptable limits prescribed by MoEF. There being no fragile environmental consideration in the area, no degradation is apprehended.

4.2.6 Other Infrastructural Facilities

For a power plant, appropriate location has a major impact on proper functioning in a cost effective manner. The requirements include favourable land features, proper infrastructure, supply of inputs at an optimum delivered cost and resulting design with ambient of the site to ensure efficient and trouble-free stable operation of the units throughout the lifetime of the plant. The proposed unit being replacement of existing Power Station, advantages of advanced infrastructure would be available. These include road and rail access, construction power and construction water, housing facility for construction personnel, ancillary and small scale industries to support the new installation at project stage, skilled and unskilled manpower etc.

The National Highway (NH-6) is passing beside the proposed power plant site. The approach road to the site can be constructed to ensure movement of heavy equipment including ODC. Telecommunication facility, post office, banks, police station, health care, education centre facilities will be augmented.

4.3 METRROLOGICAL DETAILS

The Climatological Table is given in **ANNEXURE IV.** It may be seen that this area does not have any strong prevalent wind direction.

The annual rainfall of the area is about 112 mm with 80% of precipitation being in the months of June to September. Other meteorological features which will form the design basis for the units are given hereunder. (Details for June 08 to Oct 10 are as under)

(a)	Maximum Temperature	:	48.7 °C
(b)	Minimum Temperature	:	13 °C
(c)	Average Annual Rainfall	:	112 mm
(d)	Maximum Rainfall in 24 hours	:	240.03 mm
(e)	Seismic Zone	:	Zone-III as per IS 1893

5.0 POWER GENERATING EQUIPMENT

5.1 INTRODUCTION

The Maharashtra State Power Generation Company Limited (MAHAGENCO) intends to build a coal based 1x660 MW capacity power project with coal from Machhakata and Mahanadi coal blocks in Orissa. The project would be located near Bhusawal in Jalgaon district of Maharashtra. The proposal is mooted to deploy the state-of-the-art technology and accordingly unit of size 660 MW is being considered with supercritical steam parameters to attain high cycle efficiency. Water would be available from the Ozerkheda Reservoir and transported through pipeline covering a route distance of nearly 18 Km.

The basic plant design would consider unitised concept as far as possible. Judicious provisions would be considered for reasonable spare capacities in various systems and system components and inter-changeability of equipment / system. State-of-the-art technology has been considered for design of the proposed station. Basic design parameters for equipment and systems are as follows:

(a)	Ambient temperature, Extreme	:	
	High		50 °C
	Low	:	13°C
(b)	Seismic zone as per IS:1893	:	III
(c)	Cooling water inlet temperature	:	33 °C (max.)
(d)	Instrument air/plant air	:	Oil-free (instrument air – moisture free)
(e)	Power supply to drives (3 Ph, 50 Hz)	:	Upto 160 KW rating at 415 V. Above 160 KW and upto 1000 KW at 3.3 KV.

1000 KW & above at 11 KV.

(f) Control voltage for electrical equipment : At 220 V D.C. (unearthed)

(g) Power supply for control and Instrumentation : At 24 V D.C.

5.2 SELECTION OF TECHNOLOGY

For the proposed station, one (01) unit of 660 MW has been planned with supercritical steam parameters. MAHAGENCO have already started developing three supercritical units of 660 MW capacity each at Koradi Expansion Project. The choice of supercritical units is guided by mainly the increase in combustion efficiency compared to sub critical units.

For the present study, the details of power cycle equipment for 660 MW supercritical units are given below:

Boiler	Once-Through
Turbine	1HP+1 IP+1LP
Generator (MVA)	780
Turbine Cycle Heat Rate	1850 Kcal/kW.Hr
LP Heaters	Three (03) to Four (04) Nos.
HP Heaters	Two (02) to Three (03) Nos.
Deaerator	One (1) No.
Condensate Extraction Pumps	3 x 50%
Boiler Feed Pumps	2 x 50% of BMCR Turbine Driven + 2 x 30% of BMCR Motor Driven
Vacuum Pumps	2 x 100%

Condensate Polishing Units	3 x 50% / 4 x 33.3%
Recirculation Pumps	Two (02) Nos.
Condenser Cooling Water pumps	3 x 50 % Concrete Volute type or 4 x 33% conventional type.
Auxiliary Cooling Water Pump	2x100%, Vertical Wet pit type

The steam parameters and basic inputs are as under:

5.2.1 660 MW Supercritical

Main Steam	:	255 kg/cm^2 (Abs), 568°C (min)
Reheater Steam	:	*, 596°C (min.)
Feed Water Temperature	:	180.0 °C (BFP Outlet)

* Bidder to specify reheat pressure.

The above values are subject to change as per manufacturer's design conditions. Approximate improvement in heat rate on weighted average basis as indicated for 660 MW supercritical sets over conventional sub-critical 660 MW machine is about 2.5%. The advantage in improvement in heat rate is however marginally eased out by high investment requirement. The high capital investment requirement for supercritical Steam Generator and Turbine Generator set is attributable to high priced quality alloy steel involved. With the improvement in cycle efficiency and incentive for CDM available and the environmental benefit attainable, the supercritical unit is preferred to subcritical unit. However, it is expected that with considerable R&D efforts underway, the cost of superior quality of high-creep strength martensitic steel (P91, P92 and P122) would taper off by the turn of this decade. Considering above points, it is decided that the proposed 1x660 MW station of MAHAGENCO at Bhusawal shall be of supercritical technology.

5.3 THERMODYNAMIC CYCLE

As mentioned above, considering the operational experience of large sized units in the country, burning high ash coal with reasonable thermodynamic efficiency backed by high availability, it is considered prudent to opt for higher overall efficiency with steam parameter in the super critical range. In line with the established practice now coming up globally, super critical plant manufacturers have developed designs of 600 MW / 660 MW / 800 MW & 1000 MW sets using coal as main fuel and are gaining preference of the planners in the country.

For the proposed station, the fuel considered is coal from Machhakata coal blocks in Orissa to be transported by rake load of BOX-N wagons on railway. The thermodynamic cycle will consist of super critical Steam Generator, the Steam Turbine, the condenser, the Condensate Extraction and Boiler Feed Systems, the condensate and feed water heaters along with all other necessary equipments for single reheat, regenerative feed heating system.

EXHIBIT III shows the Typical Process Flow Diagram of Steam And Water system envisaged for the proposed 660 MW unit. A single reheat steam cycle with regenerative feed heating system is proposed. A typical feed heating scheme with 3 HP Heaters, 4 LP heaters and one direct contact heater – De-aerator are presented in the drawing. Project specific HMBD (Heat Mass Balance Diagram) shall be provided by Turbine vendor. A Typical Heat Mass Balance Diagram for 660 MW is shown in **EXHIBIT II**. Heat mass balance diagram is based on 'Zero' make-up, 33 ^{0}C condenser cooling water inlet temperature with condenser backpressure of 0.11 bar Abs.

As shown in the scheme and heat mass balance diagram, the main steam from the Boiler, after expansion through the HP Turbine, would be sent back to the Boiler for Re-heating. The Reheated steam, after expansion through the single casing IP Turbine & then through one double flow LP casing would

be exhausted into the main Condenser. The exhaust steam from the LP Turbine would be condensed by circulation of cooling water. Vacuum would be maintained in the condenser by two (02) (1 working + 1 standby) 100% capacity Vacuum Pumps. The LP feed heating system would consist of three (3) to four (4) stages of Low Pressure Heaters, one (1) Gland Steam Condenser, one (1) Drain Cooler for the low pressure heater, Drain Flash Tank and one (1) De-aerator. HP feed heating system will consist of three (3) High Pressure Heaters. However, number of heaters may vary from manufacturer to manufacturer. The condensate from the hot well would be extracted by 3 x 50% capacity Condensate Extraction Pumps (2 working + 1 standby) and pumped to the Deaerator through Gland Steam Condenser, Drain Cooler and the LP heaters. The feed water after being deaerated in the Deaerator would be pumped to the Boiler through the High Pressure Heaters. Provision would be kept for dosing hydrazine solution in the Condensate Extraction Pump discharge and in Deaerator feed tank or Boiler feed suction line for oxygen scavenging and pH control of the feed condensate steam cycle. 2x50% of BMCR Turbine driven & 2x30% of BMCR motor driven BFP with booster pump mounted on common shaft is envisaged. Normally the steam turbine driven pumps would be in operation. The Boiler Feed Pumps would be provided with lube oil system, automatic leak off and minimum flow re-circulation valves. Motor driven Boiler Feed Pump would be provided with modulating variable speed hydraulic coupling. Condensate drain from the HP Heaters would be cascaded to the Deaerator feed storage tank and the condensate drains from the LP Heaters would be cascaded to the Condenser through the Drain Cooler.

The auxiliary steam for the station would be divided into two sub-systems, One Boiler Auxiliary Steam (BAS) and other Turbine Auxiliary Steam (TAS). Both BAS & TAS would receive steam supply after pressure reducing & desuperheating from Boiler final SH & CRH line. The auxiliary steam supply system of the unit would supply steam to the Deaerator, Turbine Gland Sealing System during low load and start-up conditions. Auxiliary steam will also be supplied for soot blowing, atomisation system etc.

The units will also be provided with HP and LP Turbine bypass system for quick start and large load rejections. The Turbine Generator units would be so designed that these will be capable of cyclic duty and frequent start-ups and shutdowns during the lifetime. The salient features and parameters of major equipments of the 660 MW set are furnished hereinafter. The details of the unit may vary to some extent as per vendor's standard product. The basis of technical parameters of the main plant and auxiliary equipments are discussed hereunder which describes the general requirements but is not intended to be exhaustive.

5.4 TURBINE GENERATOR UNIT

5.4.1 Steam Turbine Plant

The Turbine component and its auxiliaries will be designed and selected to meet the stringent requirements in respect of superior thermal performance, excellent product reliability and operational flexibility.

The Turbine manufacturer will have Turbine designed based on modular design approach that divides the Turbine into three main parts:

(a) High pressure (HP) section

(b) Intermediate pressure (IP) section and

(c) Low pressure (LP) section.

5.4.2 Turbine

The proposed Turbine will have one HP, one IP and one double-flow low-pressure casings. All components will be selected based on long-proven records and standardized modules. The Turbines will be of the tandem compound design. The individual shafts of the cylinders and the generator rotor shaft will be coupled rigidly together and all the shafts will be machined

from single forgings. The HP/IP/LP Turbines will be supported on Fixed/spring mounted/supported foundation. The turbo-generator set would be designed for a maximum throttle steam flow at Turbine Valve Wide Open (VWO) condition of 105% of Turbine Maximum Continuous Rating (MCR) flow.

5.4.3 HP Turbine

The HP Turbine will be designed with single flow. This will have a double-shell casing consisting of inner casing carrier and barrel-type outer casing. Main steam to the HP Turbine will be supplied through two combined stop and control valves. The exhaust branch will be located below the turbine.

5.4.4 IP Turbine

The IP Turbine will be designed with double flow. This will have a double-shelled casing with horizontally split inner and outer casing. Reheat steam will be admitted through two combined stop and control valves of the turbine. The valves will be arranged on either side of IP casing. The exhaust branches will be on the top of the casing. The steam flows to the LP Turbine through a crossover pipe.

5.4.5 LP Turbine

The LP Turbine will comprise horizontally split multi shell casing. The outer casing will consists of two end walls, a bracing system, the top half and the sidewalls. The inner casing will be double shell axially split supported by support arms that are bolted to it and that rests on the bracket supports of the bearing pedestals. The bearing pedestals will be mounted on the foundation. They will carry the shaft seal casings, which shall be joined to the outer casing by means of expansion joints.

5.4.6 Valves

The HP Turbine will be fitted with two combined stop and control valves and one overload control valve for main steam admission. Two combined stop and control valves will be installed at the IP Turbine for hot reheat steam admission.

Each combined valve consists of a stop valve and a control valve that will be mounted on a common body. Every stop valve and control valve will be equipped with an electro-hydraulic-actuator. The main steam valves will be directly mounted on the HP Turbine. A quick acting HP and IP bypass station would be provided as a part of the Turbine package.

5.4.7 Gland Steam Sealing System

A fully automatic Gland Sealing steam supply system will be provided for the TG Set and the Turbine driven BFPs. HP & IP Turbine shaft glands will be sealed to prevent escape of steam into the atmosphere and the LP Turbine Glands will be sealed for preventing leakage of atmospheric air into the Turbine. Steam will be used for sealing these spring backed labyrinth glands.

During start-up and low loads (say 40% load), seal steam will be supplied to the Turbine glands from the auxiliary steam header or cold reheat line through a seal steam-regulating valve. During normal operation (above 40% load), the HP and IP Turbines will be of self-sealing type and under that condition the auxiliary/CRH steam source will be cut off and the leak-off steam from HP and IP glands will be used for sealing the LP glands. The excess leak-off steam shall be led to the Condenser. A Gland Steam Condenser will be provided to condense and return to the cycle, all gland leak off steam including that from BFP Turbines. A desuperheating type bypass will be provided during outage of Gland Steam Condenser. 2x100% capacity vapour exhausters will be provided to remove non-condensable

gases from the Gland Steam Condenser. The exhaust gases will be led over the TG hall roof level.

5.4.8 Shaft Glands

All shaft glands will be of the axial flow labyrinth type. The glands on the LP Turbine will be mounted in gland casings that will be bolted to the bearing pedestals.

5.4.9 Lube Oil System

The oil system will supply oil for lubrication and cooling of Turbine and Generator bearings, and to the hydraulic shaft turning gear during start-up and shutdown. This system will be provided with AC & DC powered oil pumps. To improve lubrication of the bearings during start-up and shutdown, a jacking oil system will be installed which also supplies motive oil to the hydraulic turning gear with hydrometric gear motor.

A separate, self-contained high-pressure fluid system with dedicated pumps will be provided for valve actuation. The system will specifically include the following:

(a) The Main Oil Pump will be centrifugal / gear type. The Turbine shaft will directly drive it. It will have sufficient capacity to handle lube oil requirement of the bearings and emergency seal oil requirements.

(b) 2 x 100% AC Aux Oil Pumps for start-up, slowdown of TG unit and as standby to MOP for automatic operation. These pumps will be in service during start up till the main oil pump takes over.

(c) 1 x 100% DC Emergency Oil Pump for meeting lube oil requirements of bearings during emergency with automatic starting on low lube oil pressure preset value.

(d) One (1x100%) each AC & DC Motor Jacking Oil Pumps will be provided to lift the rotor at the bearing during turning gear operation.

The unit will be provided with an oil tank of sufficient capacity for oil charges, 2 x 100% duty vapour extraction fans. The 2 x 100% capacity Oil Coolers will be provided for oil cooling.

A lube oil purification unit will be permanently installed for the unit for the total oil charge on a continuous basis.

5.4.10 Turbine Control Fluid System

For the governing and control system of the Turbine, a complete self-contained control fluid system will be provided. Fire resistant fluid will be employed to eliminate fire hazards. The system will comprise:

(a) A control fluid reservoir of adequate capacity to ensure fluid supply.

(b) 2 x 100% AC Motor Driven Pumps to pump the fire resistant fluid from the reservoir.

(c) 2 x 100% capacity control fluid coolers designed for service with DM water.

A control fluid purifying unit will be provided for the turbo-set for purifying at least 2% of the total fluid charge in the system per hour on a continuous bypass basis. 2 x 100% capacity AC motor driven purification pumps to circulate oil through purification system will be provided. Necessary filters, strainers, piping, fittings, valves and instruments shall be provided.

5.4.11 Governing / Regulation Systems

The Turbine will have throttle or nozzle controlled type Governing. The Steam Turbine Generator unit will be equipped with an electro-hydraulic Governing System backed up by 100% mechanical-hydraulic or electro-hydraulic control system. The Governing System will be highly reliable and operationally safe and it will be capable of controlling with stability, the speed of the Turbine at all power outputs between zero and the specified maximum power output when the unit is operating isolated, or the energy input to the Steam Turbine when the unit is operating in parallel with other units in the grid. The Turbine Governing System will be designed for high accuracy, speed and sensitivity or response. The Governing System will limit the over speed of the Turbine on loss of full load to value less than 8% of the rated speed.

5.4.12 Turbine Drain System

To avoid thermal stress and possible deformation of the Turbine casing, the condensate produced by the condensing steam during warm up of the Turbine will be discharged into a standpipe of the condenser.

5.4.13 HP – LP Bypass Station

60% (BMCR) HP and LP Turbine bypass station will be provided to act not only as a protection to the Turbine during pressure rise resulting from sudden load throw-off but also to enable operation of the unit at loads lower than the control load. Further HP/LP bypass will permit quick, repeated hot starts of the unit on its tripping.

The LP bypass station will be connected to the hot reheat line and discharges the steam into the Condenser. The hot reheat steam will be desuperheated by means of condensate injection. The bypass system shall be in operation when the Steam Turbine is not able to receive the entire steam quantity, e.g. during start-up or in case of a load rejection. The HP and LP bypass stations will be capable of meeting the following requirements:

(a) Quick start up of the Steam Generator from cold, warm & hot conditions.

(b) Parallel operation of the bypass with Turbine under large load throw-off.

(c) House load operation followed by large load throw-off.

(d) To keep the Steam Generator in operation so as to avoid a trip out of the Steam Generator following full load rejection.

5.5 CONDENSING PLANT

5.5.1 Condensing Equipment & Accessories

The function of the Condenser is to condense the steam exhausted from the LP cylinders and to produce and maintain as high a vacuum as possible in order to increase the enthalpy drop, which can be utilized in the Turbine.

5.5.2 Design Features

The Condenser will be a single-flow box-type surface condenser with water boxes on each end. The steam space will be of rectangular cross-section to achieve optimum utilization of the enclosed volume for the necessary condensing surface. The Condenser will be located below the LP Turbine and form an integral part of it.

The steam dome, shell and hot well are steel fabrications, like the water boxes. The Condenser will be fixed supported on the foundation beneath.

The double-flow LP Turbine outer casing will be connected to the condenser through the steam dome. The steam dome will be welded to the exhaust

casing of the Turbine with the result that the LP Turbine cylinder and the condenser form a unit.

The direction of circulation water flow will be at right angle with the turbine axis and in one pass. The Condenser tube bundles, on which the exhaust steam from the Turbine condenses, will consist of straight tubes with smooth surfaces and running right angle with the turbine axis in the steam space of the Condenser. The Condenser tubes rest in tube support plates at regular intervals along their length to prevent impermissible tube vibration when the condenser is in service. Tube sheets on the circulating water inlet and outlet sides will act as partitions separating the steam space from the cooling waterside. Both ends of the tubes, through which circulating water flows, are roller-expanded into the tube sheets. On the cooling waterside, the water boxes will be provided with a coating to prevent contact corrosion.

The Condenser tubes will be divided into tube bundles designed to promote uniform flow. The following general aspects of possible improvements will be considered:

(a) Lowest possible Condenser inlet pressure influenced by the pressure drop between the LP Turbine diffuser and condenser tubes, the heat transfer coefficient of the tubes and the activation of the entire heat-exchange surface

(b) Smallest possible condenser heat losses.

(c) Minimized oxygen content in the condensate.

5.5.3 Air Extraction

The unit will comprise of 2x100% (1 working +1 standby) vacuum pumps along with all accessories and instrumentation for condenser air evacuation. The Vacuum Pumps and accessories will be used to create vacuum by removing air and non-condensable gases from steam condenser during

plant operation. Vacuum Pumps will be of single / two- stage liquid ring type with both stages (if two-stage pump is selected) mounted on a common shaft. Vacuum Pumps will be sized as per latest HEI requirements.

5.5.4 Condensate Extraction Pumps

The unit will have 3 x 50% capacity motor driven Condensate Extraction Pumps (two operating and one standby). The Condensate Pumps will be vertical canister type, multistage centrifugal diffuser design with a double suction first stage designed for condensate extraction service having low suction head requirement. The pumps will discharge through check valve and motor operated stop valves into a common discharge header. Connection for condensate supply to the following major services will be tapped off from this condensate discharge header.

(a) LP by-pass de-superheating spray
(b) Turbine exhaust hood spray
(c) Gland sealing system de-superheating

Condensate will then pass in series through the Gland Steam Condenser and Drain Cooler before being passed through the low pressure Feed Water Heaters.

The pumps will be capable of handling the condensate from the condenser together with feed heater drains when the machine is operating at maximum unit output with HP Heaters out with 1% make-up and discharging this quantity through the LP heaters to the Deaerator. The pump will have adequate margins on capacity and head to cater for most adverse conditions of operation such as:

(a) HP & LP bypass in operation.

(b) HP Heaters out of service and unit operating at its maximum load during an under frequency operation.

5.5.5 Regenerative Feed Heating Cycle

Regenerative feed heating plant will be designed for all operating conditions including transients like sudden load throw-off, HP-LP bypass in operation, one or two heaters going out of service etc. The condensate from the Condenser will be pumped by the Condensate Extraction Pumps through the train of LP Heaters to the Deaerator. In Deaerator, the condensate will be heated to saturation temperature and fed to the Boiler Feed Pump, which increases the feed water pressure to suit the Steam Generator requirements. Finally the feed water is fed to the Boiler through a feed regulating station.

5.5.6 HP & LP Heaters

Regenerative feed heating cycle will consist of LP Heaters, one Drain Cooler, Deaerator and HP Heaters. The number of LP & HP Heaters will be based on the optimisation of feed heating cycle.

Feed water will be heated by uncontrolled Turbine extraction steam from Turbine inter-stage tap-offs and cold reheat line in feed water heaters. The Deaerator will normally be operated under variable pressure on extraction steam from IP Turbine. Each feed water heater will be capable of handling the drains from the preceding heater under operating conditions of the unit.

The equipment will be designed in accordance with latest applicable standard / codes of Heat Exchanger Institute, ASME, IBR etc. The feed water heaters will be of U-tube with all welded stainless steel tubes, surface type and horizontal with integral condensing and drain cooling zones. The HP Heaters will also have desuperheating zone.

5.5.7 Deaerator

Horizontal spray cum tray type or stork type Deaerator with a storage tank will be provided. The Deaerator will be capable of deaerating the dissolved oxygen and carbon dioxide in condensate & HP Heater drains. The minimum capacity of the Deaerator will be 6 minutes between normal operating level and low level with a filling factor of 0.66. The Deaerator will be normally operating by taking extraction steam from IP Turbine except during low load operation and start up when the steam is drawn from the auxiliary steam header.

5.5.8 Boiler Feed Pumps

The unit will comprise of 2 x 50% of BMCR Turbine driven and 2 x 30% of BMCR motor driven Boiler Feed Pump with the booster pumps mounted on the common shaft. Each pump will be designed to give parameters to suit the Steam Generator requirements, such that motor driven feed pump will be used for start-up of unit and will also act as standby BFP. Turbine driven Boiler Feed Pumps will be located at operating floor and the Motor Driven Pump will be located on ground floor and both types will be accessible to Turbine house EOT crane for erection and maintenance. The feed pump will be able to handle feed water of pH 8.5 to 9.5 and of temperature up to 190 ^{0}C (tentative).

The Boiler Feed Pumps will be of horizontal, centrifugal type with single shaft design. The Boiler Feed Pumps outer casing will be of barrel type with end removal. The inner pump assembly comprising of shaft, impellers, stage casings will be capable of being removed and replaced as a unit without disturbing the feed piping. Each feed pump will be provided with ON-OFF / modulating type re-circulation control valve to protect the pump under low flow condition. The Boiler Feed Water system will be designed to operate primarily in an automatic mode over the range of system design loads. The arrangement will provide automatic start-up of one of the standby motor

driven Feed Pump under conditions like tripping of the running TDBFP's and/or discharge header pressure low etc.

Control of the feed flow will be achieved by Throttling the drive Turbine steam inlet control valve in case of Turbine driven pumps whereas hydraulic coupling will be utilized to achieve speed control of Motor driven pumps. Provisions will be made for warm up to standby pump, if required.

5.5.9 Technical Data: Steam Turbine & Auxiliaries

The data indicated below is typical only.

Type	-	Tandem compound
Number of cylinders	-	3
Type of governing	-	Electro hydraulic
Speed	RPM	3000
Rated output (continuous)	KW	660,000
Steam pressure before Emergency stop valve	Kg/cm^2 (a)	247
Main Steam temperature before emergency stop valve	°C	565(min)
Reheat steam inlet pressure	Kg/cm^2	Vendor to specify
Reheat steam outlet temperature	°C	593(min) (To be finalised by Vendor)
Number of LP exhaust connections	-	One
Steam flow required for 660 MW	T/hr	1902
Rated pressure at exhaust of LP turbine	bar	0.11
Rated quantity of circulating water to condenser	m^3/hr	Vendor to specify
Temp rise of circulating water	°C	10 (Maximum)

5.6 STEAM GENERATOR

Super Critical Pressure ("SCP") power plant is envisaged with a view to capture better plant efficiency, minimizing basic fuel coal consumption and most important criteria being the drastic reduction of emission quantities of SO_x, NO_x, CO_2 and particulate matters etc.

The SCP technology have been presently accepted in India and is adopted by NTPC for their SIPAT, BARH (660 MW) and MAHAGENCO for 3X660 MW Koradi Thermal Power Plant using high ash content coal.

5.6.1 Steam Generator Configuration and Technical Features

5.6.1.1 Furnace Type

(a) Two pass / tower type

Furnace configuration is derived from each plant manufacturer's speciality. Two-pass type is mainly adopted in Japan and tower type is typical in Europe.

No significant difference is observed in the applicability to kind of coal. It is because Boiler design can be adjusted in accordance with coal characteristics.

(b) Spiral (plain/bare tube) Wall and Vertical (rifled/ribbed tube) Wall Type.

The principal concern with a variable-pressure/sliding pressure super critical-pressure design is the requirement for once-through operation. The mass flow in the furnace-wall tubes must be sufficiently high to avoid overheating or departure from nucleate boiling (DNB) while

generating steam at sub-critical pressures and to avoid excessive metal temperatures and uneven steam outlet temperatures when operating at super critical pressure at higher boiler loads.

To accomplish these objectives, the spiral-wall design is used for the unit. The principle of the spiral or helical-wall furnace is to increase the mass flow per tube by reducing the number of tubes needed to envelope the furnace without increasing the spacing between the tubes. This is done by arranging the tubes at an angle and spiralling them around the furnace. For instance, the number of tubes required to cover the furnace wall can be reduced to one half by putting the tubes at a 30-degree angle. The centre line spacing or pitch (P) is made the same as on a vertical wall to prevent fin overheating. Additionally, by spiralling around the furnace, every tube is part of all the walls, which means that each tube acts as a heat integrator around the four walls of the combustion chamber.

The spiral-wall concept thus addresses two major challenges of the full variable pressure super critical pressure boiler.

(i) Achieving the required mass flow to avoid overheating and excessive metal temperature by reducing the number of tube circuits.

(ii) Minimizing difference in tube-to-tube heat absorption by exposing each tube to all four-furnace walls.

As an alternative to the spiral-wall design for larger-size steam generators, a certain manufacturer offers a tangentially fired unit with vertical walls consisting of rifled tubes for ease of fabrication, erection, and maintenance. A stable fireball is formed in the centre of the furnace with tangential firing, with essentially equal distribution of the lateral heat absorption on all furnace walls. Unbalances are minimized

and lateral heat absorption patterns are predictable over the entire load range.

Rifled tubing is used in the furnace walls to avoid overheating or DNB at sub critical pressures.

(c) UP type / Benson type

UP type is applied to constant pressure once through boiler and Benson type is applied to variable pressure once through boiler. Variable pressure Benson type boiler is suitable to improve plant efficiency at partial load and flexible operability.

5.6.1.2 Start up System

In the case of UP type (constant pressure) boiler, it is necessary to keep the super critical pressure at boiler and the minimum water flow rate at water wall from the early stage of unit starting in order to prevent the water wall from tube burning-out, while the turbine needs low pressure superheated steam at starting. For these purposes, UP type boiler usually has flash tank drainage start up system and uses de-pressurized steam from flash tank for starting Turbine. This start up system requires so-called ramping operation which means switching operation from starting system to main system during load increasing operation, because this start up system capacity is only around 10% of turbine TMCR. This ramping operation is so complicated operation under the large differential pressure that some valves are required with enough durability.

On the other hand, Benson type Boiler can start from under the low pressure condition because Benson type Boiler has availability of variable pressure operation owing to spiral structure of water wall tube (or rifled tube used for vertical water wall), and circulation system with Boiler Circulation Pump

(BCP) can be applied to this type of boiler. This system can shorten the start up time and heat loss during start up period.

5.6.1.3 Minimum Load with Dry Range / Control Range

Changing point (Benson Point) or dry / wet condition is about 30% TMCR load. Minimum control range is set at 40% TMCR load with consideration of undershoot during load reducing, turn-down of pulverizes, ignition stability etc. There is no difference is spiral water wall and vertical tube water wall in minimum load requirement.

5.6.1.4 Material Selection

The materials for the range of steam temperature to the level of 568°C are already proven. There is no difficulty in technical aspects in material selection.

On the other hand, the applicable materials shall be selected considering the combination of applied temperature and pressure levels.

Table below shows the typical material selection in boiler pressure parts. This material application just shows the general concept and each manufacturer has his criteria considering his design concept.

Temperature Range / Component	At 255 Kg/Cm^{2}A, 568 ^{0}C
Super heater tubes	1-2% CrMo Steels
Re-heater tubes (596°C)	1-2% CrMo Steels Austenitic Steels
Main Steam pipes, headers, valve bodies	2-1/4 CrMo Steels
High temperature re heater pipes	9% Cr Steels

5.6.1.5 Emissions

Coal consumption is reduced with efficiency improvement led by upgrading of steam conditions. Consequently, emission of CO_2, NO_x and SO_x is reduced.

(a) CO_2 emissions

Supercritical plant reduces CO_2 emission at least 2-3% compared to sub-critical plant.

(b) SO_2 emissions

Securing of FGD (Flue Gas Desulfurizer) space and the installation of 275 m tall chimney as per MoEF guidelines.

(c) NO_x emissions

The amount of NO_x emissions is estimated as 300-700 mg / Nm^3 when unit is operating at BMCR.

(d) Particulate Emissions

MoEF guidelines for particulate emission of less than 45 mg/Nm^3 will be satisfied by adoption of high efficiency Electrostatic Precipitators.

5.7 STEAM GENERATOR AUXILIARIES

5.7.1 Draft System

The draft system comprises of two (02) sets of FD fans, each set rated for 60% of BMCR capacity. The FD fans will be axial type, blade pitch/inlet guide vane control arrangement offering a favourable efficiency for regulation purpose. Two (02) Induced Draft (ID) Fans, each rated at 60% of

BMCR flow, will be axial inlet vane control type with variable frequency drive arrangement. The equipment will be complete with lube oil, hydraulic regulations and all other accessories required for continuous operation and all equipment would be suitable for outdoor installation.

5.7.2 Primary Air System

With cold primary air system, it is possible to reduce the capacity of Primary Air Fans (PAF) compared with hot primary air system. Cold primary air system is adopted in all cases.

5.7.3 Pulverized Fuel Preparation System

For firing high ash content abrasive coal, pulverizes of slow speed large capacity bowl mills or ball and race mills will be provided having low auxiliary power consumption and relatively high life expectancy of grinding parts and armour plating. The mills size and numbers will be selected such that on an average one mill remains standby while one of the mills is under maintenance.

Considering the grinding fineness required, it is suggested equipping the mill with rotating classifiers having speed adjustment to control grinding fineness. The firing system will employ latest the ‘state-of-the-art’ burners and permit load variation from 40 to 100% BMCR without use of support fuel. The ratio of fuel and air flow will be controlled. Due to sufficient burner wall distance and the burner swirl direction, operation with low excess air is possible without the risk of wall damage.

5.7.4 Start-up Fuel System

The fuel oil system will be provided for boiler start up; and for flame stabilization during low load operation with or without coal firing. Two (02) types of fuel oils will be used:

(a) Light Diesel Oil (LDO) oil for boiler start up (up to 10% of BMCR) and

(b) Heavy Fuel Oil (HFO) for low load operation and flame stabilization (40% of BMCR), as necessary.

5.7.5 Electrostatic Precipitators

It is proposed to install high efficiency electrostatic precipitators having an efficiency that will limit the outlet emission to 45 mg/Nm^3 (max) while the boiler is operating at its BMCR, firing worst coal having maximum ash content.

The electrostatic precipitators will have four (04) or more parallel gas streams, isolated from each other on the electrical as well as gas side and will be provided with gas tight dampers at inlets and outlets of each stream, so as to allow maintenance to be carried out safely on the faulty stream, while the unit is working. Electrostatic precipitator will be provided with microprocessor based programmable type rapper control system and ESP management system to ensure the safe and optimum operation of ESP. ESP transformer rectifier sets will use high fire point oil as the cooling medium. The dust collection hoppers at all strategic locations will have a minimum storage capacity of eight (08) hours. The hoppers will have heating arrangements to prevent ash sticking to the sloping sides and down pipes. Level indicators to indicate and trip the ESP in case of high ash levels in the ash hoppers, which will jeopardize the safety of ESP otherwise.

5.7.6 Flue Gas De-sulphurizing System (FGD)

Space provision for the FGD system, to be installed in future (if required), will be kept behind the chimney. The design and layout of steam generator and its auxiliaries will be such that a wet/dry flue gas desulphurization system can be installed, taking suction from duct after ID fan and feeding the desulphurized flue gases back to the chimney with provision for bypassing the FGD system.

The steam generator is designed to achieve the maximum continuous rate (BMCR) with an appropriate control margin. The steam generator performance data at VWO and firing design coal are listed below. The data mentioned below is indicative and each supplier will offer the data for the machine being offered.

Technical Data: Parameters of Boiler and Auxiliaries (Typical)

Particulars	**Units**	**Boiler MCR**
Boiler capacity	TPH	2100
Outlet Pressure	$Kg/cm^2(a)$	255
Temperature	Deg C	568 °C
RH Pressure	Kg/cm^2	45
Temperature at outlet	Deg C	596 °C
Temperature at Econ inlet	Deg C	303 °C
Ambient air temp (design)	Deg C	35 °C
Excess air	%	20
Gas temp at APH outlet	Deg C	>130
SH temp Control		By spray / As per manufacturer's practice
RH temp Control		As per manufacturer's practice
Soot blowers (steam operated)		Adequate No. of wall type, long retractable and half retractable
Safety valves		As per IBR
FD fans	Nos./Type	2 / Axial Blade pitch/Blade pitch control with Variable Frequency Drive.
ID fans	Nos./Type	2 / Axial Blade pitch control and Variable Frequency Drive.

6.0 AUXILIARY SYSTEMS

6.1 INTRODUCTION

The philosophy of design of the auxiliary system would be pre-dominantly guided by the site features, technology, basic design parameters, infrastructure and ambient. Adequate redundancy shall be adopted to ensure high availability of the plant.

All the systems and system components would be designed for simplicity of operation and ease of maintenance so as to call for minimum manual labour and low degree of supervision. Redundancies in systems and sub-systems would be considered taking into account the operating experience of similar capacity units being operated elsewhere.

6.2 PLANT WATER SYSTEM

The source of water for 1x660 MW shall be considered from Ozerkheda Reservoir about 18 Km away from plant site.

The cooling water requirement for the proposed 1x660 MW station is about 78900 M^3/HR of water.

Water analysis data as available and furnished earlier would form the design basis for finalising the Plant Water System. For the purpose of the present study the cooling and consumptive water requirement have been estimated and presented in **ANNEXURE VI**. The estimates are based on the Raw Water Analysis given in **ANNEXURE V.**

The raw water requirement is based on consumptive requirements like, power cycle make-up, potable use, Cooling Purpose, Fire Fighting System purpose etc. Water will also cater to the requirement of Air Conditioning and

Ventilation Plant, Coal Handling, Ash Handling Systems and other Auxiliaries.

Raw water would be treated in Clariflocculators and Filtration plant. Clarified water would be passed through Sand Bed Gravity Filters where adequately sized filter beds with redundancy in number as well as capacity shall be provided. Ozonisation System shall be provided for Pre-Treatment Plant. The water quality at the outlet of the filtration units shall be maintained within 2 NTU. Filtered water would be stored in a RCC tank with storage capacity of 24-hours (1 Day Storage) filter water requirement for the station. Filtered water will be required for DM plant, Non – DM Plant (Cooling Purpose), Service and Potable use.

DM water will be used for Heat Cycle Make-up, Chemical Feed System, HP Dosing, LP Dosing & DM Closed Cycle Cooling Water Make Up.

Non – DM water will be used to cool primary coolant in heat exchangers for the Auxiliary Cooling System of Boiler (SG auxiliaries), TG auxiliaries and other common auxiliaries. The heated DM water would be subsequently cooled in Plate Type Heat Exchangers using filtered water from Cooling Tower basin through a set of Auxiliary Cooling Water Pumps in the secondary circuit.

Cooling water in circulation is estimated at 78900 m^3/hr including the requirement of auxiliary cooling circuit. The makeup water requirement for cooling circuit at full load is estimated about 1946 m^3/hr. A Cycle Of Concentration (COC) of 5 has been considered in the CW circuit. The Cooling Tower blow down is expected to be about 341 m^3/hr. Ozonisation System shall be provided for Cooling water System. CT blow down would be led to the Blow Down Cooling Pit where Boiler Blowdown & Cooling Tower Blowdown will be mixed & led to guard pond.

Out of total waste water collected from different effluent sources (like Cooling Tower Blow Down, Boiler Blow down, DM regeneration, CPU regeneration),

a portion of the wastewater shall be used for Service Water System, Coal Handling Plant (Dust Suppression & Extraction), Ash Handling System and Horticulture and the balance quantity, if any, shall be disposed after necessary monitoring as per MoEF norms.

Backwash from Gravity Filters, Activated Carbon Filters and re-generation effluent from DM Plant, CPU would be neutralized before being led to Guard Pond. Attempt will be made to attain zero discharge under normal operating conditions.

6.3 DEMINERALISATION PLANT & HEAT CYCLE MAKE-UP SYSTEM

The basic scheme of Demineralization System plant is shown in flow diagram provided in **EXHIBIT VI & EXHIBIT IV .** Assuming average 1% make-up for the Heat Cycle make up, a DM Plant with two (02) (1 W + 1S) chains each of capacity 60 m^3/hr capacity has been envisaged for the proposed TPS. DM Plant shall supply to Heat Cycle make-up. Filtered water will be pumped to the DM Plant for Demineralization Purpose. In DM Plant, water would be first filtered and then would pass through Activated Carbon Filter, Cation Resin Bed Exchanger, Degasser tower, Anion Resin Bed Exchanger and Mixed Bed Exchanger. After Demineralization treated water will be stored in DM tanks (MSRL) for distribution to different consumption points. Acid and Alkali Handling, Storage and Feeding system will be installed for resin regeneration.

6.4 COAL HANDLING SYSTEM

The Coal Handling System (CHS) for the station is designed to operate with coal from Machhakata coal blocks in Orissa to be transported to the plant by rail route. Two number of wagon tipplers shall be installed for unloading coal. Coal at mine end shall be beneficiated and loaded on rakes of BOX-N wagons and unloaded at the station by two (02) nos wagon tipplers. For the purpose of equipment selection, raw coal with quality mentioned in Section III of the report has been adopted.

The scheme of the proposed Coal Handling System is shown in **EXHIBIT VII**. Adequate redundancy has been adopted to ensure uninterrupted operation of this vital auxiliary system.

The following are the salient points of design basis of the Coal Handling Plant:

Sr. No.	Salient Points	Design Coal
(a)	Gross calorific value	3731 Kcal/Kg
(b)	Gross calorific value Of Worst Coal	3500 Kcal/Kg
(c)	Maximum daily consumption of coal at MCR	9640 TPD
(d)	Annual coal requirement for proposed 660 MW station with 330 days running per year	3.18 Million Ton
(e)	Maximum size of coal delivered	(-) 300 mm
(f)	Mode of coal transportation	By rail route from the mine to plant in BOX-N rakes.

The plants and equipment of CHS would be designed for about 8 hours operation. The design capacity of Coal Handling System, both for receiving and handling, would be 1200 TPH. With the plant operating at MCR, maximum 8 hours operation will be required. The stacker / reclaimer capacity considered will be 1200 TPH. Coal of 300 mm size would be sized to (-) 20 mm in the Crushers. The crushing plant would be equipped with Wobbler feeders followed by Impact type Crushers. Crushed coal would thereafter be led either to the Boiler Bunkers or to the Stack Yard. The reversible stacker-cum-reclaimer would be rail-mounted, self-propelled unit with about 40 m boom length having adequate slewing and luffing provision to stack coal up to a height of 10 m and reclaiming the same afterwards. For the proposed station, one (01) no. Stacker-Cum-Reclaimer is proposed. In the main route, coal would be directly taken to the powerhouse bypassing the coal stack.

This arrangement would be operational under normal conditions during daylight hours till the Bunkers are full. Excess quantity would thereafter be stacked in the yard. In the other route, crushed coal from stack would be transported to the coalbunkers through reclaimer. In case of emergency, twin 100% capacity stream of conveying system is proposed to ensure high availability. Bunkers would have a storage capacity of about 16 hours coal requirement for the Boiler. The Bunkers will be provided with SS liners and rod and slide gates, arch breakers etc. to facilitate operation. Necessary belt weighing at Bunker level conveyors, electronic type level indicators, coal sampling units, reversible conveyors, flap gates etc. would be provided in the system as required. Wagon Tipplers, Stacker-cum-Reclaimer, Apron Feeders, etc. shall have hydraulic direct drives.

Special precautions will be taken for pollution control by providing dust extraction and dust suppression systems at different transfer points and ventilation system for underground tunnels. In addition, roof extraction fans will be provided in key areas like Boiler bunker floors. Pressurized ventilation system with unitary air filtration unit will be provided for control room and MCC buildings.

Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc. will be provided for distributing water at all transfer points, control rooms etc. Adequate Fire Fighting / Fire Detection System shall also be provided.

A centralized Control Room with microprocessor based control system is envisaged for operation of the Coal Handling System. This will be located near the Crusher House. Except locally controlled equipment like dust extraction / dust suppression / ventilation equipment, sump pumps, water distribution systems etc. all other in-line equipment would have provision of remote control. However, provision of local control would also be provided. All necessary interlocks, control panels, MCCs, mimic diagrams etc. will be provided in the main control room for safe and reliable operation of the Coal Handling System.

The major equipment for the Coal Handling System is listed below:

(a)	Two (02) nos. Wagon Tipplers	:	25 Tips / Hrs. capacity each
(b)	Conveyors	:	Twin stream conveyor line of 1200 TPH.
(c)	Stacker-cum-reclaimer (Reversible)	:	One (01) No. of 1200 TPH capacity.
(d)	Two (02) nos. Apron Feeders	:	1200 TPH capacity each
(e)	Reversible conveyors and belt feeders	:	As required
(f)	In-line magnetic separators	:	Two (02) Nos.
(g)	Wobbler Feeders	:	Four (04) Nos.
(h)	Crushers	:	Four (04) Nos.
(i)	Metal detectors	:	Two (02) Nos.
(j)	Belt weighers	:	Four (04) Nos.
(k)	Coal sampling unit	:	Two (02) Nos.
(l)	Flap gates, rack & pinion gates, etc.	:	As required.
(m)	Level indicators	:	Electronic type.
(n)	Chute liners and chute supporting structures	:	One lot
(o)	Bulldozer	:	Two (02) Nos.
(p)	Locomotives	:	Two (02) Nos
(q)	Augur Coal Sampling System		
(r)	Elevators in Crusher house and in Transfer Point near Bunker Bldg		

6.5 ASH HANDLING SYSTEM

The ash generated in the furnace by burning coal needs to be removed periodically / continuously to avoid undue build-up in the furnace bottom / flue duct hoppers and resultant obstruction.

Ash Handling System of the proposed Power Station is described below:

Under the proposed system, a wet extraction and wet disposal is considered for bottom ash. For coarse ash (Eco, APH & duct hopper) wet disposal is considered. For the fly ash, vacuum-pressure system is envisaged to convey the same up to HCSD silo & ash utilisation silo in dry mode. From silo, HCSD system for Fly Ash is considered. The detail of the above system is described below.

In keeping with the design system capacity envisaged for Coal Handling System, worst coal parameters (from Annexure IV) are used for equipment selection of the Ash Handling System. It has been estimated that with worst coal available for this station about 182 tons/hr (max.) of ash would be generated from the proposed station at MCR. Assuming the ratio of ESP fly ash, Bottom ash, APH & ECO 90 : 25 : 5 : 5**,** usual for such application, about 46 tons/hr of Bottom ash, 9 TPH Economizer hopper ash, 9 TPH APH hopper ash and 164 tons/hr Fly ash is required to be removed from the station. **EXHIBIT VIII**, the scheme proposed for the Ash Handling System is shown.

6.5.1 Bottom Ash Conveying System

6.5.1.1 Wet Bottom Ash System

Bottom ash from the furnace would be collected in a water-impounded hopper provided with feed gates, feed hoppers and clinker grinders. The bottom ash clinkers will be ground in clinker grinders and will be transported

by Jet Pumps to Ash Slurry Sump (common for bottom ash and coarse ash) from where bottom ash slurry will be pumped to Ash Pond outside the Plant Boundary at @ 10 km. The design capacity of Bottom Ash Conveying System considered should be adequate to clean bottom ash, APH and economiser hopper ash collected in a shift of eight (08) hours within 2 hours per shift (including sufficient flushing time).

The Jet Pumps would receive high-pressure water from 2x100% capacity bottom ash H.P. Water Pumps. Out of which one (01) HP water pump will be continuously operating for BA cleaning & one (01) pump will be standby. 2x100% capacity bottom ash L.P. water pumps will supply water for seal trough make-up and refractory cooling of Bottom Ash Hopper, sump make-up etc.. The bottom ash H.P. & L.P and 2x100% HCSD LP water pumps for HCSD system are to be located in a common Ash Water Sump which receives make-up water from CT blow down, recycled ash water from Ash Pond and Raw Water System, if required. The seal trough overflow water would be led to BA overflow sump and then to tube settler. Each Jet Pump capacity shall be around 80 TPH (dry ash basis). Total Six (06) nos. jet pumps shall be provided in each 'VVV' type BA Hopper. Out of these Jet Pumps, three (03) will be working and three (03) will be standby.

6.5.1.2 Coarse Ash Handling System

Coarse ash from all duct hoppers, Air Pre-Heaters, Economizer Hoppers, duct hoppers close to ESP and furnace & stack hopper shall be collected in coarse ash tank with feeders ejectors and shall be transported to Bottom Ash Slurry Sump with Jet Pumps (2W + 1S).

6.5.1.3 Bottom Ash and Coarse Ash Lean Slurry Transportation

The bottom ash & coarse ash slurry from Ash Slurry Sumps is transported to Ash Pond by 2x100% Ash Slurry Pump (1 Working + 1 Standby). Since BA cleaning time is 2 hours (including margin), it is envisaged that one slurry pump will be sufficient to remove BA & CA. The Ash Slurry Disposal System

as mentioned is common for bottom ash and coarse ash transportation. The number of ash pumps in series shall be decided as per disposal area location with provision for one more stage for future consideration. Removal of BA & CA either combined or separate shall be decided during detailed engineering.

6.5.2 Fly Ash Handling System

6.5.2.1 Fly Ash Vacuum Conveying System

All ESP hoppers will be provided with Fly Ash Vacuum Conveying Systems having capacity to evacuate fly ash generated in a shift of eight (08) hours within 4 hrs. 40 min. The Vacuum Conveying System shall have four (04) streams operating in parallel, each stream having a conveying capacity of not less than 60 TPH. For each vacuum stream, two (01 Working + 01 Standby) water ring type vacuum pump is to be provided. Below each hopper, one Ash intake valve will be provided to discharge fly ash into the ash-conveying pipeline to be conveyed pneumatically. The ash-air mixture flows through each ash conveying pipeline for collection of fly ash in dry state into a buffer hopper. The fly ash and air mixture flows into a highly efficient bag filter system where almost entire fly ash is removed and discharged into the buffer hopper located below through separation in filter bags in the filter-separator unit. There shall be four nos. buffer hoppers provided. Capacity of each buffer hopper will be 30 Te (30 min. storage capacity).

Necessary transfer hopper with airlock vessels will be provided below the filter separator unit to ensure continuous discharge of fly ash without affecting the operation of the upstream vacuum system. Buffer hopper will have fluidizing pads distributed properly at the bottom to allow smooth flow of fly ash into the downstream pressure conveying system. Suitably sized vent filter will be provided at buffer hopper along with pressure/vacuum relieving equipment.

Necessary vacuum for the system will be created by water ring type vacuum pumps. Air discharged from bag filter separator will be flown into air washer unit for scrubbing of finer ash particles. Clean air will then flow to the vacuum pump.

All ESP hoppers shall be provided with continuous fluidizing system.

6.5.2.2 Fly Ash Pressure Conveying System (Dry)

Dry fly ash from the Buffer Hopper will be conveyed to the terminal Fly Ash Silos either to 2 Nos HCSD silo and 1 No ash utilization silo each having a capacity of 1125 TPH (min) by a positive pressure conveying system. Ash feeder vessels shall be installed beneath the Buffer Hopper and fly ash shall be transported to the terminal Fly Ash Silos thru' pipeline from the Buffer Hoppers via feeder vessels. The total storage capacity of terminal Fly Ash Silos shall be to store fly ash generated in 24 hours. Three (03) nos. terminal Fly Ash Silos shall be provided, each having 6-7 hours effective storage capacity. Among these three silos, two shall be dedicated for HCSD system and one shall be for moist/dry FA removal on truck/wagon. Non lubricated oil free Screw compressors shall provide pressurized air required for conveying. For the proposed unit, six (06) conveying line shall be provided. Among these six, 4 will be working and 2 will be standby. Arrangement shall be made such that each fly ash conveying line can dump fly ash to either of the terminal Fly Ash Silos (HCSD/Ash utilization silo). 6x50% capacity (04 Working + 02 Standby) screw compressors will be provided. Screw compressors shall be oil-free non-lubricated type.

6.5.2.3 Fly Ash Disposal thru' HCSD System

Two silos shall be dedicated for HCSD system. These silos are termed as HCSD silo. HCSD system will be continuous one. Since ESP FA generated (145-150 TPH @ 90% of total ash), each HCSD stream capacity is envisaged as 300 TPH (dry ash basis). Concentration of slurry in HCSD system shall be minimum 60-65%. Two (02) nos. HCSD pumps (1W +1S), Two (02) Nos.

mixing tanks will be provided to dispose FA of unit through HCSD system. HCSD pump shall be single acting triplex piston diaphragm type.

Each HCSD silo shall have three openings. One opening shall be dedicated for HCSD system and two openings shall be dedicated for future use.

6.5.2.4 Dry Unloading of Ash in Terminal Silo (Ash utilization silo)

One silo shall be dedicated for dry/moist unloading of fly ash on truck/wagon. These silos are considered as ash unloading silos. In the proposed system, each ash unloading fly ash silo shall have four (04) outlets as follows:

(a) One outlet with dust conditioner arrangement with rotary feeder/ orifice feeder for unloading dry fly ash into wagons/open trucks.

(b) Two telescopic spout arrangement to discharge dry fly ash in closed tanker.

(c) One outlet for future use.

Dry fly ash unloaded into wagons/trucks is disposed for the purpose of subsequent use like mine-fill, landfill, cement plant, etc. The terminal fly ash silo shall be provided with suitably sized vent filter and pressure/ vacuum relieving equipment as well as suitable vent filter at ash dropout at truck/wagon.

6.5.3 Ash Water Recirculation System

The ash water recirculation system would be provided for the Base System to recycle ash water from the Ash Pond to the plant Ash Handling System after treatment. The system would have the capacity to recycle 100% ash water from the Ash Pond. The system would comprise 2x100% ash water recirculation pumps, a pump house, a clariflocculator, clariflocculator sludge

disposal system, piping, valves etc. as required. The pump house and the clariflocculator would be located at plant area and necessary 2 nos (1W+1S) clean recycle water pumps shall be provided.

6.5.4 Fluidizing Air System

Continuous supply of fluidizing air during ash evacuation has been envisaged in all the hoppers of the ESP and intermediate surge hopper to facilitate smooth and effective ash flow. For this, Fluidizing Air Blowers, 2 nos (1W+1S), of adequate capacity and pressure will be provided. The terminal fly ash silos will have separate independent Fluidizing Air System, 3 nos (2W+1S) at HCSD and 3 nos (2W+1S) at fly ash utilization silo. Fluidizing pads are distributed properly at the bottom of intermediate surge hopper and terminal fly ash silos to allow smooth flow of fly ash into downstream system. The Fluidizing Air System would be complete in all respects with necessary electric air heater, insulated piping, valves and instruments to ensure satisfactory system operation. The in-plant surge hopper will also receive fluidizing air from the ESP hopper-fluidizing blower.

6.5.5 Compressed Air System

Compressed air system for operation of different equipment and control instruments of Ash Handling System would be complete in all respects with 2x100% compressors (non-lubricated oil free screw type), 2x100% refrigerant type air drying system, piping, valves and instruments.

6.5.6 MCC & Control Panel

415 V MCC and control panel for the Ash Handling System would be located inside a separate room of Ash handling System. Ash Handling System operation can be done in automatic sequential manner and / or remote manual mode from the PLC based control panel.

6.6 FUEL OIL HANDLING SYSTEM

Fuel Oil required for the proposed Power Station shall be taken from existing Storage tanks. LDO would be required for light up and Heavy Fuel oil with similar arrangements and steam tracing arrangement for load carrying purpose and also for flame stabilization. The fuel oil handling systems for the proposed 660 MW TPS shall include LDO and HFO day tanks, pressurising pumps.

From the existing storage tanks HFO/LDO would be delivered to day-tanks located near the main plant by means of the existing or new unloading pumps with necessary piping and interconnections.

Pressurising pumps will supply oil from the day-tanks to the Burners. There will be two (02) nos. of HFO and two (02) nos. of LDO Pressurising Pumps, each of 100% capacity to meet the requirement of the Boiler. One (01) no. HFO day tank of capacity 400 m^3 and one (01) no. LDO day tank of capacity 200 m^3 are considered.

All instrumentation and control facilities including tank level controllers, pressure / temperature gauges, control valves etc. along with a local control panel in the Fuel Oil Pump House will be provided for safe and reliable operation of the system.

The Auxiliary Oil System and its facilities will be designed as per Pollution Control / Petroleum Rules / Explosion Acts / Fire Rules of Govt. of India. HFO and LDO analysis is given in Section III. A flow diagram showing the proposed Fuel Oil System is as per **EXHIBIT IX**.

6.7 VENTILATION & AIR-CONDITIONING SYSTEM

Right environment for operation and maintenance of the plant as well as for proper functioning of the equipment, controls and accessories is an

important aspect which has been given due consideration in the proposed Ventilation and Air-conditioning System.

6.7.1 Ventilation System

Adequate Ventilation System has been considered for the Power House Building, ESP control building and other areas like Air Compressor Room, A/C Plant Room, DM Plant Building, Elevator Machine Rooms and various Pump Houses like CW Pump House, Filter Water and DM Water Pump Houses, etc. to achieve the following:

(a) Dust-free comfortable working environment.

(b) Scavenging out structural heat gain and heat load from various equipment, hot pipes, lighting etc.

(c) Dilution of air polluted due to generation of obnoxious gaseous/aerosol contaminants like acid fumes, dusts etc.

Ventilation system proposed for important areas are described below:

(a) Powerhouse

Supply / exhaust ventilation system with evaporative cooling has been recommended for the Powerhouse Building. Ambient air would be drawn through automatic viscous filters, spray bank and moisture eliminator. Air will be supplied by means of centrifugal fans to powerhouse through ducting and grilles to achieve proper distribution. The sprayed water will be re-circulated by means of centrifugal pumps, piping, valves and other accessories. 'Exhaust' system consists of axial flow wall / roof-mounted exhaust fans with rain protection cowl/hood, short ductwork, etc. Part of the supplied air will be exhausted and the rest will ex-filtrate through the various openings in the structure, preventing infiltration of dusty air. This arrangement also

ensures more or less ambient dry bulb temperature inside the powerhouse.

Various rooms in powerhouse e.g., cable spreader room, switchgear room etc. will be ventilated by means of transfer fans or by extending duct as required and found suitable.

The primary and secondary crusher house in CHP area will have adequate louvers for natural ventilation. Coal tripper floors are proposed to be provided with exhaust system to eliminate building-up of hazardous gases like carbon monoxide, methane etc.

(b) ESP Control Building

For ventilation of this building (except the control room), ambient air will be drawn through unitary air filtration unit comprising fresh air intake louvers, automatically cleanable nylon filters (with water spray) and moisture eliminator. In addition to filter cleaning, the water spray will have an evaporative cooling effect too. This will produce some cooling as an added advantage.

The supplied air will be exhausted through wall mounted gravity operated dampers to maintain an overpressure of 1-2 mm of water column to reduce dust ingress.

(c) Other Buildings

Other buildings like ash plant, compressor house, DG set room, air compressor room, A/C plant room, CW pump house, DM plant etc. will be ventilated by means of dry system comprising axial flow fans, dry filter wherever required, cowls, ducting etc. Inside temperature shall be maximum 3°C above the design ambient temperature during summer for mechanically ventilated areas. Fire dampers will be provided as per code wherever there is electrical installation.

For the specific design of motors and associated auxiliaries refer Electrical section of the specification.

6.7.2 Air-conditioning System

Various control rooms in Power Station, housing a group of sophisticated and precision control panels and desks call for controlled environment for proper functioning and for personnel comfort.

The following areas are proposed to be air-conditioned:

(a) Control room, control equipment room / UPS room located at 17 m floor in B-C and C-D bay of powerhouse

(b) Electrostatic precipitator control room

(c) Coal Handling System control room

(d) DM plant and CPU control room

(e) Office area, lecture rooms etc. in the service building

(f) Switchyard control room

To cater to the above requirements the following systems are proposed**:**

(a) A central chilled water plant for the control rooms etc. mentioned under (a), (e) & (f) of above, comprising Compressor, Condenser, direct expansion / flooded type evaporator, Condenser cooling water circulating pumps, Cooling Towers, chilled water circulating pumps, cooling water piping with valves, accessories, fittings etc. has been envisaged. The chilled water produced will be circulated through the coils of air handling unit located near control room.

(b) Separate direct plant will be provided for ESP control room, CHP control rooms and DM plant and CPU control room etc. Each direct expansion plant will be complete with condensing units, air handling units, cooling tower, piping with valves, fittings etc.

(c) Water / air cooled packaged air conditioners will be provided adjacent to respective isolated areas.

6.8 COMPRESSED AIR SYSTEM

Three (03) nos. of Instrument Air Compressors (2W + 1S) of 50% capacity each are proposed for the **BHUSAWAL T.P.S. UNIT – 6: 1X660 MW PROJECT** to take care of continuous and intermittent demand. Normally two (02) Compressors will continuously run to meet the sustained demand of unit and will also serve on automatic mode and will run to meet the intermittent peak demand. Other compressor will be kept as standby. The estimated capacity of each Instrument Air Compressors is 55 Nm^3/min (normal) at 8.5 Kg/cm^2 (g) pressure rating. The Instrument Air Compressors will be oil-free, dry Screw, water cooled, horizontal, two stage, direct driven, rotary screw, continuous duty type, and will be provided with individual Air Receivers to absorb pressure pulsations and for acting as reserve supply of compressed air to permit continued operation following failure of the operating compressor until the standby one comes into service. A Refrigerant type with non cyclic version, fully automatic, continuous duty, Indoor skid mounted dryer unit with 110% capacity of the compressor capacity will be provided for each Instrument Air Compressor for supply of clean, dry air to Control and Instrumentation system.

The station service air requirement for normal cleaning purposes, atomising air medium for warm-up guns and ignitors, motive power for burner drive mechanism etc. of air pre-heaters will be met from separate Service Air Compressors. It is proposed to install 3x50% Service Air Compressors, each of capacity 55 Nm^3/min. (normal) at 8.5 Kg/cm^2 (g) pressure rating. The

Service Air Compressors would be identical to the Instrument Air Compressors and would run in a manner, similar to that described above for the Instrument Air Compressors. Capacities of all the Instrument and Service Air Compressors selected are same, so as to achieve interchangeability of parts. Independent Air Receivers will be provided for each compressor. Plant Service Air System will have suitable inter-connection with the instrument air header for augmenting instrument air supply in emergency. A Flow diagram of Compressed Air System is given in **EXHIBIT X**.

For the specific design of motors and associated auxiliaries refer Electrical section of the specification.

6.9 FIRE PROTECTION SYSTEM

For protection of the plant against fire, all yards and plant will be protected by any one or a combination of the following systems:

(a) Hydrant system

(b) Automatic high velocity and medium velocity sprinkler system

(c) HV & MV water spray (Emulsifier system)

(d) Automatic fixed foam system.

(e) Portable and mobile chemical extinguishers

The system will be designed as per the recommendation of Tariff Advisory Committee (TAC) of the Insurance Association of India. Applicable Codes and Standards of National Fire Prevention Association (NFPA), USA, would also be followed.

In view of vulnerability to fire and its importance in the running of the Power Station, effective measures are to be taken to tackle fire in the following susceptible areas:

(a) The Cable Galleries, and

(b) Coal Handling areas, mainly Coal Conveyors, Transfer Points, Crusher House and Tunnels.

For containment of fire and preventing it from spreading in cable galleries, unit-wise fire barriers with self-closing fire resistant doors will be provided. The ventilation systems, provided in the cable galleries, would be so interlocked with the fire alarm system that in the event of a fire, the ventilation system is automatically switched off. Also to avoid spreading of fire, all cable entries/openings in cable galleries, tunnels, channels, floors, barriers etc. would be sealed with non-inflammable/fire resistant sealing material.

The source of water for the firewater pumps of the hydrant system, water spray and sprinkler system etc. will be raw water. Two (02) electric motor driven firewater Pumps with one (01) diesel engine driven Pump shall be provided for Hydrant system. One (01) electric motor driven firewater Pump with one (01) diesel engine driven Pump shall be provided for sprinkler system. To keep system pressurised two (02) nos. Jockey pumps are considered. Additional Booster Pumps to meet the pressure required at landing valves at higher elevations of boiler floors and coal conveyor transfer points shall be provided. In addition to these, Hydro-Pneumatic Tanks, Compressors, pipes and fittings as required will be provided. The hydrant system will feed pressurised water to hydrant valves located throughout the plant and also at strategic locations within the Powerhouse. Hydrant point shall specifically be provided near Air Pre-Heater.

Inert gas extinguishing system shall be provided to cover the following rooms including area above false ceiling.

(a) Main Plant Control room

(b) Control Equipment Rooms, adjoining computer room

(c) Programmers room

(d) Data storage Room

(e) UPS and Inverter Room

Automatic high velocity Sprinkler Protection System will be provided for cable galleries, Cable Trenches / vaults, Coal Conveyors etc. Automatic medium velocity sprinklers will be used for protection of burner zone of boiler front.

Automatic type water Spray (Emulsifier) Protection System would be provided for the following equipment:

(a) Generator Transformers

(b) Unit Transformers

(c) Station Transformers

(d) Turbine Oil Storage Tanks

Suitable Fire Detection System as necessary for all the above-mentioned Fire Fighting System with adequate supervisory circuitry will be provided. Automatic fixed foam installation is envisaged in Fuel Oil Storage and Handling areas. In addition to these, adequate number of portable and mobile (wheel mounted) chemical fire extinguishers of foam and soda acid type and carbon dioxide type will be provided. Portable units would be placed at suitable locations throughout the plant area. The extinguishers may be used during the early stages of fire to prevent spreading.

6.10 MISCELLANEOUS AUXILIARIES

6.10.1 Turbine Oil Purification System

A suitable centrifuge or other type Of Turbine Oil Purification Plant will be provided as an auxiliary of the Turbo-Generator to condition the Turbine oil continuously, in order to remove the water and other impurities from the system to maintain the Turbine oil at the optimum condition. In addition to the above unit system, a central Turbine oil storage unit comprising one clean oil tank, one dirty oil tank, one purifier unit and necessary pumps, vent fans etc. will be kept. This would also receive the refill of Turbine oil from outside. The Purification Plant to be provided with the unit system will be complete with oil purifiers, storage tanks, filters, necessary pumping sets, vent fans etc.

6.10.2 Condensate Polishing System

The proposed 1 x 660 MW Station will be provided with 100% capacity condensate polishing system. Condensate polisher will comprise four (04) demineralisers operating in parallel. Any three (03) of these units will be capable of treating the full condensate flow at Boiler MCR condition. Condensate polishing will ensure elimination of ammonia, silica, sodium or potassium from the condensate before being recycled to the feed water system. During normal operation, all the polisher units will remain standby. In case of high condensate conductivity, it will be pressed in service when three (03) of the exchanger vessels will be working in parallel and the fourth one will remain isolated from the system. The fourth vessel will act as standby and will be brought into operation when regeneration is required or during any emergency period. The polishing unit would be located at the Powerhouse Building. The operation of the condensate polishing system will be semi-automatic, remote / manual.

The regeneration system will be external. For regeneration, the resins from the exhausted exchanger vessel will be transferred hydraulically to this facility located at DM plant and regenerated resin sent back in the same way.

6.10.3 Chemical Feed System

For maintaining supercritical steam parameters, water chemistry assumes greatest importance. Use of All Volatile Treatment (AVT) programme is adopted with 100% Condensate Polishing Plant which has proven essential for once-through system. Chemical feed system will be provided for feeding neutralising amines and / or hydrazine in the condensate pump discharge / boiler feed suction line to maintain the chemical concentration in the feed water circuit within permissible limits for trouble-free operation of the plant.

The Low Pressure chemical dosing system will consist of:

(a) A mixing tank provided with stirrer and a metering tank

(b) Two (02) full capacity, variable volume metering pumps, complete with suction filters and other accessories and fittings as necessary. These LP pumps will inject hydrazine or other chemicals into the condensate pump discharge / boiler feed suction. Normally one pump will be running and the other will be standby.

(c) Necessary piping, valves, fittings and instruments.

In circulating cooling water system Ozonisation will be done to contain algae growth. Continuous chlorination will be required for the Potable Water System.

6.10.4 Elevators

As mentioned earlier, two goods-cum-passenger elevators will be installed in Boiler area. In addition, two passenger elevators will be installed on either

ends of the Powerhouse Building. Besides, an elevator would be provided for the 275 m stack.

6.10.5 Cranes & Hoisting Equipment

One (01) EOT Crane having 130/40 T capacity is proposed to be provided in the Turbine hall and will be used for maintenance of the TG hall equipment. Jacking / rigging are proposed for lifting Generator stator and heavy equipment.

Conventional and special type of Cranes required for maintenance of certain SG and TG equipment such as FD / PA / ID fans, Condenser water box, ESP Transformer rectifier sets etc. will be supplied by the respective equipment supplier. For Clarified Water Pump House, a crane of 7.5 Tons capacity (pendant operated) has been considered. For Circulating Water Pump House a pendant operated 25 Tons capacity electric Travelling crane has been considered. Two pendant-operated 10 Tons EOT cranes are proposed for ash slurry pump house and store building.

Maintenance cranes / handling devices of suitable capacities have been considered for all other pump houses and other places such as Coal Handling Plant transfer points, DM plant, etc. Monorails for lifting heavy motors and other equipment within the Powerhouse not covered by EOT crane such as Air Compressors, miscellaneous pumps, Heat Exchangers etc. will also be provided. Suitable rails will be provided, if necessary, on floor for bringing the horizontal feed water heaters under the approach of EOT crane.

6.11 ASSOCIATED FACILITIES

6.11.1 Repair Workshop

For achieving higher availability of the plant, the plant maintenance would be done following a concept of unit exchange system for repair and maintenance.

Under this system, the defective components would be replaced immediately by sound ones from the stores. The defective components would thereafter be repaired in the workshop and sent back to the stores. Following this system, two types of activities namely maintenance and reconditioning would be physically separated thereby speeding up maintenance activity.

In order to carry out the repair activities, it is envisaged to provide the following shops:

(a) Main workshop near the main Powerhouse Building.

(b) Electrical and Instrument repair shop housed within the Powerhouse Building or in the workshop.

(c) A repair shop for mobile equipment would be located near the coal storage yard.

(d) Motor vehicle repair shop.

Necessary machinery, tools and tackle required for the nature of repair involved would be provided at all the above shops.

6.11.2 General Stores

Both covered and open space will be required for storage of various materials required for construction as well as operation and maintenance of the plant. While the construction stores will be temporary, the other stores will be permanent. Consumables, tools and tackle and other relevant items required for the 660 MW set size will also be kept in the stores.

The stores will broadly have the following divisions to house material of different categories:

(a) Heavy materials store will house boiler tubes of various sizes, boiler and auxiliary parts, turbine heavy parts, stainless steel plates, conveyor belt and other coal handling equipment spares, dumper and dozer spares, motors, transformer windings, fire fighting equipment, insulators and hardware connectors, copper and aluminium conductors and similar heavy items.

(b) Mechanical, electrical and instrument stores will accommodate small spare parts for mechanical and electrical equipment and instruments respectively.

(c) Fast moving spares store will house electrodes and welding materials, blow lamps, bulbs and light fittings, grease, soap, battery, cotton waste and cloth, brooms, motor vehicle spares, gas cylinders, gloves, aprons, safety belts, goggles, ropes, refill for the fire fighting equipment etc.

(d) Chemical stores will house alum, lime, morpholine/hydrazine resin, spirit and other chemicals required for steam, feed water and condensate system and chemical laboratory.

(e) Civil engineering store will accommodate cement, sanitary materials, filtering sand and filters, pipe and pipe fittings etc. for water supply.

(f) Refractories and lubricants will be stored under separate covered sheds.

Open storage-yard will be provided to store structural steel, rail, sleeper, heavy castings, cable reels etc.

Suitable enclosures will be provided for storing the insurance spares. Arrangements will be made for storing items like relays, motors, and instruments under controlled atmospheric conditions.

6.11.3 Chemical Laboratory & Testing Facilities

A central chemical laboratory in the Service Building is envisaged for the station. This will have necessary equipment and facilities to test and analyze steam, water, oil, fuel etc. required to ensure satisfactory operation and maintenance of the station. The testing and calibration laboratories for C&I and relay-metering will also be housed in the same building, with necessary equipment and standard instruments for chemical analysis of various items, testing of electrical items and testing/calibration of instruments.

6.11.4 Thermal Insulation

Adequate insulation will be provided to reduce heat losses from the equipment, piping and ducts and to ensure adequate personnel protection in critical areas. Insulation would be so selected that the covering jacket surface temperature does not exceed the surroundings ambient temperature by more than 15 °C.

6.11.5 Pollution Monitoring System

Monitoring of various environmental aspects is of prime relevance in setting-up the proposed unit. The following aspects would be critically monitored:

(a) To keep watch on the state of pollution

(b) To generate data for predictive and corrective measures

(c) To quantify environmental impacts

The important area requiring periodic/conditions monitoring are:

(a) Stack emission

(b) Ambiant air quality

(c) Disposed water quality

Electronic smoke density analyser and gas analyser equipment is proposed to be provided for continuous monitoring of particulate matters at the outlet of ESP. Sample analysis of SO_2 and other pollutants from Stack would be carried out. Waste water would be checked for any harmful pollutants before discharging to outfall.

An oil/water separation unit has been envisaged near fuel oil day tank/pump house area in order to keep plant drains free of oil and to reclaim waste oil as far as practicable. Oil thus separated would be returned to the fuel oil tank and used or disposed off by incineration.

Coal Handling and Ash Handling Plants will be equipped with dust extraction / suppression system to combat fugitive dust.

7.0 ELECTRICAL SYSTEMS AND EQUIPMENT

7.1 INTRODUCTION

The proposed 1x660 MW Bhusawal Thermal Power Station Replacement Project will have one generating unit of 660 MW.

Power from the proposed power station will be available at 400 KV level of the new switchyard. This 400 KV switchyard will be constructed by Maharashtra State Transmission Company separately. Power from this switchyard would be evacuated through 400 KV lines.

The 400 KV switchyard of the generating station is to be located in front of the transformer yard as shown in plot plan.

Generator will be directly coupled to the steam turbine and will have a nominal rating of 660 MW at 0.85 p.f.(lag). Generation voltage is considered as 21 KV, 3phase, 50Hz with frequency variation of +3% (51.5 Hz) and –5% (47.5 Hz). Generator voltage may change as per the manufacturer's standard

The generator will be connected to the 400 KV switchyard bus through a 810 MVA, 21 KV/ 420KV generator transformer (GT), comprising 3 single phase unit each having 270 MVA capacity. Connection between generator and GT low-voltage terminal will be done by isolated phase bus duct. The 400 kV terminals of GT will be connected to 400 kV switchyard by overhead conductors. 400 kV Switchyard system to be adopted by MAHATRANSCO is of 1½ breaker scheme.

Three voltage levels viz. 11000 V, 3300 V and 415 V have been envisaged to supply power to unit and common auxiliaries. Electrical power distribution scheme to the plant auxiliaries has been shown in **EXHIBIT XVI, EXHIBIT**

XVII and a brief technical particular of major equipments is given in **ANNEXURE XII**.

During start-up, power will be fed to the unit auxiliaries from the 400 kV grid through the Station Transformers, 11 kV Station Switchgears. At start, unit 11kV switchgear gets power from 11kV Station switchgears through interconnection. On synchronisation of generator with grid, power is fed through unit transformers to 11kV unit switchgear. This will be normal operation for unit auxiliary power.

If due to any reason, any one UT is not available, then only that unit auxiliary will be fed from respective station switchgear through closing of tie breaker. UT will be directly connected to generator bus duct through phase segregated busduct. Two (02) UTs will be rated for 35 MVA (min.), 21/11.5 kV and with ONAN/ ONAF cooling. In order to take care of grid voltage variation, the transformer will be provided with On-Load tap changer.

UTs will supply power to unit auxiliaries like ID fan, FD fan, PA fan, CW pump, Mill motors etc., through required number of 11 kV breakers, 11 kV/3.3 kV, & 11 kV/433 V transformers, along with their respective 415 V power and motor control centres.

7.2 GENERATOR

The generator will be a two-pole, three-phase unit rated for 660 MW at 0.85 p.f. (lag), 50 Hz. The nominal voltage rating considered 21 kV. That may change as per manufacturers' standard.

The Generator shall be capable of continuous safe operation at rated output and power factor under any of the following conditions:

(a) Terminal voltage variation of ± 5% of the rated value.

(b) Frequency variation within 47.5 to 51.5 Hz.

(c) Absolute sum of combined voltage and frequency variation of 5%.

The generator neutral will be grounded through a distribution transformer having a secondary loading resistor limiting the ground fault current to 5-10 amps.

The stator winding shall be cooled by demineralised water flowing inside the hollow conductors of the winding. The rotor winding shall be directly cooled by hydrogen. The stator core shall be cooled by hydrogen flowing through radial/axial ventilating ducts. For cooling of hydrogen, the heat exchangers located inside the generator frame shall be supplied with demineralised water.

Excitation system shall be of state-of-the-art microprocessor based system of latest version. The generator excitation system will be selected to provide the following basic requirements. There shall be two automatic and two manual channels in the DAVR.

(a) Maintain the generator terminal voltage constant within 0.5% of the pre-set value over the entire load range of the machine.

(b) The response time must be short so that the Digital Automatic Voltage Regulator (DAVR) can control the generator during system disturbances or transients in which rapid changes in excitation are required to maintain system stability margins, both in steady state and transient condition.

The excitation system will be of brushless/static microprocessor based type of latest version. The ultimate aim of the excitation system selection will be to achieve an ideal condition in respect of rate of response, simplicity, reliability, accuracy and sensibility.

7.3 TRANSFORMERS

7.3.1 Generator Transformer

The generated voltage as per manufacturer's standard will be stepped-up and fed to 400 kV switchyard by a step-up two-winding generator transformer (GT) connected to the generator through isolated phase bus duct. GT will be a bank of three single-phase units, each rated for 270 MVA; the total capacity of GT will thus be 810 MVA. One spare 270 MVA, single phase unit will be provided. This spare unit will be located in the transformer yard and will be kept charged at no load from 11 kV feeder of station switchgear with protection. The Transformer will have ONAN/ONAF/OFAF type of cooling with 'Off-circuit' tap change system having range of tap of ±5% @ 2.5% per tap. Vector group will be YNd11. The high voltage terminals of the Transformer will be connected to the 400 kV outdoor Switchyard by overhead conductors. Lightning arresters will be provided near HV terminals of the transformer to protect it from atmospheric disturbances.

Selection of the rating of Generator Transformer has been done considering that the full generated power can be transmitted by GT, if it is required at any time.

7.3.2 Unit Transformer (UT)

During normal operating condition of generator under unit concept, the power supply to unit auxiliaries will be given through two (02) unit transformers (UTs). UTs will be directly connected to the generator bus-duct. The unit transformer will be rated 35 MVA (minimum), 21/11.5 kV, ONAN/ONAF cooled, 3-phase, 50 Hz, provided with On load tap change system on the high voltage side to take care of voltage variation to the extent of ±10% @ 1.25% per tap. HV side will be ungrounded and LV side will be grounded through resistor. The capacity of the unit transformer has been selected on the basis of the unit auxiliary load with due consideration to the starting of the

largest motor, available breaker capacity and voltage regulation requirement expected fault level.

7.3.3 Station Transformer (ST)

The station transformer will be of 90/45/45 MVA, three phase, three winding, two (02) nos, 400/11.5/11.5kV, outdoor oil-filled with ONAN/ONAF cooling. The station transformers supply the 11 kV Station Switchgears. The transformers will be provided with On-Load tap changer with ±10% @ 1.25% per tap on HV side. Each Station transformer will be designed for 50% station auxiliary loads with HP-LP bypass load of UT load In case of failure of one UT and one ST with MDBFP running and trips which needs to again starting as per CEA recommendation. Downstream 11 kV distribution system will be designed in such a manner that power supply to all 11 kV switchgear is maintained in the event of the outage of station transformer or bus fault on any one section of 11 kV station switchgear. The station transformer will be Star/Star/star (YNyn0yn0) connected. HV side will be solidly grounded and LV side will be grounded through resistor limiting fault current limited to about 300 Amps.

7.4 <u>BUS DUCT</u>

7.4.1 Generator Bus duct (Isolated Phase)

The generator will be connected with the generator transformer and unit transformer through bus duct. The bus duct will be of isolated phase, continuous type with aluminium conductor in aluminium enclosure. Lightning arrestors and surge protection cubicle of proper rating will be provided at a location as close as practicable to the generator terminals.

The main section of bus from generator to generator transformer will be suitable for 26,000 Amp. The tap-off connection to unit transformers will be suitable for 1600 Amp. The maximum temperature of the bus conductor will

be limited to 105°C for silver plated joints and 90°C for other joints and that of enclosure will be limited to 70°C.

7.4.2 11/3.3 kV Bus Duct (Phase-segregated)

The 11 KV side of Unit Transformer (UT), Station Transformer (ST) & 3.3 kV side of Unit Auxiliary Transformer (UAT), Station Auxiliary Transformer (SAT) will be connected with the associated switchgears through phase segregated bus duct respectively. The maximum temperature of bus conductor will be limited to 105°C for silver plated joints and 90°C for other joints. In case of enclosure the maximum temperature will be limited to 70°C.

The minimum rating of bus duct for connection of unit transformer/ station transformer with 11 kV switchgear is envisaged as 2500/3150 Amps and that of the 3.3 kV switchgear as 2500 Amp.

3.3 KV &11 kV Bus duct for connection between equipment are listed below:

7.4.2.1 11 KV Busduct

(a)	UT-1 and Unit SWGR # 1	:	One (01) set
(b)	UT-2 and Unit SWGR # 2	:	One (01) set
(c)	ST-1 and Station SWGR #1	:	One (01) set
(d)	ST-1 and Station SWGR #2	:	One (01) set
(e)	ST-2 and Station SWGR #3	:	One (01) set
(f)	ST-2 and Station SWGR #4	:	One (01) set
(g)	Unit SWGR#1 and Station SWGR#1	:	One (01) set
(h)	Unit SWGR#2 and Station SWGR#3	:	One (01) set
(i)	Station SWGR#1 and Station SWGR#3	:	One (01) set

(j) Station SWGR#2 and Station SWGR#4 : One (01) set

7.4.2.2 3.3 KV Busduct

(a) UAT-1 and 3.3 kV Unit Aux Switchgear : One (01) set

(b) UAT-2 and 3.3 kV Unit Aux Switchgear : One (01) set

(c) SAT-1and 3.3 kV Station Aux. Switchgear : One (01) set

(d) SAT-2 and 3.3 kV Station Aux. Switchgear : One (01) set

7.4.3 Power Supply Arrangement to Unit & Common Auxiliaries

The power supply to unit auxiliaries will be from the 11 kV & 3.3 kV Unit Switchgears fed by the unit transformer (UT) & Unit Auxiliary Transformer (UAT). UT will be directly connected to the generator bus duct. The capacity of the unit transformer (UT) & Unit Auxiliary Transformer (UAT) have been selected on the basis that the unit auxiliary load and common auxiliaries corresponding to the maximum continuous rating of the unit with due consideration to the starting of the largest motor, system fault level, available breaker capacity and voltage regulation requirement.

The station auxiliary loads will be fed from the 11 kV/3.3 kV station switchgears located in powerhouse. Separate 11 kV, 3.3 kV and 415 V switchgears will feed the loads for Coal Handling Plant, Ash Handling Plant, WT Plant etc., located in the respective plants as required. HT and LT power distribution scheme is shown in the above referred drawing.

Motors rated 160 kW and below will be supplied from 415 Volts system. For this purpose, 11 kV/433 Volts, 3 phase, 50 Hz, dry-type LV auxiliary transformers rated 2.5MVA, 2 MVA, 1.6 MVA and 1 MVA will be used as required. These transformers will receive power from the 11 kV, 3.3 kV/433 Volts or 3.3 kV buses. The LV side of these transformers will be connected to the respective LV Switchgear / Power Control Centre (PCC) / Power-cum-

Motor Control Centre (PMCC) through non-segregated phase bus duct. These transformers will be provided with off-circuit tap changing device in five (5) equal steps to take care of voltage variation to the extent of ± 5% in steps of 2.5% per tap.

7.5 SWITCHGEARS

The drives for auxiliary equipment, having capacity above 160 kW and up to 1000 KW will be fed from 3.3 kV and 1000 kW and above will be fed or from 11 kV system and those with capacity 160 kW and lower will be fed from 415V, 3-phase, 4-wire system. Suitable HV and LV switchgears, as described below, will be provided for operation of these motors. The distribution system for HV switchgears has been indicated in the above referred drawing. The metering shall be as per latest CEA regulations.

7.5.1 11 kV & 3.3 kV Switchgears

Power received at 11 kV from unit transformer will be fed to the respective 11 kV switchgear through circuit breakers for further distribution to high voltage motors and also to transformers intended to step down this voltage to 3.3 kV & 415 volts. These feeders will be controlled by VCB/SF6 gas circuit breakers.

The 11 kV & 3.3 kV systems will be designed for 44kA & 40 kA fault level respectively. The interrupting capacity of 11 kV & 3.3 kV breakers has been selected as 44kA & 40 kA considering the maximum possible fault contribution from the system and also the motors under the most severe fault condition. Motors rated above 160 kW shall be connected to 11 kV & 3.3 kV switchgear. Short-circuit withstand capability of 11 kV & 3.3 kV equipment shall be 3 seconds. Inter-changeability will be possible with breakers having identical rating. Duplicate feed will be provided for 11 kV & 3.3 kV switchgears where considered necessary. Auto fast Bus transfer scheme shall be provided for transfer from station to station, station to unit and vice versa.

7.5.2 415 V Switchgears

415 volts supply from LV auxiliary transformers will be fed to the respective 415 V switchgear bus through air circuit breaker to facilitate distribution for different motors and other electrical loads at the downstream. LT Motors of rating 90kW and above will be controlled by 415 V circuit breakers. The rupturing capacity of all 415 V circuit breakers will be 50 kA. Short-circuit withstand capability of 415 V equipment shall be 1 second. Duplicate feed will be provided for 415 V switchgears. LT distribution system is also shown in **EXHIBIT XVI**. The metering shall be as per latest CEA regulations.

Motor control centres (MCCs) will be provided for the control of LV motors up to 110 kW. Magnetic contactors with required protection and Fuse Switch will control the motors. 75 kW and above, motor protection relay shall be provided. MCCs are envisaged to be located at respective load centres as far as possible. All the 415 V MCCs / Switchgears shall be double front type. However, PCCs with breakers shall be single front.

7.6 CONTROL OF ELECTRICAL SYSTEM

One common Control Room has been envisaged for unit control panels, DCS and control equipment room shall be provided for locating the electronic control equipments.

Generator synchronization and its control will be done from Powerhouse Control Room. However, bus selection for generator transformer breaker, outgoing 400 kV feeders control shall be done from Switchyard Control room. Operation of 400 kV disconnecting switches shall be done from switchyard control room.

Control and metering of Generator, Generator Transformer, Unit Transformers, Station transformers, Unit auxiliary transformer and station auxiliary transformer 1&2 will be from Central Operating Console located in

Unit Control Room. Back-up panels will be considered for control, indication, metering and monitoring of the electrical auxiliary power distribution system comprising of 11 kV and 3.3 kV circuit breakers (except those for motor feeders), LT Transformers, 415 V Switchgear breakers for incomers and bus couplers, DG system. Same shall also be achieved from operator's consoles through DCS. For details relevant section of C&I shall be referred.

Control panels for service system like AHP, CHP, plant water system, etc. will be located in the respective control room. In addition, some local panels will be provided near respective system / equipment such as Boiler Feed Pump, Hydrogen Seal Oil System, Electrostatic Precipitator, etc.

7.7 PROTECTIVE SYSTEM

For protection of equipment against abnormal system conditions, adequate protective devices will be installed in the respective switchgears and/or control and relay panels. A group of such protective devices will be necessary to protect the equipment under different abnormal conditions arising in the system. Numerical relays with 100% redundancy through different algorithm also will be used for protection of equipment like Generator etc. Numerical relay shall also be used for HT and LT switchgears.

The following protections are envisaged for major electrical equipment:

7.7.1 Generator

Sr. No	Protection Function		Device No.
(a)	Generator Differential Protection	:	87G
(b)	Dual Zone phase distance protection for phase back-up (Pre-Synchronizing and Post-synchronizing)	:	21G-1 & 2

Sr. No	Protection Function		Device No.
(c)	Generator Low Forward Power protection	:	37G
(d)	Generator IDMT Overload protection	:	51G
(e)	Generator Over Voltage protection	:	59G
(f)	Generator 95% Stator Earth Fault protection	:	64G1
(g)	Generator 100% Stator Earth Fault protection	:	64G2
(h)	Generator Stator Inter-turn fault protection	:	87GI
(i)	Generator Loss of excitation protection	:	40G
(j)	Generator Under Voltage Relay	:	27G
(k)	Generator Negative Sequence protection	:	46G
(l)	Generator Reverse Power protection	:	32G
(m)	Generator Pole Slipping Protection	:	78G
(n)	Generator Over Frequency protection	:	81O
(o)	Generator Under Frequency protection	:	81U
(p)	Generator Rotor Earth Fault protection Two Stage Insulation Monitoring Type	:	64R
(q)	Dead Machine Protection	:	50 GDM
(r)	Generator Thermal Over Load protection	:	49G
(s)	Over fluxing protection	:	99G
(t)	Stator Earth fault protection (95% and 100%)	:	64S
(u)	Stator stand by earth fault protection	:	51NS

Stator and rotor earth fault protection through low frequency voltage injection.

7.7.2 Discrete Misc. / Lock Out Relays (For Generator)

Sr. No	Protection Function	:	Device No.
(a)	Overall Differential Protection including Generator, Generator Transformer, Unit Transformer and 400kV line from GT upto switchyard	:	87 OA
(b)	Generator V.T. Primary and Secondary Fuse Failure Relays.	:	60G
(c)	Master Unit Trip Lockout Relay	:	86-U1 & U2
(d)	Synchronizing Check Relay with Accessories	:	25
(e)	Master Generator Trip Lockout Relay	:	86-G1& GX
(f)	Back up voltage operated earth fault Relay	:	64 B-G
(g)	Master Trip Relay and necessary auxiliary relay for Turbine Lockout	:	86T, 86TX

7.7.3 Generator Transformer Protection

Sr. No	Protection Function		Device No.
(a)	Transformer HV side Restricted E/F Protection	:	64RGT
(b)	Transformer H.V. side Stand By E/F IDMT Protection	:	51NGT
(c)	Generator transformer differential protection	:	87GT
(d)	Generator transformer HV side O/C back up Protection with timer	:	50/51GT, 2
(e)	Local Breaker back up protection with its run trip relay	:	50LBB

Sr. No	Protection Function		Device No.
(f)	GT HV & Overhead line connection differential protection	:	87HV
(g)	Volts/Hz. Over fluxing Protection	:	99GT
(h)	Buchholz Relay	:	63TX
(i)	Winding Temperature	:	49 WTX
(j)	Oil Temperature	:	49 OTX
(k)	Pressure Relief Device operation	:	63 PTX
(l)	Master Trip Relay	:	86
(m)	Tripping relays for protection devices of Generator Transformer (GT) and 63X / 49X for multiplying the contacts of protections.		
	(i) For trip function	:	63X1/49X1
	- GT Bucholz II stage	:	63TX
	- GT winding temperature very high	:	49 WTX
	- GT oil temperature very high	:	49 OTX
	- GT pressure relief device operated	:	63 PTX
	- GT fire protection trip	:	FRTX
	- GT sudden Pressure relay trip	:	63SPR
	(ii) For annunciation function	:	63X2/49X2
	- GT Buchholz I stage	:	63AX
	- GT winding temperature high	:	49 WAX
	- GT oil temperature high	:	490AX
	- GT oil level low	:	OLAX
	- Cooler supply failure	:	
	- Cooler trouble	:	

7.7.4 Discrete Misc. / Auxiliary Relays (For GT Protection)

	Auxiliary relays for transformer accessories	:	30

7.7.5 Unit Transformer Protection

Sr. No	Protection Function		Device No.
(a)	Transformer Differential Protection.	:	87UT
(b)	Transformer H.V. side back-up IDMT over current protection with high set instantaneous unit	:	50/51 UT
(c)	Transformer L.V winding restricted earth fault protection	:	64R UT
(d)	Transformer L.V neutral back-up definite time earth fault protection	:	51N UT
(e)	Buchholz Relay	:	63TX
(f)	Winding Temperature	:	49 WTX
(g)	Oil Temperature	:	49 OTX
(h)	Pressure Relief Device operation	:	63 PTX
(i)	OLTC surge protection.	:	
(j)	Master Trip Relay	:	86
(k)	Tripping relays for protection devices of Unit Transformer (UT) and 63X/49X for multiplying the contacts of protections.		
	(i) For trip function	:	63X1/49X1
	- UT Bucholz II stage	:	63TX
	- UT winding temperature very high	:	49 WTX
	- UT oil temperature very high	:	49 OTX
	- UT pressure relief device operated	:	63 PTX
	- UT fire protection trip	:	FRTX

Sr. No	Protection Function		Device No.
	(ii) For annunciation function	:	63x2/49x2
	- UT Buchholz I stage	:	63AX
	- UT winding temperature high	:	49 WAX
	- UT oil temperature high	:	490AX
	- UT oil level low	:	OLAX
	- Cooler supply failure	:	
	- Cooler trouble	:	

7.7.6 Discrete Misc./Aux. Relays (For UT Protection**)**

Auxiliary relays for transformer accessories.	:	30
Master trip Lockout Relay	:	86 UT

7.7.7 Station Transformer Protection

Sr. No	Protection Function		Device No.
(a)	Differential protection	:	87ST
(b)	IDMT Phase over current	:	50/51
(c)	Restricted earth fault for HV and LV1, LV2 separately	:	64R ST
(d)	Back up Earth Fault protection for HV and LV1, LV2 separately	:	51N ST
(e)	Instantaneous earth fault	:	50N
(f)	Local Breaker Back up	:	50 LBB
(g)	Over fluxing	:	99
(h)	Transformer Buchholz	:	63
(i)	OLTC surge protection	:	

(j)	High winding temperature	:	49 WTX
(k)	High oil temperature	:	49 OTX
(l)	Pressure relief device operation.	:	63 PTX
(m)	Master Trip Relay	:	86
(n)	Tripping relays for protection devices of Station Transformer (ST) and 63X / 49X for multiplying the contacts of protections.		
	(i) For trip function	:	63X1/49X1
	- ST Bucholz II stage	:	63TX
	- ST winding temperature very high	:	49 WTX
	- ST oil temperature very high	:	49 OTX
	- ST pressure relief device operated	:	63 PTX
	- ST fire protection trip	:	FRTX
	(ii) For annunciation function	:	63x2/49x2
	- ST Buchholz I stage	:	63AX
	- ST winding temperature high	:	49 WAX
	- ST oil temperature high	:	490AX
	- ST oil level low	:	OLAX
	- Cooler supply failure	:	
	- Cooler trouble	:	

7.7.8 Unit Aux Transformer/Station Aux. Transformer Protection

Sl. No	Protection Function		Device No.
(a)	Differential protection	:	87T

(b)	Transformer H.V. side back-up IDMT over current protection with high set instantaneous unit	:	50/51
(c)	Transformer L.V winding restricted earth fault protection.	:	64R
(d)	Transformer L.V neutral back-up definite time earth fault protection.	:	51N LUT
(e)	Buchholz Relay	:	63TX
(f)	Winding Temperature	:	49 WTX
(g)	Oil Temperature	:	49 OTX
(h)	Pressure Relief Device operation	:	63 PTX
(i)	Master Trip Relay	:	86
(j)	Tripping relays for protection devices of UAT/SAT and 63X/49X for multiplying the contacts of protections.		
	(i) For trip function	:	63X1/49X1
	- UAT/SAT Bucholz II stage	:	63TX
	- UAT/SAT winding temperature very high	:	49 WTX
	- UAT/SAT oil temperature very high	:	49 OTX
	- UAT/SAT pressure relief device operated	:	63 PTX
	- UAT/SAT fire protection trip	:	FRTX
	(ii) For annunciation function	:	63x2/49x2
	- UAT/SAT Buchholz I stage	:	63AX
	- UAT/SAT winding temperature high	:	49 WAX
	- UAT/SAT oil temperature high	:	490AX
	- UAT/SAT oil level low	:	OLAX

- Cooler supply failure :
- Cooler trouble :

Transformer WTI / OTI / OIL LEVEL/ Pressure Relief / OLTC Surge Protection / Tap Changer Trouble etc. shall be provided through binary input of numerical relay distributed properly considering outage of one group.

7.7.9 Legend

(a)	`H.V.'	:	High Voltage
(b)	`L.V.'	:	Low Voltage
(c)	G	:	Generator
(d)	UAT	:	Unit Aux. Transformer
(e)	GT	:	Generator Transformer
(f)	UT	:	Unit Transformer
(g)	ST	:	Station Transformer
(h)	SAT	:	Station Aux Transformer

Note: The protection philosophy indicated above is for general guidance and represents the minimum requirement only. Additionally protection of electrical equipment shall also meet the requirement of CBIP publication no.274.

The protections provided for different kind of feeders in 11 kV & 3.3 kV switchgears are as follows:

(a) Incomer

(i) IDMTL Over current (50 / 51) shall be with timer

(ii) IDMTL Over current earth fault (50N / 51N) shall be with timer

(iii) IDMTL over current (51SN) for stand by earth fault (for incomer from transformer only).

(iv) Restricted E/F (64) (for incomer from transformer only)

(v) Under voltage with time delay (27)

(vi) VT fuse failure

(vii) Circuit breaker failure

(b) Tie Feeder

(i) IDMTL Over current (50 / 51) shall be with timer

(ii) IDMTL Over current earth fault (50N / 51N) shall be with timer

(iii) Under voltage with time delay (27)

(iv) VT fuse failure

(v) Circuit breaker failure

(vi) Synchronizing check relay, if applicable, complete with guard relay and hard wires.

(c) Motor Feeder

(i) Thermal overload (49)

(ii) Phase fault (50)

(iii) Unbalance (-Ve seq.) (46)

(iv) Locked rotor (50 LR)

(v) Definite time O/C (50G) for earth fault (through CBCT)

(vi) Differential (87) protection for motor above 1000 KW rating.

(vii) Circuit breaker failure

(viii) Winding temperature

(ix) Bearing temperature

(d) Auxiliary Transformer

(i) IDMTL over current (50/51) with high set instantaneous units for phase faults

(ii) Definite time O/C (50G) with timer for earth fault (through CBCT)

(iii) Differential protection (for transformers rated 5MVA and above)

(iv) Gas pressure alarm and trip.

(v) Winding temperature alarm and trip.

(vi) Oil temperature alarm and trip.

(vii) Pressure relief device operated alarm.

(viii) Conservator oil level low alarm.

(ix) Circuit breaker failure.

(e) Outgoing Feeder

(i) IDMTL over current (50/51) shall be with Timer.

(ii) IDMTL over current earth fault (50N/51N) shall be with Timer.

(iii) Circuit breaker failure.

(f) Bus-coupler

(i) IDMTL over current (50/51) shall be with Timer.

(ii) IDMTL over current earth fault (50N/51N) shall be with Timer.

(iii) Circuit breaker failure.

(iv) Partial differential scheme shall be provided, wherever applicable.

(g) 220 V DC System

(i) Short-circuit protection by fuse.

(ii) E/F alarm

In all cases, proper discrimination would be achieved so as to isolate the faulty elements only, keeping the healthy part of the system in service.

7.8 PLANT LAYOUT

400 kV switchyard comprises of 6 no. of bays (1 bay for GT, 2 bays for ST, 3 bays for 400kV Line). 400 kV switchyard is of one and half breaker scheme.

7.9 INTERCOMMUNICATION SYSTEM

An intercommunication system will be provided to facilitate plant operations by establishing quick communication among the operating personnel at various location of the plant.

Two-channel voice communication system with ‘Paging’ mode as well as ‘Private’ mode is envisaged. Speaking in ‘Paging’ mode will be heard all over the plant on selective basis, while ‘Private’ mode will facilitate conversation between two or more stations through close-talk channel without being heard over the loud speakers.

Hand sets for transmitting or acknowledging message would be installed at all important locations. The sound level throughout the area covered by a TG unit varies from place to place. Each unit will be divided on the basis of sound level and adequate power amplifiers will be used to cover these zones. Each handset/loudspeaker station will have its own pre-amplifier, line amplifier suitable for long line signal transmission and power amplifier to suit loudspeaker capacity. Provision for spare power amplifier will be made to serve as standby.

In addition to this, telephone system will be provided for quick and reliable communication between different personnel located at various plants, offices, departments, etc. as well as with outside parties. A microprocessor based

Digital Electronic Private Automatic Branch Exchange (EPABX) is envisaged for the telephone communication system.

7.10 ILLUMINATION SYSTEM

Suitable illumination is necessary to facilitate normal operation and maintenance activities and to ensure safety of working personnel. This would be achieved by artificial lighting. Required illumination levels in different areas as per standards/code of practice would be provided.

For outdoor yard illumination, floodlights would be installed at suitable locations to provide requisite level of illumination. Pole-mounted high-pressure sodium vapour lamp fixtures will be used for approach and work roads.

Generally fluorescent fixtures will be used for indoor illumination. Combination of sodium vapour, fluorescent and incandescent fixtures would be used for turbine hall and boiler platforms/galleries as may be necessary. For hazardous location, appropriate type of fittings would be used.

The lighting system design would ensure uniform illumination at working levels. Illumination levels as per standard will be followed for illumination system design. Energy efficient lighting fixtures shall be used with electronic ballast/LED lamps etc. powerhouse in auxiliary buildings, outdoor area.

Power for the illumination system would be supplied from 415V switchboard through lighting distribution boards and lighting panels. Lighting distribution boards would be located in different buildings as per the requirements.

Suitable number of lighting panels will be located in each area, power to which will be supplied from lighting distribution boards. The lighting panels will be installed at convenient locations for ease of operation. In addition to normal illumination scheme, emergency AC and DC lighting scheme would be provided in the powerhouse complex. Emergency AC lighting would be

supplied from AC emergency lighting boards, which would be connected to the AC emergency MCC. The AC emergency MCC would be energised from diesel generator during emergencies. The station emergency DC lighting will be provided in critical and safety related areas and would be fed from station 220 Volt DC distribution system during extreme emergencies. On failure of the AC supply, these lights will glow from DC system. For isolated buildings in remote areas where station 220 V DC is not available, DC lighting will be derived from self-contained battery with charger units, energised upon loss of normal AC supply in such isolated areas.

7.11 POWER & CONTROL CABLES

Main factors which are considered for selection of sizes for power cables are as follows:

(a) System short circuit current and allowable withstand time

(b) De-rating factors due to higher ambient temperature and grouping of cables

(c) Continuous current rating

(d) Voltage-drop during starting and under continuous operation

(e) Standardisation of the cable sizes

11 kV & 3.3 kV cables will be of stranded aluminium conductor, 11/11kV & 3.8/6.6 V grade 90°C continuous rating under normal condition and 250 °C rating under short circuit condition heavy duty XLPE power cable suitable for use in 11/3.3 kV non-effectively earthed system conforming to IS-7008, IS-8130, IS-5831. Galvanized single round steel mine armour for twin and multi-core cables non-magnetic hand drawn aluminium single round wire conforming to H4 of IS-8130 for single core cable.

LT power cables will be 1,100V grade with stranded aluminium conductor. 90 °C continuous rating under normal condition and 250°C under short circuit condition rating, XLPE heavy duty, power cable conforming to IS-7098, IS-8130, IS-5831, and IS-3975. Galvanized single round wire armour for twin and multi-core cables. Non-magnetic hard drawn aluminium single round wire conforming to H4 of IS-8130 for single core cables.

Control cables will be multi-core 1100V grade HRPVC insulated, HRPVC inner sheathed 85°C continuous rating under normal condition and 160°C under short circuit condition, galvanised round steel wire armoured and with FRLS HRPVC outer sheath having 2.5 sq. mm stranded copper conductors conforming to IS:1554, IS-8130, IS:5831, IS:3975. Fire survival (FS) power & control cables will be used for system, which are necessary for protection and safe shutdown of plant in case of fire.

Fire Survival Cables shall be used for important auxiliaries / area as recommended by Standard Technical Specification by CEA as below for the following:

Fire Survival Power & Control Cables shall be used for important auxiliaries/areas like but not limited to

(a) DC emergency lube oil pump

(b) DC hydrogen seal pump

(c) Turbine lube oil pump/barring gear

(d) DC emergency lighting for main building and service building

(e) DC cables for battery to charger & DC distribution boards

(f) Jacking oil pump

(g) Emergency turbine trip in control room

(h) Boiler Turbine : Generator inter trip which include the interconnection between

(i) Boiler master fuel trip and turbine trip relays

(ii) Generator trip relays & turbine trip relays

(iii) Generator trip relays & generator breaker

(iv) Generator trip relays & field breaker

(v) Generator trip relays & unit auxiliary transformer breaker

(vi) Incomer cables for DG board, emergency board, DC lighting board etc.

7.12 PLANT DC SYSTEM

A reliable DC power source would be provided to supply those loads, which are required to function for security, protection and safe shutdown of plant in the event of failure of normal AC power supply. Two (02) sets of 220 V Ni-Cd/Plante Lead acid batteries are required with adequate capacity for plant. Four (04) nos. 220 V Ni-Cd/Plante Lead Acid battery of adequate capacity will be provided for plant raw water system, AHP, DM plant and CHP.

DC power supply system comprises:

(a) 220 Volt DC battery

(b) Battery charger (float and boost charger)

(c) DC distribution and sub-distribution boards

Basis of selection of the above items will be as follows:

7.12.1 Battery

Normal requirement of the battery is to supply power for the following:

(a) Control and monitoring of the plant

(b) Alarm and annunciation of plant condition under emergency. During the first one minute after occurrence of emergency the battery will be called on to supply the following loads:

(i) Tripping power for all major circuit breakers simultaneously

(ii) Starting of emergency drives to protect the machines from damage

(iii) Plant emergency DC illumination system

(iv) Other miscellaneous loads

Battery would be Plante Lead acid and SMF Lead Acid type and the capacity of each of the 220 V battery sets would be such that it will meet the above requirement.

7.12.2 Battery Charger

Battery chargers of suitable capacity will be provided with quick boost and trickle charging facility for each of the aforesaid battery sets. Completely automatic and self-regulating type of battery charger will comprise one float charger and one float-cum-boost charger for each of the battery set.

The float charger will be capable of floating the battery for Plante at 1.42V/cell and 2.2V/cell for Plante Lead acid.

The boost charger will be capable of quick charging the battery at 2.75 volts (max.) for Ni-Cd and 1.7V for Plante lead acid will have the capacity to restore a fully discharged battery to a state of fully charged condition in 10-12 hours for Plante.

7.12.3 DC Distribution Board

One main DC distribution board with bus coupler unit will be provided with DC sub-distribution boards as required. The main unit DC distribution board will have two incomers and one bus coupler having switch-fuse units and required number of outgoing switch-fuse units which will be selected to have a continuous current rating of not less that 125% of the nominal load current. All 220V DC cables for downstream of 220V DCDB. DC distribution boards will be used to give DC power supply as required to plant auxiliary systems like CW system and various pump houses. Separate battery with charger will be used to give DC power supply to equipment located in AHP, CHP, Raw water system and DM Plant etc.

7.13 GROUNDING & LIGHTNING PROTECTION

Comprehensive grounding system, meeting requirements of IS 3043/IEEE 80/IEEE 665 and IER, will be provided in the power plant. A ground mat will be laid below ground level in transformer yard and powerhouse extended up to stack. The mat will be laid up to the fence and 1.5 meter beyond it on all sides. Suitable ground electrodes shall be provided at intervals. All metallic part of transformer equipment, powerhouse electrical equipment shall be connected to this ground mat by means of suitable risers. In other areas the type of grounding may be mesh type. Power house ground grid and transformer ground grid shall be connected by means of ground rods at least in four points.

The grounding requirement of a power station complex could be divided into the following two main categories:

(a) System Grounding

(b) Equipment Body Grounding

The system grounding is adopted to facilitate ground fault relaying and to reduce the magnitude of transient over voltage. The system grounding involves primarily the grounding of the generator and transformer neutrals. The generator neutral will be high resistance grounded through distribution transformer and secondary loading resistor.

For 11 kV & 3.3 kV system of the proposed 660 MW units high resistance grounding will be provided to limit the fault current to the order of 300 Amp. 415 V power supply system will be solidly grounded. DC system will be ungrounded. Necessary annunciation will be provided for detection of first earth-fault on positive or negative pole. The equipment body grounding will be provided to protect personnel from potential hazard caused by ground faults and lightning discharges by providing a low resistance, conducting path to the ground. A suitable ground grid will be provided for grounding of equipment and structures maintaining the step and touch potentials within safe limits.

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

For lightning protection, meeting requirements of IS 2309/IER, lightning mast/shield wires would be provided on towers to cover the switchyard area for protection of the switchyard equipment against lightning. Similar protection will be provided for powerhouse, transformer yard, boiler area chimney also. Besides, this lightning arrestor at required locations will be provided to protect the outdoor equipment from lightning and switching surges. Lightning protection system will be installed for protecting the buildings/structures against lightning discharge. This would be achieved by providing lightning masts on stacks, cooling towers, powerhouse building, towers in switchyard, floodlight towers etc. and connecting them with the ground grid.

7.14 EMERGENCY POWER SUPPLY SYSTEM

The emergency power system provides power to essential auxiliary loads required, to permit a safe shut down of the unit in the event of a plant blackout. In addition, power is provided for auxiliaries and services required for personnel safety and equipment safety during the blackout. The emergency lighting, Battery and Battery charger, chimney, NDCT for the station, etc. would be fed from the emergency power supply system.

One (01) no. of 1500 kVA diesel generator set will be installed meeting the requirement of emergency load for the unit.

7.15 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

Two (02) sets of uninterruptible power supply (UPS) system of continuous duty On line dual redundant is envisaged to supply regulated, filtered and uninterrupted 240 V, 50 Hz, single phase power within acceptable tolerances to critical AC loads like computerised data acquisition system, microprocessor based control and instrumentation system, analog control system, burner management system, annunciation system, indicators/ recorders mounted on unit control boards and other critical loads of such

nature. The system would comprise static inverters, static transfer switches, UPS system battery (Ni-Cd type or Plante lead acid type), float-cum-boost chargers for the battery, step down transformer, voltage stabilizer, DC distribution board, AC distribution boards etc. Both automatic and manual mode of operation will be provided.

8.0 CONTROL AND INSTRUMENTATION

8.1 INTRODUCTION

The Plant Control & Instrumentation System has been envisaged for Control and Monitoring of Turbo-Generator, Steam Generator, Power Cycle, Auxiliaries & Offsite Plants, electrical system and switchyard. The Control & Instrumentation System shall support complete remote operation of the plant from CCR with high degree of automation and shall provide monitoring feature of all major systems, equipment and related subsystems so that all salient parameters of the plant are made available to the operator/s at the Central Control Room. The requisite provision of field instruments and sensors shall be provided for the purpose. All routine operations including hot/warm/cold start-up, loading, run-up, run-down, run-back, administrative & emergency shutdown etc., can be performed remotely from the CCR without any local operation or intervention. The design philosophy shall aim at automatic self-checking & diagnostic features and failsafe operation resulting in reduction of maintenance manpower. High level of supervisory automation and computation algorithm shall provide guidance towards most safe and efficient unit operation. Facility shall be provided to monitor all critical manually operated valves, gates and dampers as well for information to the Operator in the CCR. C&I System shall be based on the state of the art smart Instrumentation and Distributed Control System (DCS) with functional and part geographical distribution of Inputs and Outputs at different locations of the plant to optimize the use of direct cabling from sensors. The DCS shall be built around Open Architecture configuration offering high system availability and reliability, with appropriate redundancies at various levels.

The system design shall be aimed at safe, efficient and trouble-free remote operation of the plant under various regimes of plant operation. The system and component MTBF is expected to be very high. In EXIBIT XI, the Control Room Layout is shown.

8.2 CONTROL PHILOSOPHY & PLANT OPERATION

8.2.1 Design Considerations

8.2.1.1 Design Objectives

Design objectives of the Instrumentation and Control System shall be as follows:

(a) Ease of Operation and Maintenance

(b) High degree of reliability and availability

(c) Plant and personnel safety & avoidance of Emergency

(d) Optimum performance

(e) Continuous self-checking & monitoring and easy fault diagnostic

(f) Achieving of data and information retrieval

(g) Continuous surveillance of the unit

(h) Use of proven instruments & technology

(i) Uniformity of instruments in similar application and homogeneity

8.2.1.2 Redundancies

Following redundancies shall be created in the system to enhance system availability:

(a) For critical controls, both binary and analog, field inputs (transmitters / sensors) shall be three fold redundant. Wherever redundant sensor are employed in CLCS, each sensor shall be wired to a separate input module so that if one input module fails then also the parameter will be available from other input module.

(b) For all other control and trip applications, field inputs shall be 1 out of 2 redundant.

(c) Redundant output cards shall be provided for the signals from CLCS going to final drive control element.

(d) For critical controls, controllers shall be three fold redundant.

(e) For all other applications, controllers shall be dual redundant.

(f) “Redundant controllers shall be located at different sub-racks”, preferably in different panels.

(g) Where power supply units are mounted on sub-racks, same shall be dual redundant.

(h) Each electronic panel for DCS shall receive power from separate redundant 24 V DC supply system.

(i) Redundant and standby equipment shall be not assigned to the same controller pair.

(j) Redundant 24 Volt DC system is required for C&I power supply and 240 V AC UPS supply is required for DCS panels & MMI system.

(k) The basic system shall be connected through redundant data highway/bus system. All network switches shall be dual redundant.

(l) Controllers and HMIs each shall have dual active network connections

(m) All servers and historical storages shall be dual redundant as separate units or by disc imaging.

(n) Global data base shall permit fall back of HMIs, in case of failure, without any data loss or process interruption.

(o) Two (02) Engineering and Configuring stations, one acting as a hot standby shall be provided. The standby unit shall be kept constantly updated in terms of real time data and program changes. However, to avoid double licensing, hardware lock may be provided so that one is operational at a time.

(p) As regards redundancy for drive control function
For open loop system input/output modules for realizing drive control functions redundancy in input/output and processing modules shall be envisaged for HT drives and critical LT drive (approx. 20); HT/LT incomer, bus coupler & generator.

Following measurements shall have 2 out of 3 redundancies:

(a) Feed Water Flow

(b) Turbine First Stage Pressure

(c) Main Steam Pressure (Each Side)

(d) Main Steam Temperature (Each Side)

(e) Hot Reheat Temperature (Each Side)

(f) Secondary Air Flow (Each Side)

(g) Oxygen in Flue Gas

(h) Furnace Pressure

(i) De-aerator Level

(j) Condenser Hot well Level

(k) Condenser Vacuum

(l) Turbine speed

(m) HP Heaters Level

(n) BCW pump Differential pressure

(o) PA header pressure

(p) Auxiliary steam pressure

(q) Wind box furnace DP

(r) Fuel oil pressure control

(s) Air pre-heater (APH) outlet temperature

(t) Cold re-heat (CRH) steam pressure

(u) HP bypass flow

(v) BFP suction temperature

(w) BFP discharge temperature

(x) HP bypass pressure

(y) HP bypass temperature

(z) LP bypass pressure

(aa) LP bypass temperature

(bb) Frequency transducers

(cc) Load control (MW transducer)

(dd) LP heater level

(ee) SH inlet and outlet temperature

(ff) RH inlet and outlet temperature

Following closed loop controls shall have 1 out of 2 redundancies:

(a) Desuperheater Inlet and Outlet Temperature

(b) Feed Water Temperature at economizer inlet

(c) BFP Suction Flow (each)

(d) Mill Air Flow

(e) Mill Outlet Temperature

(f) De-aerator Pressure

(g) Spray Water Flow (each)

(h) Ejector Steam Pressure

(i) LP Heaters Level

(j) Main Condensate Flow

(k) PRDS Pressure Inlet and Outlet

(l) PRDS Temperature Inlet and Outlet

(m) HP bypass flow

(n) Burner atomising steam pressure

(o) Separator level

(p) DP across feed control station

(q) RH spray water flow

(r) BFP discharge header pressure

(s) Gland seal steam pressure control

(t) Auxiliary steam flow

(u) CEP discharge pressure

Triple redundant binary outputs have been envisaged only for critical trip signals related to TMR systems.

All switches and Sensors for tripping of Boiler and Turbine auxiliary equipment (like BFP), which in turn cause Boiler and / or Turbine Trip, shall be implemented on 2 out of 3 philosophy.

8.2.1.3 Safety Features

Following safety features shall be provided:

(a) All field inputs shall be optically / galvanically isolated and shall meet the Surge Withstand Capacity criterion.

(b) All trip conditions will precede alarm condition to enable the plant operator to take remedial measure.

(c) All power supplies extended to the field devices shall be separately fused.

(d) Interface with external devices shall be through suitable firewall.

8.2.1.4 Design Margin & Spare Capacity

Following margins and spare capacity shall be built into the system:-

(a) Controllers shall be uniformly loaded to not more than 60% of the duty cycle under worst-case data loading condition.

(b) Loops are assigned logically to the controllers so that peer-to-peer active data transactions are kept at minimum.

(c) There remains a clear assignment between plant equipment/system and its corresponding controller (hardware-wise) for ease of maintenance.

(d) Not more than twenty (20) analog control loops shall be assigned to one controller (redundant pair). However, OLCS & CLCS can be combined in a controller.

(e) There shall be hot-on-rail spare I/Os of not less than 20% in any category in any individual panel and 20% on overall count.

(f) There shall be 30% spare terminals in Marshalling cabinets.

(g) There shall be 25% spare rack slots on an average for future expansion and ventilation.

8.2.1.5 Performance Criteria

The system shall fulfil following performance and Response criteria:

(a) The system shall conform to the performance criteria outlined in various international codes and standards including IBR, ASME, ASTM, ISA, PTC, and DIN etc.

(b) “Controller Cycle Time shall be adjustable meeting the requirement of the control. And will typically be set at 250 m sec (adjustable) for CLCS **except for furnace draft and separator level it shall be not more than 100 m sec** and 100 m sec for OLCS for critical loops and 500 m sec for non-critical loops, **50 m sec for protection**”

(c) All analog inputs to CLCS & OLCS will be acquired and database updated within an interval of 250 m sec (adjustable).

(d) Analog inputs solely used for data acquisition will be scanned and updated within 500 m sec (adjustable). For temperature measurement not related to control, the measured values may be scanned at an interval of 1 second.

(e) Keyboard command will be executed in less than 1 second under worst loading conditions.

(f) Updating of dynamic data on screen will take 1 second (maximum) under worst data loading condition.

(g) The response for Operator request display (time between pressing of last key and appearance of last character on screen) will be two (2) seconds maximum under worst loading conditions.

(h) Total number of controller shall be decided based on the conformance of the above criteria.

(i) The digital input for sequence of event (SOE) shall be monitored at 1 m sec resolution.

8.2.2 Plant Operation

The control system shall be designed for combined variable pressure throttling operation in coordinated mode. The procedure shall be of fixed pressure (low) start-up assisted by HP & LP bypass followed by variable pressure operation based on turbine governing valve position during ramping and part load operation and fixed pressure (high) during and near about rated operating point. Run backs shall automatically limit the capability of the unit in case of failure of a major auxiliary like a fan or a pump. Turbine shell stress computation will decide the safe ramp-up and ramp-down rate band of the unit.

8.3 DESCRIPTION OF COMPONENTS OF THE SYSTEM

8.3.1 Distributed Control System

The DCS will be the only operation and monitoring interface for the unit. However a hardwired backup panel is to be envisaged for very critical drives for safe shutdown of the plant incase of an emergency. The main functions to be performed by DCS shall the following:

(a) Automatic sequencing of the start-up and shutdown of equipment and auxiliaries including group / unit level start-up/shut down.

(b) Automatic regulation of various valves, drives and dampers to achieve optimum performance of various controlled variables and to achieve most fuel-efficient operating regime.

(c) Control and monitoring of plant mechanical and electrical system.

(d) Create interface for electrically operated drives.

(e) Create a high-speed network within the system for fast data exchange between all elements in the network without bottlenecking even under worst-case data flow.

(f) Interface with GPS master clock system for uniform and authentic time stamping.

(g) Acquisition, display (in the form of trends, mimics, histograms etc) and archiving of plant data and maintain historical records.

(h) Generation of alarms of various levels, sequence of event recording.

(i) Generation of time and event based logs and reports.

(j) Create a plant-wide high integrity data network for interfacing with auxiliary and off-site plants having their own proprietary control

systems & existing plant units to make the data accessible to plant operator. Maintain fidelity of the network through suitable firewalls.

(k) Create a Management Information System network based on the real time data to appraise the supervisory, administrative and management personnel of salient plant information to aid decision-making.

(l) Create a preventive and predictive maintenance schedule based on plant data.

(m) Create a spares' inventory management database.

(n) Run the performance calculation programs in real-time to compute efficiencies and other performance related factors to monitor health of various equipment. Energy Management and audit of the plant and equipment by measuring consumption of power of all major equipment in the plant, measurement of Fuel, Steam and all other relevant parameters.

An integrated system synthesized from one general family of identical interchangeable multifunction hardware and networked together has been envisaged for the plant. The DCS shall broadly comprise the following sub-systems:

8.3.1.1 Input / Output Signal Processing

Input/Output process interface sub-system shall directly acquire process data from transmitters, thermocouples, resistance temperature detectors and other sensors.

Input/Output (I/O) modules shall be intelligent having the following features as minimum.

(a) Every channel shall be addressable during routine periodic diagnostic check.

(b) Any failure in the module, loss of signal (both analog & digital) or any signal input crossing the permissible range shall be immediately detected and displayed.

(c) Such failures shall lead to failsafe situations.

8.3.1.2 Closed Loop & Open Loop Control Subsystems (CLCS/OLCS)

Multi-loop Multi-function controllers shall be dual hot redundant and shall be capable of handling both Close and Open Loop Controls. Controllers shall connect to dual redundant network with a minimum bus speed of 100 Mb/Sec.

The CLCS will perform modulating controls with optional auto-tuning facility that will act on valves, dampers or other regulating devices to achieve stable control with permissible variation in parameters.

Parameters assigned to controller pairs shall be grouped logically and not on a random mix-and-match basis. Controller pairs can be directly correlated to major equipment for the ease of maintenance. Irrespective of the power of the processors, the total number of pairs of controllers for the unit shall not be less than 16. To avoid cross communication to the extent possible, parameters related to a drive group shall be connected to one controller pair. An extensive library of standard control and sequencing subroutines shall be resident in the controller to be strung together to realize the desired algorithm for control.

Multi-loop Controllers shall interface with their associated I/O cards.

8.3.1.3 Data Acquisition Subsystem

Bulk non-control-related data shall be acquired in similar Multi-loop Controllers and shall be processed and stored for monitoring purpose.

The data collected will be used for point display, overview alarm, graphics, trends, logging, historical storage and performance calculation alongside control-related parameters.

8.3.1.4 Historical Storage Sub-system

The Historical Storage Unit (HSU) will augment the Global Memory database in the system and will archive data and parameters for logs and historical records including trends, alarms and events. These will be used for analysis and performance calculation.

Historical Storage Facility shall be redundant so that any single failure of the storage medium or electronics will not lead to loss of historical data.

Assignment between globally distributed memory and the historical storage will be judiciously determined during system engineering stage for optimal response and use of storage space.

8.3.1.5 Performance Calculation and Optimization Subsystem

Plant performance calculations and other complex computations will be performed periodically and automatically by retrieving plant data and some manually inputted information. Efficiency, heat balance, and other calculations as per ASME PTC and other relevant standard will be performed in the subsystem. The findings shall be presented to the plant engineer in an easy to comprehend guidance mode to enable the plant operators to operate the plant in an optimum regime.

Plant Optimization calculation shall combine thermodynamic models of the plant components with economic parameters like revenues from electricity sales, variable and fixed cost. The thermo-economic optimization shall take account of all important constraints of operation and shall be able to update on current equipment performance.

8.3.1.6 Engineering & Configuration Station

Two (2) Engineering and Configuration Stations shall be provided for engineering, program development, customizing, configuring & modification.

The stations can be kept on line to access plant data directly. It should also be possible to access the programs and database within the controllers and Operator's station for modification. Normally, this station will hold the back up programs resident within all active elements in the network so that in case of a loss or catastrophic failure, the replacement unit can reboot automatically from the station.

Engineering station shall be located in the computer room and shall be used to perform configuration of the entire system, modification of programs and algorithm for performance calculations etc.

8.3.1.7 Operator's Station

"Latest range of processor based PC or workstation with 24" SVGA 256 colour TFT monitors, keyboard, cursor control device like trackball etc. shall be envisaged for human-machine interface units."

The system shall have the capability to operate and monitoring of any plant section from any one of the Operator's station. However, provisional assignment shall be as below:

Total number of Operator's Console, will be as below:

(a) SG monitoring & controls

(b) Burner Management System

(c) Balance of Plant

(d) Plant Electrical System

(e) Turbine, Generator & auxiliary

(f) Auxiliaries and off-sites

Over and above the Operator's consoles one terminal each shall be provided for, the Shift Charge Engineer, maintenance Management and Plant Performance Calculation.

There will be also 67" Large Video Screen systems for monitoring of the entire plant. These shall be independent stations on the network and shall display subsystems etc, on real time, independently. Furnace flame image monitor for each unit is to be provided in the control room. One (1) color Video Copier (supported from an engineering station) and necessary number of Printers shall be provided for printing logs and alarms. One (1) DVD writer shall be included to store historical data.

Provisionally, ten (10) MIS Terminal, (Plant inside network) as soft clients, with limited and selective data access, are foreseen at different plant locations viz. C&I Maintenance Engineer's room, administrative offices, stores etc. to present plant related data in real time.

8.3.1.8 Data Network & Gateways for interfacing with proprietary Systems

The DCS shall be based on Open System Architecture system having globally distributed database and connectivity with third party systems

following standard protocol. Redundant Fast Ethernet switches shall be utilised for connecting and routing of data. All active items on the network shall be identified by unique address as their location in the network.

All Controllers and HMI units shall be resident on a common redundant high-speed data highway for global distribution and access of data. Any data will be available at any point of the network as and when required unless protected or masked.

The network shall be modular, expandable and flexible so that expansion is possible by adding extra stations on the data highway modularly and assigning the required network address, without disrupting the operation of rest of the system.

Comprehensive automatic and periodic self-diagnostic features shall be provided to facilitate easy fault location and detection of failure. On-line testing facility, while the unit is in operation, shall be provided with suitable indication for easy identification of faulty module up to channel level. Extensive error checking (CRC-16/12) or error correcting codes shall be used to improve the reliability of communication.

It is the intent to have the DCS to cover the entire main plant area with uniform range of hardware and software. However, if the main equipment suppliers would prefer to supply proprietary control units from their guarantee standpoint, for instance for the electro-hydraulic governing system for the main and BFP drive turbines or Automatic Voltage regulator etc, suitable interfaces shall be created between such systems and the DCS. In general, MODBUS/RS-485 or such low speed interfaces may be used for passive data exchange for reporting and archiving only and shall not be utilized for the exchange of control related parameters. Active parameters shall be connected directly through hardware links or through fast Ethernet or similar high speed connections.

8.3.1.9 Sequence of Event Monitoring System (SOE)

A high resolution Sequence of Event Monitoring System shall be an integral part of Distributed Control System. However a standalone SOE from a separate vendor can also be considered

All SOE inputs shall be sourced directly from the primary switches and primary relay/contactors for “real time-stamping” based on GPS master clock following any tripping of major equipment, sub-systems and the plant as a whole.

The system shall be capable to discriminate inputs with a resolution of one millisecond. All SER points entering from normal state into the alarm state or returning from the alarm state to normal state shall be reported and time tagged.

8.3.1.10 DCS Panels & Cabinet Footprints

Unitized central control has been envisaged from the Central Control Room. Major geographical distribution is not foreseen for the DCS. The electronic cabinets and marshalling cabinets shall be located in the air conditioned areas of the Control Equipment Room adjacent to CCR with an approximate area of 300 square meters (per unit), the Central Control Room housing the HMIs shall approximately be 250 square meters (per unit) and the Engineer’s room area shall approximately be 50 square meters (per unit). The controls related to the CW & ACW pumps and miscellaneous pumps, which are remote I/O units of the DCS, shall be located at the pump house annex rooms respectively. The environmental rating of the indoor electronic panels shall not be less than **IP 30**.

8.3.1.11 Displays & Reports

A few typical displays and logs are given below as general guideline:

(a) Real Time Parameter / Status Display (default screen)

(b) Real Time Trend / Historical Trend Graph Display

(c) Alarm Summary Display with alarm limits Printout (on demand)

(d) Alarm Summary Display with alarm limits Printout (Shift Log)

(e) Boiler Start-up Log / Printout (event actuated)

(f) Turbine Start-up Log / Printout (event actuated)

(g) Synchronization / Loading Log / Printout (event actuated)

(h) Hourly log/Shift Log / Daily Log / Printout (on demand)

(i) Generator Trip Log / Printout (event actuated)

(j) Turbine Trip Log / Printout (event actuated)

(k) Boiler Trip Log / Printout (event actuated)

(l) Operator Control Screens

(m) Group Display Screens

(n) Individual Display Screens

(o) Flow Chart / Logic Screens

(p) Operator's Guidance Message Screen

(q) Process Subsystem Display Screens

(r) Pre Trip and Post Trip Log

(s) Characteristic point display

(t) X-Y plots.

(u) Bar display

(v) Profile display

(w) Trend logs

(x) Log of disrupted and simulated values

(y) Log of operator action

(z) Log of scan period

(aa) Log of point-out of scan

(bb) Maintenance log

(cc) Performance calculation log

8.3.1.12 System Software

The rugged Application Software shall be truly user friendly with graphic interface, based preferably on latest multi-user platform with a relational database management system overlay. The system software will follow open architecture protocols. For networking, TCP-IP and ISO-OSI model will be used. The system shall utilize a readily up-gradable, public domain software platform proven for real-time operation environment at the control and monitoring level.

The operating system shall be suitable for truly real-time operation both at process as well as HMI end.

The system shall be truly modular.

The software shall meet the following general requirements:

(a) Simple, easy-to-learn editing language for editing and on-line operation.

(b) Wide range of standard and non-standard peripheral support capability.

(c) Effective task scheduling and support of multiple priority structure including event based interrupt etc.

(d) Effective debugging.

(e) Provision for on-line editing and program development without interrupting on-line functions.

(f) Self-diagnostic routines.

(g) Efficient memory management and effective utilization of system time.

(h) Quick start-up and loading.

(i) Support of multiprogramming and multi-user operation.

8.3.2 Burner Management System (BMS)/FSSS:

The steam generator integral controls – BMS/FSSS will include the binary controls related to purging, starting and tripping of the boiler, sequential

start/stop operation of burners, milling system, draft system and all relevant safety protection of furnace and boiler as a whole. The hardware including the cabinets assigned to BMS shall be exclusive and shall not be shared with any other system.

Burner Management System shall be either DCS based or PLC based and the associated engineering station shall be utilized for configuring the BMS. Monitoring and control of BMS/FSSS shall be carried out from Central Control Panel.

Functionally the entire system shall be divided into various sub-groups within the following groups:

(a) Mill Group/coal elevations

(b) Oil elevations & igniters

(c) ID and FD Fan draft group and air & flue path

(d) Boiler/Common Group

Functional sub-groups shall be assigned to redundant control processors connected to common redundant system bus to interact with the dedicated Human Machine Interface unit for BMS for monitoring and Operation through various graphics, displays, sequence flow diagrams etc. on screen to guide the operator towards optimal safe and efficient operation.

Safety tripping of the boiler shall be implemented in two-out-of-three or Triple Modular Redundant system. The system will consist of three completely independent protection channels with respect to modules for (i) Binary Inputs / Outputs, (ii) Analog Inputs and Outputs, (iii) Signal processing and (iv) Signal transfer.

8.3.2.1 Other Boiler Integral Controls

The secondary air damper control will be carried out in the DCS. Soot blower controls shall also be implemented in DCS / PLC. Sonic tube leakage detector shall be an independent system comprising the detectors, amplifiers etc. and separate PC is envisaged for this purpose.

8.3.3 HP & LP Bypass Control System:

HP & LP Bypass Control Systems shall permit faster start up of the BTG unit, establish re-heater flow during starting and low load operation and also will act as a pressure relief device in case of sudden load throw off or turbine trip by bypassing the active steam to condenser via re-heater. HP & LP Bypass Control Systems shall be implemented in DCS with adaptive set point generation algorithm based on the BTG parameters and combined variable pressure-throttling mode of operation.

8.3.4 Turbine Control Systems:

Various controls related to the Turbine shall be implemented in DCS.

8.3.4.1 Electro-Hydraulic Governing (EHG) Control System

The Electro-Hydraulic Governing (EHG) for the main TG shall be implemented in two-out-of-three or Triple Modular Redundant system. If, however, proprietary system is offered, TUV approved TMR system shall be provided, which will be interact with the DCS for operation from (by hardwiring) and monitoring (through high speed link) at the Operator's console. The EHG shall be a part of coordinated control of the BTG.

8.3.4.2 Automatic Turbine Start-up & Shut-down System

The steam turbine shall be started up under cold, warm or hot condition with a single Operator's command, shall speed up, cross the critical speed/s, synchronize and load the initial sustainable block load automatically conforming to the stress limits set by metal and steam conditions. The operations shall include pulling of vacuum, sealing of glands, starting the lube and jacking oil system, turning operation, opening of drains, steam admission etc in sequence. Such sub-system areas of control will form functional sub-groups which shall be activated in order. Similarly, during emergency or administrative shut down, similar routines shall be followed to bring the turbine down to barring gear without Operator's intervention. The Automatic Turbine Start-up and Shut-down System shall be implemented in DCS with dual redundant control processors.

8.3.4.3 On-load testing system

The Trip devices shall be stroked and tested for readiness under simulated situation even with the turbine in operating condition. This sub-system shall be implemented in DCS and shall be activated under operator's command.

8.3.4.4 Turbine Protection System

The Turbine Protection System for emergency tripping of the steam turbine shall be implemented in DCS in two-out-of-three mode. There will be three (3) independent channels each having its own processing unit, input modules and output modules. All primary sensors related to protection shall consist of three (3) different sensors each connected to the three processors.

8.3.5 Maintenance Management & Stores Management

A computerized and proven Maintenance Management and Stores Management System covering various equipment, components and parts of the unit have been envisaged. The system will support a Local Area Network with about six (6) PC units to be located at various offices in the plant like maintenance workshop, stores etc., and will integrate with the DCS to utilise

the real time global database to retrieve data like running hours and conditions of various machines to provide various menu for implementation of preventive and predictive maintenance as per equipment manufacturer's recommendation and practice established in the plant.

8.3.6 Rotary Equipment Monitoring System

Important rotary equipment shall be continuously monitored for their mechanical health. The entire machinery monitoring system will integrate into a common "Machine Condition Monitoring Package" to acquire all related information, process and analyze them to produce data related to bearing wear, lubrication and stability margins etc. with its own special diagnostic software and a terminal providing machinery diagnostic data for monitoring and balancing. The machinery diagnostic data shall be presented in an easily comprehendible form for high level of fault finding and Operator's guidance. High speed link shall be established with DCS for data transfer and archiving. The system shall encompass turbines and electrically operated drives.

8.3.6.1 Turbine Supervisory Instrument System (TSI)

Turbine Supervisory Instruments shall continuously monitor the behaviour of mechanical parameters related to the rotation of BFP drive turbines, main turbine and generator under various operating conditions. The system will provide adequate information on the operational aspect of the rotating machines, generate alarms and trip the machines in the event of excursion beyond allowable limits of operation. The system shall generate adequate information for dynamic balancing of the machines. The measurements shall include shaft vibrations at both X- and Y-axes and seismic vibration at all salient bearings as well as a key phasor per equipment. Other measurements like case and differential expansion, axial movement etc shall follow equipment manufacturer's recommendation. The supervisory system shall be complete including sensors, transmitters etc., with required accessories viz., Special Cables, Junction Box, for all measurements. The

Monitors shall be Micro-processor based and shall have flexibility for easy configuration. The system shall have facility to suppress false alarm and tripping due to defective transducer, power supply, etc.

8.3.6.2 Vibration Monitoring of Auxiliaries

Bearings of all high speed HT motor-driven equipment shall be monitored for vibration both at driving and non-driving end of the drives as well as the driven equipment in the same fashion as the turbine bearings. Each such equipment will have X-Y axes probes on each bearing and a key phasor probe. Vibration monitoring of auxiliaries shall be provided from the same family of hardware as the Turbine Supervisory System for system integration. This shall encompass ID, FD, PA fans, coal mills, feed pumps and condensate extraction pumps and CW & ACW pumps, as the case may be along with their motors.

8.3.7 Auxiliaries & Offsite Plant Control System

The basic design philosophy being one of centralized monitoring of data, various stand-alone control units shall be connected to the main plant DCS for data exchange and control, where specified. The general guideline for interface with the Plant Auxiliary Systems and Off Site Plants through OPC connectivity shall be as follows.

Plant Auxiliaries System shall generally include the following plants:

(a) DM Cooling Water System

(b) Condensate Transfer (CT) pump & DM Service Water (DMSW) pumps

(c) Compressed Air System

(d) Mill Reject Handling System

(e) Fuel Oil Pressurizing & Heating System

(f) Circulating Water (CW) and Auxiliary Cooling Water (ACW) System

(g) Miscellaneous pumps

(h) Condenser On-load Tube Cleaning System

(i) Automatic Self-cleaning Strainer Control

(j) Condensate Polishing Unit

(k) HP/LP Chemical Dozing system

(l) Fire fighting

(m) DG set

(n) Ventilation and air conditioning

(o) ETP and waste water treatment plant

(p) CW treatment plant

In addition to the above, there shall also be following Off Site Plants for which input data acquisition have been envisaged at central control room DCS.

(a) Raw Water and Pre-treatment Plant

(b) Demineralization Plant

(c) Ash Handling Plant

(d) Coal Handling Plant

(e) Fuel oil Unloading & Storage Unit

(f) Cooling Tower

(g) Switchyard SCADA & SAS

While some of the plant areas will have their own control system (PLCs / monitor stations) operated from their respective local control rooms, functioning independently; other plant areas, which directly relate to generation will be directly controlled from DCS via remote I/O units. Some of the auxiliaries will have operational facility from central control room as well as from local panels. The control system for of the plant auxiliaries, Off Site Plant and their Human machine interface requirement and DCS interfaces in the Central Control Room.

PLC's to control the various off-site areas shall be high-end, dual redundant units with rugged I/O modules including relay interface units to connect to electrical drive power system. In plants like CHP, spread over wide geographical area, remote I/O units or remote processor units shall be provided, say, in crusher area or tripper floor, to reduce dedicated cabling. Links to RI/Os shall be dual as well. Special RI/O devices with radio links shall be provided for stacker-reclaimer areas.

Considering the high ambient noise, distance and electromagnetic interference prevailing in power plant, the links, where mentioned, between Plant auxiliaries/Off Site Plants and plant DCS shall be based on Optical Fibre Communication (OFC) extended from various data sources through optical router switches in a star/tree network.

The PLC/Proprietary control systems of the plants shall have suitable optical output ports available at the PLC units. The ports shall be extended with pig

tail cable of suitable length to be brought over to a splice kit. Multi-fibre mono-mode OFC cables shall be run from the respective control nodes to a central splice kit near control room where all the signals shall be spliced and connected to DCS. Ethernet is the preferred mode of communication so that the signals can be brought to an optical switch.

Off-site plants like AHP, CHP, DMWP etc, shall be operated from their local control rooms. TFT based Operator's consoles, printers etc shall be provided. Back-up hardwired conventional desks / panels shall only be provided if recommended by the plant supplier. The engineering & programming units for the PLCs shall preferably be lap-top units that will be detached after initial programming. If there are multiple work stations, one of the work stations will be converted as programming, engineering and diagnostic work station, in addition to operating function.

Data acquired from Plant auxiliaries/Off Site Plants shall seamlessly integrate with DCS database and shall be treated at par with all other variables so far as the computation and presentation of the data is concerned.

8.3.8 Steam Water Analysis Systems (SWAS)

Considering the criticality of the water chemistry of the supercritical unit, a centralized Steam and Water Analysis System (SWAS) has been envisaged for measurement of pH, Conductivity, Dissolved Oxygen, Sodium, Silica etc. contents in feed water, steam and condensate at various sections of the process. Measured values and health of the Analyzers will also be monitored in plant DCS through hardwiring and will interface with the dozing system to control the dozing pumps. SWAS will consist of a Wet Section and a Dry Section. Together, an approximate area of 100 square meters shall be allocated for the SWAS. Wet Section shall condition the sample to bring the sample to reference temperature by cooling at the primary cooler/s with DMCW and at the secondary cooler by cooling with chilled water and also bring the sample to a pressure level acceptable to the analyzers. Dry

Section shall house the Analyzers and the sensors. All samples shall be conditioned at 20°C temperature before entering any sensor assembly of the Analyzer under worst ambient condition.

Provisionally, the following measurements are foreseen:

(a) Superheated Steam

(i) Cation Conductivity : Indication, Alarm high

(ii) pH : Alarm high/low, Indication

(iii) Silica : Alarm high, Indication

(iv) Specific Conductivity : Indication, Alarm high

(b) Feed Water at Economizer Inlet

(i) Specific Conductivity : Indication, Alarm high

(ii) Cation Conductivity : Indication, Alarm high

(iii) Hydrazine : Indication, Alarm high

(iv) pH : Alarm high/low, Indication, Control

(v) Dissolved O_2 : Alarm high, Indication

(vi) Phosphate : Alarm high, Indication, Control

(vii) Silica : Alarm high, Indication

(c) Condensate after Polisher

(i) Specific Conductivity : Indication, Alarm high

(ii) Cation Conductivity : Indication, Alarm high

(iii) pH : Alarm high/low, Indication

(iv) Silica : Alarm, Indication

(v) Chloride : Alarm, Indication

(vi) Sodium : Alarm, Indication

(d) Demineralized Make-up Water

(i) Specific Conductivity : Indication, Alarm high

(ii) Silica : Alarm high, Indication

(iii) pH : Alarm high/low, Indication

(iv) Cation Conductivity : Alarm, Indication

(v) Sodium : Alarm, Indication

(e) Condensate Extraction Pumps Discharge

(i) Cation Conductivity : Indication, Alarm high

(ii) Specific Conductivity : Indication, Alarm high

(iii) Dissolved O_2 : Alarm high, Indication

(iv) pH : Alarm high/low, Indication

(v) Sodium : Indication, Alarm high

(vi) Chloride : Alarm , Indication

(vii) Silica : Alarm , Indication

(f) De-aerator Outlet

(i) Dissolved O_2 : Alarm high, Indication, Control

(ii) pH : Alarm high/low, Indication

(g) Condenser Hotwell (right and left)

(i) Specific Conductivity : Indication, Alarm high

(h) Re-heater Steam

(i) Cation Conductivity : Indication, Alarm

(i) Stator Water

(i) Specific Conductivity : Indication, Alarm

(j) Separator Water

(i) Specific Conductivity : Indication, Alarm high

(ii) Silica : Alarm high, Indication

(iii) pH : Alarm high/low, Indication

(iv) Chloride : Alarm, Indication

(v) Sodium : Alarm, Indication

(k) Condenser Cooling Water

(i) Specific Conductivity : Indication, Alarm high

(ii) pH : Alarm high/low, Indication

(iii) Residual Chloride : Alarm, Indication

(l) DMCW Pump Discharge (Turbine)

(i) pH : Alarm high/low, Indication

(m) DMCW Pump Discharge (Boiler)

(i) pH : Alarm high/low, Indication

8.3.9 Flue Gas Analysis

The chemical composition of flue gas, being an index of combustion, shall be precisely monitored for components.

8.3.9.1 Continuous Emission Monitoring System

In conformity with the local and state pollution control norm, Continuous Emission Monitoring System shall be installed in the chimney to analyze the constituents of the combustion products. The system will comprise of isokinetic sampler/s to draw representative samples, coarse and fine filter, line heater, manifolds etc for drawing the sample from specified elevation

recommended by EPA. An analyzer shelter, located near chimney, shall house the SO_x, NO_x, CO_2 and Oxygen analyzers, span and reference gas bottles, sample processing system, calibration manifold and an Operator's console for display and report generation. Particulate analyzer, measuring dust content in mg/m^3, shall be located at specific chimney elevation for across the stack measurement. Opacity monitor shall be installed at the outlet of ESP on each pass. Link shall be established between CEMS and DCS for data reporting and central monitoring.

8.3.9.2 Combustion Gas Analyzers

To monitor the efficiency of combustion, Oxygen shall be measured in flue gas at each pass in a total of three points after the boiler radiant zone with zirconium oxide cells and the resulting signal shall be utilized in the combustion control loop in two-out-of-three mode to regulate the secondary air flow. Carbon monoxide shall also be measured at an appropriate location with infrared analyzer to serve as a guide signal for potential oxygen starvation. Oxygen shall also be measured after each pass of the air pre-heater to detect air ingress by leakage

8.3.10 Electrical System Interface:

8.3.10.1 Electrical System Controls

All electrical controls and monitoring related to the "Unit Auxiliary System", "Station Auxiliary System" and "Bus Transfer System" shall be performed from DCS. One Operator's station shall be assigned for the purpose. The necessary protection relays, like synchro-check, bus under voltage relays etc. will be connected to DCS to ensure the safety of the operation. A fold-back type synchronization sub-panel shall be provided at the auxiliary console. All Electrical panels housing protection relays etc. related to Unit Auxiliary Control, Station Auxiliary Control and Bus Transfer System will be located in the Electronic Equipment Room.

8.3.10.2 Electrical Parameter Monitoring

Electrical parameters such as voltage, current, frequency, power, power factor, consumption of electrical energy etc. as per the electrical system SLD will be monitored at the DCS for the display of complete status of the electrical system in the form of electrical system mimic. Necessary transducers with dual 4-20 mA output shall be housed in the respective electrical switchgear.

8.3.10.3 Electrical Drive Interface

Electrically operated drives of the unit; HT & LT unidirectional and bi-directional or DC drives, shall be operated from DCS. Necessary interposing relays for the purpose shall be located within the respective Starter, MCC or switchgear Units. HT motors, important LT AC and DC drives shall be monitored for current through transducers. All drive related interlocks, permissive, trips, auto starts etc will be implemented in DCS in drive groups and in sequential mode to reduce Operator's intervention during routine operation. HT motors shall be monitored for hot spot formation with embedded RTDs in each stator winding. Bearings of forced lubricated drives shall be monitored for over-temperature.

8.4 FIELD INSTRUMENTS & DEVICES

This section provides general guideline for the field instrument and sensor to be used in the plant for the measurement and control of the process parameters. Instrumentation shall be adequate for remote operation of the plant under various conditions without any local operation under normal circumstances. However, adequate number of local instruments shall be provided for local maintenance, fault finding and trial operation.

Pressure gauges shall be provided at each major pump output and at the inlet/outlet of heat exchangers, at various points of distribution of instrument and service air etc.

Transmitters shall be normally used for switching application as well by setting limit values in DCS. Direct acting switches shall be used only if recommended by equipment manufacturers. Temperature sensors viz. thermocouples and resistance temperature detectors shall be directly connected to DCS without any intermediate conversion. Temperature switches shall be avoided altogether.

All field transmitters are envisaged to be of smart type with 4-20 mA DC signal output with superimposed digital device bus signal conforming to Field Bus Foundation or any other internationally accepted protocol. The calibrated range shall be so selected that the normal parameter shall generally be between 50 to 75 % of the range, depending on expected excursion.

All temperature elements shall be duplex type. All Thermocouples will be mineral insulated.

Field devices shall have an ingress protection class of IP65 or better. Instruments shall be grouped together in closed (outdoor areas) or open (indoor areas) type racks. General specification for the field instruments shall be as given below:

8.4.1 Flow Element

Significant flow measurements like bypass steam flow, auxiliary steam flow, feed water flow, condensate flow etc. for line sizes more than 4” shall be carried out with long radius flow nozzles with radius tap. Flow measurements for indication purpose and in smaller line sizes shall be carried out with square edge concentric orifice plates with carrier rings and flange taps. Fuel oil flow measurement shall be implemented with mass flow meters. The material of construction of flow elements shall be SS 316 for temperature up

to 450 °C. Air flow (primary & secondary) measurement shall be by Aerofoil or galvanized Venturi tube in the duct. CW flow measurement shall be by Annubar.

8.4.2 Final Control Element

The final regulating control elements envisaged shall be Electro-pneumatic type with single or double acting power cylinders for dampers and pneumatic diaphragm or cylinder actuators for the control valves, unless the process demands the use of electro-hydraulic actuators due to stroke time limitation. HP & LP Bypass valves shall, however, be hydraulically operated. Trip valves shall be pneumatically actuated solenoid operated type with quick open characteristics.

Inching duty (remote-manually operated) and On-Off duty valves and dampers will be motor operated with non-integral/integral starter.

All valves shall be suitably sized so that under normal conditions the maximum design flow shall be able to pass through the valves with not more than 80% opening. The absolute maximum flow foreseen, even under unusual conditions should be handled by the valves with not more than 90% opening. The characteristics of the valve trim shall be so selected that the installed characteristics offer good control resolution. Equal percentage or modified parabolic characteristics shall generally be used. Heater drain valves shall have linear characteristics.

Suitable noise abatement techniques shall be adapted preferably by source treatment so that the aerodynamic/hydrodynamic noise caused by the valves is restricted within the limits specified by OSHA or any other internationally acknowledged standard and in no case exceed 85db at a distance of 1 meter from the valve.

Special attention shall be paid to the design of severe duty valves like super heat/ reheat spray control valve, start-up feed water flow control valve,

auxiliary PRDS valves, BFP recirculation valves, soot blower etc to avoid excessive erosion, flashing or cavitation. Multistage-Multipath, cage guided, anti-cavitation or noise abatement type trims shall be provided for such areas to avoid long-term deterioration. Especially for all such critical applications, the valves shall be of proven track record for similar applications.

All metal-to-metal seated regulating control valves shall be with a leakage Class–IV, as minimum. For critical applications like BFP recirculation control valve, temperature control spray line control valves shall be with leakage Class-V.

Positioners can be conventional/ smart type. Regulating pneumatic devices shall have airlock relays with automatic release to maintain their position in case of air supply failure. All pneumatic final control element shall be complete with all accessories like positioner, position transmitter, ,limit switch, solenoid valve, volume booster etc All actuators shall be brought to the fail-safe condition under following conditions:-

(a) Loss of Control Signal

(b) Wire Breakage

(c) Loss of Power Supply

(d) Loss of instrument air

8.5 CABLES & CABLING ACCESSORIES

Instrumentation cables shall be stranded, electrolytic grade tinned copper conductor, screened, armoured, FRLS outer sheath type. Junction boxes shall be provided within transmitter racks and other locations to group sensor and transmitter signal cables. Signal cables from Individual Instruments/sensors to field junction box, wherever applicable, shall be with conductor size of 1.5 mm^2. From the junction boxes multi-core overall

screened signal cables shall be used for extending binary signals, multi-pair twisted cable shall be used for analog signals and multi-triads shall be used for extending RTDs to the control room area. Multi-core/ multi-pair/multi-triad cables from field junction box or transmitter rack to control room shall be of conductor size of 0.5 mm^2.

For cable runs beyond 500 meters and where recommended by instrument manufacturer, as in case of vibration measuring equipment, 1.5 mm^2 or 2.5 mm^2 conductor size shall be used.

Extension cables shall be used to connect thermocouples. Similarly, thermocouples shall also be brought to junction boxes to facilitate the use of multi-pair cables. K-type thermocouples shall be used up to a maximum temperature of 600 °C. Beyond this temperature noble metal thermocouples shall be used. Single or Multi Pair, solid conductor, 20 AWG, overall screened & armoured extension cables will be provided for carrying millivolt signals.

Cables shall run on horizontal ladder trays on main arterial routes, except in the pulveriser area where vertical trays shall be used. Branch trays leading to instruments or junction boxes shall be galvanized perforated type. Cables shall be laid in multi-layer formation, shall be tagged at regular intervals and strapped to the trays.

Electronic earth system shall be separate from the plant earth mat, which shall be used for grounding the body of instruments and panels as safety ground.

For grounding the electronic system, a separate salt pit earth shall be created with separate riser to control room area where all the electronic earth points shall be brought and connected as System Grounding (<1 ohm).

The safety ground riser will be brought to the control room and control equipment room and various termination points will be created by running a

bus bar of bare Copper conductor below false flooring. All panel and cabinet frames will be connected to the safety ground.

Frames of field junction boxes, local cabinets, stands, cable trays shall be grounded locally at the local ground mat/structure.

For the electronic system, each circuit that requires grounding shall be individually and directly connected to the system ground bus, insulated from the cabinet enclosure. The system ground shall be distributed below the false flooring by means of insulated conductors.

Cable screens shall be grounded at electronic earth at the control room end only.

Cables shall be glanded at each point of entry with watertight glands. Screens shall be grounded at Control Room end only. For long parallel runs, separation of 300 mm will be maintained between low level signal cables and LT power/control cables. The separation of 600 mm shall be maintained with HT cable.

Junction boxes shall be IP-65 enclosures with knock-out holes and cage-clamp type terminals.

8.6 CLOSE CIRCUIT CAMERA SYSTEM

For continuous monitoring and vigilance of major equipment, plant rooms, main buildings, access roads, internal roads etc, closed circuit camera system shall be provided with facilities for night vision.

The cameras will be based on ¼” Charged Coupled Device with IP connectivity and facility for remote Pan, Tilt & Zoom. The operator’s control unit shall be located at the control room.

8.7 TELEPHONE, INTERCOM & PAGING SYSTEM

Electronic Private Automatic Exchange, with paging and intercom facility will be located in the administrative area and will have number of outgoing trunk lines. Wall mounted, rugged type field phones with paging button will be provided in various plant areas at strategic locations to make plant-wide announcements to draw attention of roaming operators to important developments in the plant. There will be provision for audio volume adjustment in the sets to circumvent ambient noise in plant areas. Intercom & Paging facilities will be provided at the Operator's desk as well as in the Engineer's table.

8.8 CONTROL AREA ILLUMINATION

Control room, Engineer's room and control equipment room shall be provided with recessed lighting fixture with diffusion lenses to ensure uniform semi-direct illumination and prevent glare on the TFT screens.

The illumination level in the control room and control equipment room shall be designed for around 400 lux and 600 lux, respectively.

Emergency back-up illumination shall be provided from DC station battery source to take over automatically in case of A.C supply failure.

8.9 FIRE DETECTION SYSTEM

Fire detection and alarm system shall comprise of intelligent & addressable fire and smoke detectors located at strategic points in plant areas, control room area and other rooms and locations. Linear heat sensing cable or fibre optic fire sensing system shall be used for detection of fire in the cable gallery and cable spreading area. Fire Alarm Panel with zone-wise alarm windows and hooter shall be located in the control area. Manual Call Points and Hooters shall be located at different plant areas, control and other

buildings. The location of the detectors shall be guided as per NFPA-72E code. A repeat Fire detection and alarm panel shall actuate an audible and visual alarm at Fire Tender House.

8.10 HVAC SYSTEM

Control Room, Engineer's Room and Control Equipment Room shall be air conditioned at around 20-24 °C, 50-60% RH at 0.1-0.2 mbar positive pressure with 0.15 m/s air velocity. The entire area will be divided into fire zones with automatic isolation facility in case of detection of fire. Overpressure alarms and status signals from the HVAC/Ventilation System will be available.

Local area control rooms, especially the ones housing remote DCS I/Os, shall be air conditioned with window cooler units.

8.11 CONTROL DESK/CABINET/ENCLOSURES

The functional area of the Unit Control Room shall house desk-top Operator's Stations in an open type table-top version, Large Video Screen Displays forming the wall panel overlooking the operator's stations, auxiliary consoles, if any and some large numerical LED displays like master clock, generated megawatts, frequency, mega VAR, Load demand etc for ready reckoning. A glass-partitioned sub-enclosure adjacent to the CCR will house network printers & copiers, Engineer's Stations, GPS master clock console, history server/s, network switches and racks for documentation. The fire alarm panel shall preferably be wall mounted at a clearly visible location.

The non-operational area of the control room i.e. Control Equipment Room, shall house System Cubicles for the DCS, Unit control panel, Electrical control panel, Interposing Relay Cabinets, Generator relay cabinets, Uninterruptible Power Supply system power distribution cabinets, Plant Communication cabinets, fire detection panel and DC power distribution boards.

The functional area of the control room shall have recessed false flooring and false ceiling for ease of marshalling field and interconnecting cable.

All panels/control desks/cabinets/enclosures shall have uniform final painting shades at both interior and exterior surfaces.

8.12 POWER SUPPLY & UTILITIES

A dual redundant single phase IJBT based Uninterrupted Power Supply System (UPS) with 240V ± 1% AC supply having redundant 2 x 100% inverters and separate chargers with single battery bank is envisaged for powering of the AC consumers in the C&I System, fire detection system, relevant C&I laboratory instruments and plant communication system etc.

The instrumentation system DCS Panels shall be largely powered from a 2 x 100% redundant 24V DC power supply and charger system extending two feeders to each electronic panel sections and electrical drives/systems respectively.

Redundant 220V DC Charger/battery system is provided for emergency electrical drives (DC) and electrical system cabinets.

All power supply systems shall be sized for 60 Minutes battery back-up to take up the entire load in case of total power blackout and with 25 % spare capacity for additional load augmentation in future. All charger feeders shall be DG backed supply.

Batteries shall be SMF lead acid/Plante type designed for a minimum 15/20 years' life.

Off site plants control systems and remote pump house control systems shall be powered from their own packaged UPS units.

8.13 SPARES & CONSUMABLES

Spares shall be included in three categories, namely, (1) commissioning spares, (2) mandatory spares as complete assembled units and (3) spare parts. Spares shall be adequate for 3 years' operation and maintenance of plant.

Consumables like reagents, salts, reference gases etc having limited shelf life shall be supplied at least to meet one year's requirement.

8.14 TOOLS, TACKLE & CALIBRATING INSTRUMENTS

Tools & tackle suitable for maintenance of the instruments and control equipment shall be included. An instrument maintenance laboratory shall be set up within the unit to attend running maintenance needs. All necessary instruments, special tools, jigs, benches, calibration units shall be included for the purpose.

In **EXHIBIT XII** Control System Architecture and in **EXHIBIT XIII**, Cable Block Diagram (Station C&I) are shown.

9.0 STATION LAYOUT AND CIVIL ENGINEERING ASPECTS

9.1 INTRODUCTION

The layout of the plant and facilities for the proposed extension station at Bhusawal shall be largely dictated by its location, contour, shape, road access, direction of coal and water sources, the wind rose pattern, land features of project area and the adjoining areas and the direction of power evacuation.

9.2 PLANT LAYOUT

The plot identified for sitting the power plant is located adjacent to the existing station.

A conventional layout for the boiler and the turbine has been suggested for the power plant with TG set axis transverse to the boiler. The turbine bay is followed by the electrical bay, mill bay, the boiler with auxiliaries, electrostatic precipitators and lastly the chimney. The plant area houses the turbine building, steam generator, circulating water system, water treatment and DM plant, coal crushers and coal conveyors and stack and the ash disposal system. The dispositions of different systems and sub-systems have been decided on the basis of their functional inter-relations and the direction of incoming or outgoing materials.

The unloading-cum-erection bay is considered at the beginning of the unit and coal conveyor entry is kept along the axis of first bay of the powerhouse.

The main power block with the switchyard is located with the direction of evacuation. The powerhouse with all the auxiliaries and switchyard (to be installed by MAHATRANSCO) would be disposed at level, above MSL, as per the available contour of the plot.

As indicated earlier, water source is from Ozerkheda Reservoir. A one day reservoir of water is planned. Suitable partition of the one day reservoir of water is suggested to permit periodic cleaning. The cooling tower is located suitably to optimize on length of C.W. piping.

The marshalling yard is proposed for the station. The coal stack along with the crusher house is located at the rear of the main power block before the marshalling yard. This location suits the direction of coal entry to the plant from the connecting rail routes. Coal Stock proposed would cater about 30 days' requirement of coal for the station. The stack yard would be equipped with one (01) no. stacker-cum-reclaimer.

The main power plant along with the auxiliaries and accessories will be surrounded within a security wall. The access road is connected to the highway. The coal entry would be by rail track. The administrative Building for the station is at the entry to the plant. The entry to the new plant will be flanked by security gate and time office. A weighbridge is shown for the proposed station. This weighbridge shall be used both during construction and operation.

Bottom ash will normally be removed by medium phase slurry system with provision of ash water re-circulation and for fly ash disposal by trucks in dry form and in high concentration slurry form from the fly ash silo is considered. Suitable rail tracks below F.A. silos are also planned for possible dispatch by rail route to the consuming industries.

9.3 CIVIL ENGINEERING ASPECTS

9.3.1 Plant Grading

As per the contour plan of the plot available for various plants and areas different grid level is proposed to be adopted to minimise the cutting and filling. The Slope of the plant drainage would be planed based on the elevations and outfall to be provided near the river.

9.3.2 Soil Characteristics & Foundations

The soil investigation of the plot shall be conducted by separate agency & report shall be prepared shortly. However, based on the existing plant, open foundation has been considered. This aspect will be revised after getting soil investigation report.

9.3.3 Seismic Consideration

The power station area is located in Zone-III as per the demarcation of IS: 1893-1984 of Indian Code of Practice. Analysis and design of structures would be carried out accordingly taking into consideration the factors related to soil characteristics and importance of the structure together with the basic seismic co-efficient as per provision of Indian Code.

9.3.4 Wind Conditions

The maximum wind pressure including winds of short duration as specified in Indian Standard Code of Practice IS**:** 875-1987 (Part-3) will be adopted for the zone where the proposed power station is located. The site is located in the zone as per above standards having design wind speed of 39 m/sec. The provision of Indian Standard Code of Practice IS**:** 875 with appropriate co-efficient for variation of heights and shape will be considered for detail design.

9.4 DESCRIPTION OF BUILDING & SUPERSTRUCTURE

9.4.1 Powerhouse Building Superstructure

The superstructure of the powerhouse building will be in fabricated structural steelwork. All components will be of welded fabrication and the field connections will be with high-tensile bolts or welding as determined in design stage. The transverse frames will be of rigid type. In the longitudinal direction

these rigid transverse frames will be braced to resist horizontal forces. Floors and roofs except the turbine hall roof will have cast-in-situ RC slabs. The turbine hall roof will be made of pre-cast RC planks in order to reduce construction time. Side cladding will be of colour coated sandwiched decorative panels.

9.4.2 Auxiliary Buildings

All other buildings namely, store, workshop, switchyard control room building, cooling water pump house, etc. would be of reinforced concrete frames with cast-in-situ RCC roof and masonry cladding. In Water Pre-Treatment Plant and DM Plant building, provision of special anti-corrosive treatment would be made. In case of long span roof, however, steel truss with sheeting would be adopted. Foundations in all cases would be of RCC.

9.4.3 Cable & Pipe Rack

The cable and pipe rack supports would be of fabricated structural steel work. All steel components will be of welded fabrication with bolted/welded joints for assembly in the field and subsequent erection Grating supported on structural steel framing would be placed for walkway portion. Foundation for supports would be of RCC.

9.4.4 Civil Works for Plant Water System

The raw water pipelines shall be M.S., underground, wrapped, coated with anti-corrosive protection. The pump house to be constructed at supply end shall be constructed to ensure adequate head to negotiate level difference and line loss. This can be worked out after the route survey is conducted.

Partition of the reservoir would be made to carry out periodic cleaning. The reservoir would be lined with clay to contain seepage loss. A reservoir water pump house would be constructed suitably to ensure water drawl from any of the chambers. This building would be RCC framed with brick wall and cast-

in-situ RCC roof. Circulating cooling water system using Natural Draft Cooling Tower is considered for condenser and auxiliary cooling by a separate set of ACW pumps.

9.4.5 Civil Works for Coal Handling Plant

For receiving coal by rail route adequately sized marshalling yard would be laid in the plant.

For coal handling plant the in-plant conveyors, conveyor galleries, supporting trestles, superstructures of transfer houses would be of fabricated structural steel work. All components will be of welded fabrication with bolted/welded joints for assembly in the field and subsequent erection. Roofing will be of sheets and necessary windows/ louvers will be provided for natural lighting and ventilation. Foundation for the crusher will not be combined with Crusher House foundation. Separated foundations will be provided for the same.

9.4.6 Civil Works for Chimney

Chimney height has been considered as 275 m. The flue path will be provided with acid-proof lining and glass wool insulation. The chimney windshield would be of RCC slip-form construction and the foundation will be with R.C. raft. In **ANNEXURE XIV** the salient features of the major civil works in plant buildings are shown.

10.0 ENVIRONMENTAL ASPECTS

10.1 INTRODUCTION

Bhusawal Thermal Power Station located near Bhusawal plain in Jalgaon district. There are a number of West flowing streams namely Tapi etc. located on the South and carry catchments to Tapi. These streams have limited catchment in dry season and a number of irrigation dams, barrages are constructed to cater to the water requirement both for irrigation and industries.

Supply of electricity is a basic need to support modern society and sustenance of economic and commercial activities. Thus availability of quality power on sustained basis at a competitive price would be the main focus of the project. High investment coupled with availability of power in the area would attract other ancillary industries to be set up in the vicinity which in turn would have economic spin off on the community at large.

The effect of the proposed project on environment should be seen in the broader perspective of overall impact on the neighborhood. There is no sanctuary, national park or archeological monuments within 25 km radius of the proposed site. Industrial growth is always associated with some effect on environment. Attempts will, however, be made both at macro level as well as micro level to minimize detrimental effect of the proposed project on the surrounding area. The proposed power station would be equipped with state-of-the-art pollution control devices to bring down the emission/discharge of pollutants within the acceptable norms of the country.

10.2 ENVIRONMENTAL POLLUTION FROM A THERMAL POWER PLAN

To evaluate the effect of the proposed project on the surrounding environment, various factors such as population distribution in the vicinity, type of land use, possibility of pollution from various sources etc. would be

taken into consideration. Being a new station within acquired land limits, Land affected People (LAP) are involved in this project.

A Thermal Power Station utilizing coal as its source of energy may pollute the environment in a number of ways. The major pollutants likely to affect the environment of the neighborhood are:

(a) Suspended particulate matters (stack emission & material handling plant)

(b) Toxic gases viz. SO_x, NO_X (stack emission)

(c) Thermal pollution (stack, cooling tower etc.)

(d) Liquid effluent from cooling water system, plant services, boiler blowdown, power house drains, oil handling run off, run off from coal pile area, DM plant regeneration waste, filter backwash waste, raw water clarifier sludge, ash disposal area run off and domestic waste.

(e) Noise generated during plant operation

(f) Fly ash will be handled in dry form and will be used in cement plants and later on for backfilling of open cast mine in the region.

The various pollution control measures envisaged for the proposed project are as follows:

(a) Emission from Stack

Since the ash content in coal is expected to be in the range of 31%, to 42% a sizeable quantity of fly ash in the form of particulate matter would be generated. An efficient Electrostatic Precipitator will be provided to limit emission of particulate matter to 50 mg/Nm^3. However, provision shall be kept for improvement in case of change in

statute. A properly designed Boiler would keep the stack emission of NO_x to 750 mg/Nm^3 according to present World Bank norms.

The stack height is chosen as 275 m to limit ground level concentration of SO_x, NO_x, etc. within acceptable limits by proper dispersion. With a properly designed furnace and burner system, generation of CO and NO_x would be minimized.

Heat loss through the stack is only about 8-10% of the total heat input to the furnace. This is nominal when compared with the capacity of earth as the heat sink and this would be adequately dispersed with the plume from the high stack. Moreover, majority of the heat in cooling tower is rejected in the form of evaporation loss. This does not cause any appreciable thermal pollution to the surrounding area. It may further be noted that the area has moderate wind speed and rainfall and high dry bulb temperature.

(b) Liquid Effluent from Water Treatment & Other Areas

The waste water treatment and management plan is developed with Minimum (Zero) Discharge Concept. Maximum Heat cycle make-up water requirement for the Power Station would be of the order of 63 m^3/hr of De-mineralized water. The Demineralising process would generate alternately acidic and alkaline effluents after regeneration of such type of exchangers. These effluents would be neutralized in a neutralizing basin where proper neutralizing arrangements for the effluent fluids would be provided and the neutralized effluent water would be discharged into an equalization basin termed Guard Pond. In **EXHIBIT XV** wastewater generated from the plant and their treatment and reuse plan are shown diagrammatically.

In the recirculating cooling water system, the make-up water would be softened water. There will be blow down from the circulating water system. This blowdown would be fully utilized as service water,

bottom ash sluicing, fly ash moistening, fly ash disposal in HCSD/ Lean slurry mode, coal handling plant dust suppression system, horticulture etc.

Other wastes from the processes include clarifier sludge and backwash from filtration plant etc. Both these effluents would be sent to sludge pond and a portion of the clear water would be taken back to the clarifier and balance if any shall be sent to the guard pond. The guard pond will act as an equalization basin for all treated/untreated liquid effluents. From here also water will be fully used in areas mentioned above. Provision will be there for use of this treated and equalized effluent in horticulture and green belt development.

Waste water from fuel oil areas shall be passed through oil traps and plate settlers and the recovered oil shall be suitably recycled. Appropriate protection shall be taken for hazardous materials and relevant protection shall be provided as per prevalent codes. Recovery from this pond shall be fed to the tertiary treated one day storage tank.

As mentioned above LAP affected people are involved and hence compensation for the affected families would be involved. However this aspect shall be adequately addressed in EIA study.

(c) Noise Emission

Noise emission from equipment will have to be controlled at source. Adequate silencing equipment will be provided at various noise sources to attenuate the noise to acceptable level as per GoI/ International norms. A noise level of 85 dB at 1 m distance from the source is planned for the proposed station. Also plantation would be developed in plant area, which would help in reducing noise level to a great extent.

(d) Guard Pond

It is envisaged to develop a guard pond to be located suitably in the low lying area of the plot for collecting the liquid wastes. The capacity of the pond would be adequate to store 24-hours design liquid effluent discharge from the station. Treated and equalized effluents from the guard pond will be treated in the effluent treatment plant by alkali/acid and let off to be reused in horticulture and green belt development within the plant. Thus, no treated effluent needs to be discharged from the station. Only in case of exigency the treated effluent after treatment and conforming to the GOI norm will be let off to the nearby natural streams.

The storm water and catchment water, which are not effluent, from the plant would be drained by a separate drainage system.

(e) Green Belt

Adequate green belt (more than 30% of total area) is planned to be developed within the plant area satisfying the requirement of State Pollution Control Board (SPCB) and the Ministry of Environment & Forests (MOEF), Govt. of India. Plantation near coal stacks to arrest fugitive dust is also proposed. These green belts, apart from arresting air-borne dust particles and acting as noise-barrier, would help in improvement of ecology and aesthetics of the area.

10.3 BASIC INFORMATION FOR ENVIRONMENTAL CLEARANCE

No other any industry located within 25 km radius of the proposed plant location, the background pollution level, in terms of SPM, SO_x, NO_x etc. of the area is expected to be well below the prescribed limits of MOEF. Project authority will commission a separate study on Environmental Impact

Assessment (EIA) to identify the effect of the project on the surrounding environment.

10.4 COMMERCIAL UTILISATION OF FLY ASH

The station will generate 1.59 MMT of ash per annum at MCR and 1.44 MMT considering 330 day / annum, of which about 80% is fly ash. Fly ash has good pozzolonic property, good flowability and low permeability, which facilitate myriad utilization of fly ash. Ash generated from the station would have sizeable quantum of inert oxides and carbonates of silica, alumina, magnesium, etc. Some of the commercially viable uses of such fly ash are as follows:

(a) As fill materials in cement

(b) Backfilling of open cast mine

(c) Building blocks

(d) Light-weight aggregates

(e) Partial cement replacement

(f) Road sub-base

(g) Grouting material

(h) Filler in asphalt mix for roads

(i) Partial replacement of lime aggregate in concrete work

(j) Road embankment

(k) Land filling material

(l) Recovery of minerals namely Aluminum & Iron.

Bottom ash, which has a relatively large grain size, finds a ready market in construction of roads and embankments in rural areas. Review of the various application areas of fly ash reveals that some usage of ash generated in the proposed extension station can be explored as mentioned below:

(a) As mine-fill of the coal mines

(b) As landfill in low lying areas

(c) For manufacture of fly ash bricks and other construction materials.

(d) As fill materials in Cement manufacture in the plants located in the adjoining districts.

There are a number of coal mines in the area which would be ready to accept ash for mine filling. Further fly ash will also be gainfully utilized by nearby cement plants for use as admixture in pozzolona cement.

However, a formal ash management plan would be adopted in an environment-friendly manner to contain the fugitive ash emission in the nearby areas to minimum. A separate EIA study would address details of ETP, STP, CDM intent, if any, details of rain water harvesting etc.

10.5 CORPORATE SOCIAL RESPONSIBILITY

Separate provision of Rs. 25 Cr. is made in project cost towards CSR.

The agency deployed for EIA study shall consider following:

(a) Income generating measures which can help in upliftment of poor section of society which is consistent with the traditional skills of the people shall be identified. The Programme can include activities such as development of fodder farm, fruit bearing orchards, vocational training etc. In addition, vocational training for individuals shall be imparted so that poor section of society can take up self employment and jobs. Separate budget for community development activities and income generating programmes shall be specified. Financial allocation to be taken up under CSR shall be specified.

(b) While formulating CSR schemes it shall be ensured that an in-built monitoring mechanism for the schemes identified is in place and mechanism for conducting annual social audit from the nearest government institutes of repute in the region shall be prepared. The project proponent shall also provide plan for the status of implementation of the scheme from time to time.

(c) Possibility for adopting nearest three villages shall be explored and details of civil amenities such as rods, drinking water, power etc proposed to be provided at the company's expenses shall be submitted.

10.6 ENVIRONMENTAL LABORATORY

An Environmental Laboratory will be set up to monitor various environmental parameters as per statute. This will be in compliance with the Environmental Management Plan (EMP).

In **ANNEXURE XV**, a list of basic equipment / instruments for environmental monitoring and testing for the proposed Thermal Power Station is given.

11.0 CONSTRUCTION FACILITIES

11.1 INTRODUCTION

For the proposed 1x660 MW coal based Thermal Power Station, construction facilities will have to be developed, keeping in view the available infrastructure and the requirement to implement the project within scheduled time frame. It is proposed to implement the project through two (2) nos. of Engineering, Procurement and Construction (EPC) contracts, namely BTG package and Balance of Plant (BOP) package. As indicated earlier, the land area available in the identified plot would be adequate to locate the proposed unit.

The plant layout has therefore been judiciously proposed to permit adequate space for construction offices, covered and uncovered storage, fabrication and assembly yard etc. keeping in view the possibility of converting some of these into permanent facilities at the end of construction with suitable augmentation / modification. Developing construction facilities would be the prima facie responsibility of the EPC Contractors. For developing suitable construction facilities, it would be necessary to develop some of the enabling facilities viz. some of the in-plant roads, identifying space for construction offices of the sub-contractors of EPC contractors, temporary fire fighting system, construction water and construction power facility etc. prior to taking up any construction work. This preparatory work would be followed by site leveling and grading, construction of in-plant road network for ease of movement of plant and equipment and developing temporary drainage facility to divert catchment from the higher reaches and ensuring other facilities viz. construction gate, watch tower, greenery, identifying area for labour hutment etc.

11.2 CONSTRUCTION FEATURES

11.2.1 Construction of Road

The existing approach road from highway to the plant site will have to be utilised for movement of men and materials and transportation of heavy equipment / machineries required for the project. The station being already connected by broad gauge railway line, heavy and ODC equipment and bulk supplies (construction materials) would be transported through rail routes as far as possible. The internal roads are to be constructed suitably in stages to provide access to different areas of construction. Imported plant and equipment, if any, would be transported by sea up to Mumbai Port and then by road.

11.2.2 Construction Building

About 2000 m^2 of construction office space and 3500 m^2 of covered storage along with 17,000 m^2 of uncovered storage space is proposed to be provided in the identified area for construction of office, stores, construction yard etc. In addition to this a small vehicle shop, garage, yard toilets, etc. are also proposed to be built within this plot. Another plot may be earmarked for batching plant, storage yard and labour hutment during plant construction. A construction space is also considered in the plant layout drawing covering more than 25,000 m^2 for locating fabrication and pre-assembly yard.

11.2.3 Construction Water

The requirement of construction water for potable and service purposes will be available from the existing plant and stored in an overhead tank. Construction water supply will be provided at a single point to each contractor for drawing necessary distribution system. A temporary fire hydrant network would be built during construction stage. The above facilities would have to be developed by the EPC Contractors.

11.2.4 Construction Power

The EPC Contractors would be provided power connection at 11 kV level at single point for site fabrication of steel to suitably step down to 415 V and to supply power to various work centres/sub-contractors. A power line ring main would accordingly be constructed encompassing the construction area for feeding construction power at pre-determined locations.

11.2.5 Construction Equipment

The EPC Contractor would bring his own construction equipment. To facilitate site work project authority would also procure a few useful construction equipment, viz. crawler mounted heavy-duty crane, tractor-trailer, road roller, some transport equipment etc. In view of the fact that the project is envisaged to be executed on EPC mode, any further addition to construction plant and machinery by the owner is deemed unnecessary.

A few transport vehicles like car, jeep, truck, ambulance, cash van etc. are, however, proposed to be procured by the project authorities.

11.2.6 Construction Materials

(a) Stone Aggregate

Quarries for stone aggregate are available in the region and the aggregate will have to be transported by road/rail suitably. A batching plant shall be set-up to cater to aggregate requirement.

(b) Sand

Coarse to medium sand is available locally from the riverbed and would be transported by trucks.

(c) Bricks

Brick plants are also available in nearby localities. The lead distance is less than 5 km.

(d) Cement

There are a number of cement plants in the adjoining area, which are capable of meeting the requirement.

11.3 ORGANISATIONAL SET-UP FOR PLANT CONSTRUCTION

Skilled, semi-skilled and unskilled workmen readily available for construction and erection of the power plant from Bhusawal TPS site. Proper manpower planning both by contractors and project authority needs attention well in advance to ensure smooth and timely execution of the project.

In view of implementation of the project on EPC mode, it is envisaged that the project wing of owner which is already existing for execution of 2x500 MW be headed by a senior executive, who will look after the overall activities in compliance with the project schedule. At present team is headed by CGM. He would be assisted by a team of senior engineers experienced in various disciplines including project planning and co-ordination, technical areas, administration, staff welfare, finance, safety and security, materials management, traffic and legal affairs. Other staff will be recruited progressively as the project activity progresses. This staff would be ultimately absorbed in operation and maintenance team after commissioning the plant. Owner's engineers may be engaged to supervise and monitor different technical activities including compliance of codes, standards, safety requirements, quality, progress etc.

11.4 SAFETY & HEALTH HAZARD MONITORING

The Owner is primarily responsible for safety and health hazard aspects during project construction. In view of this Owner shall form a standing committee comprising his own officials and of the EPC Contractor, who will constantly monitor safety and health aspects on periodic basis. Designated safety officer(s) from owner's side with power to penalise for any deviation from the adopted safety norms will make regular check. These officers would be empowered to identify unsafe construction practices, non-use of safety gears, source of potential health and safety hazards viz. gas leakage, faulty electrical connections, unsafe excavations, unsanitary conditions, fire hazards etc. in the work sites. They would suggest with the help of the designated committee, ways and means to prevent occurrence of accidents arising out of the aforesaid situations as well as bringing to task the erring personnel.

Apart from prevention measures, as detailed above, there should be an infrastructure to deal with potential accident situations. This infra-structure shall consist of, but not limited to, first-aid centre, ambulance, fire-fighting system etc. and trained personnel to take care of these emergency services.

11.5 SECURITY

An elaborate security system to be arranged by the EPC Contractor to secure the proposed project site from theft, pilferage, obstruction to work etc. shall be established for the whole perimeter, in general, and storage spaces, in particular, by installation of fencing/boundary walls and security gates manned by trained security personnel.

11.6 LABOUR WELFARE & STATUTORY REGULATIONS

Owner, being the principal employer for the project construction, shall have the primary responsibility in this regard. A separate cell, in the project

organisation, would be formed to take care of these functions. The licences required for project construction are, but not limited to, licence/clearance to engage labour under Contract Labour Regulation and Abolition Act, Workmen's Compensation Act, clearance from State Electricity Inspectorate for construction power installations, licence for use of explosives under Indian Explosives Act, clearance from State Boiler Inspectorate, Factory Directorate, etc. The designated cell shall also monitor the compliance of all the statutory regulations by the EPC Contractor and their sub-contractors.

12.0 ORGANIZATION STRUCTURE

12.1 PHILOSOPHY OF PLANT DESIGN & OPERATION

With introduction of the state-of-the-art instrumentation and control based on computerised Data Acquisition System (DAS) and failsafe mode of operation, the manpower requirement has been largely optimised.

With the advent of newer technologies and installation of larger units, management of high-energy system without human error has become the main objective not only to sustain high reliability but also to avert costly damages during any malfunction. Various safety supervisory systems like Burner Management System (BMS/FSSS) or Automatic Turbine Run-up System (ATRS) have become integral part of modern power station design with microprocessor-based control and Data Acquisition System (DAS). These facilities will be provided in the proposed station as part of the boiler, turbine and control system.

Automatic sequential steps will be provided to assure safe start-up and shutdown with minimum operator intervention. Highest availability with optimum manpower requirement thus guides the philosophy of plant design and operation.

12.2 ORGANISATIONAL SET-UP FOR PLANT OPERATION

For planning of manpower for operation of the plant, priority is set on design and operational philosophy of the plant. As discussed earlier, efforts have to be made to optimise manpower requirement for the station through proper design, layout, control and instrumentation etc.

At present, existing Bhusawal TPS is headed by Chief General Manager. Proposed power station shall also be under his control after commissioning. New unit of 1x660 MW after commissioning is proposed to be looked after by

the General Manager (G.M.). He will report to the Chief General Manager of Existing TPS. In technical disciplines General Manager will be assisted by four Superintending Engineers (S.E.) who will hold independent charge of the following departments and their functions.

(a) Operation

(b) Mechanical Maintenance

(c) Electrical & I&C

(d) Outdoor Plant

The operation of the station would be the overall responsibility of the S.E. (Operation). The total manpower requirement is estimated at 426.

The maintenance wing will be headed by S.E. (Mech. Maintenance), S.E. (Elect, C&I Maintenance) & S.E. (ODP), and would be assisted by adequate number of Executive Engineers Executive Engineers would have the required engineers and staff under them to look after the work under respective disciplines. The periodic capital maintenance is considered to be done through contract labour in line with general practice being followed elsewhere. The above manpower deployment planning is based on the philosophy of minimising the manpower requirement during evening and night shifts and concentrating on maintenance efforts during the day shifts when the General shift persons are available at the plant and are actively engaged in supervision. Less number of people, therefore, will be in attendance during the evening and night shifts on the assumption that only temporary and minor repair would be done during these hours. Under this method of operation maintaining a large work force may be avoided.

The manpower estimates shown above may undergo changes as per the prevailing practices of the project authority and possibility of deploying some staff from the existing units for the extension station.

12.3 TRAINING OF PERSONNEL

Central Power Research Institute (CPRI) already has a full-fledged Training Institute at Koradi looking after the training of Technical and Commercial Management Trainees, Supervisory Trainees, Trade Apprentices etc. to replenish the requirements of trained personnel for power stations. The same facility may be extended suitably for training of personnel for the proposed station. Suitable training programmes will be formulated under the guidance of above department for imparting different types of training, as required.

Suitable training programmes would also be formulated for special requirements of steam generators and steam turbine generators operating with supercritical steam parameters. The training programme for familiarisation with the new station will vary with the nature of duties as explained below:

(a) Maintenance Personnel

A number of personnel experienced in maintenance of mechanical, electrical and control & instrumentation would be employed and posted at the construction site immediately after the major civil work is over. This will enable them to be closely associated with the construction of all plant and equipment and thereby familiarise themselves with the components and methods of assembly.

(b) Operating Personnel

The key operating personnel would first go through the course at the thermal power plant training institute, if necessary, as mentioned above. Lectures by supplier's engineers and routine drills for various operations would be organised during this period. Training at vendors' works, both within the country and abroad, would be organised. All

operating personnel would be actively associated with all phases of the commissioning of the plant.

(c) Supervisory Staff & Senior Officers

They will be employed and posted at the construction site about six (6) months before the commissioning of the unit for familiarising themselves with the same. During the period, they will be given short orientation training on the operation of pulverized fuel-fired reheat power stations operating with supercritical steam parameters by visiting experts from the principal suppliers.

(d) Chemists

They will be initially trained at existing power stations and then placed at the work site at least two months before the initial run, so that they could set-up a laboratory for water, steam, fuel and other tests.

The training schemes mentioned above indicate the type and method of training, but the recruitment and general procedure of training would be in conformity with the existing training scheme of MAHAGENCO.

13.0 EMPLOYEE FACILITIES AND RESIDENTIAL TOWNSHIP

13.1 EMPLOYEE FACILITIES

Apart from the main power house building housing, the power generating equipment and other buildings required for their running and maintenance, the following facilities are required to be provided inside the station premises for the operation, maintenance and administration staff.

(a) Administrative Office (Already existing)

(b) Service building including technical offices

(c) Canteen

(d) First-Aid Centre

(e) Car Parks and Motor Cycle Sheds

(f) Gate House Complex including Safety and Fire Office

(g) Toilets, washrooms, change rooms, drinking water etc. provided in main buildings and yard to meet requirements of the Factories Act.

Of the above facilities, some of the buildings will be required during construction phase while the others will be required during operation of the plant. A well thought-out investment plan under these heads will ensure economy and expeditious construction and these would be converted to permanent facilities at a later date. The new plant entry gate, which would be flanked by security office and safety office on one side and time office and first-aid centre on the other would be provided for the proposed plant. Time keeping will be done by means of electronic register. A service building will be constructed adjacent to the main powerhouse building to serve as

technical office. A canteen will be located in the extension plant area near the main work centre. Car parks, Motorcycle sheds have been considered adjacent to the main plant. Toilet, washroom, change room, etc. will be provided as required.

13.2 RESIDENTIAL TOWNSHIP

13.2.1 Residential Quarters

It is estimated that a total of about 200 employees would be working for operation, maintenance and administration of the proposed 660 MW station. This excludes security and canteen staff, as these functions would be contracted out. The area is basically rural. Based on the above features and the norms set by the Bureau of Public Enterprises (BPE), it is, therefore, proposed to build an estimated 426 residential quarters for the employees for the proposed station in the existing colony.

The estimated number of quarters proposed to be built is given hereinafter:

Type	Plinth Area	Requirent of House Provided in the Project Cost
A	@ 159 m^2	1 No.
B	@ 139 m^2	4 Nos.
C	@ 84 m^2	48 Nos.
D	@ 56 m^2	114 Nos.
E	@ 35 m^2	259 Nos.
Total		426 Nos.

Besides the above, barrack would be built for the additional security staff. The township will have an erector's/project hostel, which will be, ultimately converted to Trainee Hostel.

The township being located within 10 Km from Bhusawal Town, some of the community facilities available in Bhusawal town viz. higher education, health care etc. can be utilized by the employees of the power station.

14.0 PROJECT IMPLEMENTATION AND MONITORING

14.1 INTRODUCTION

Successful implementation of a project calls for joint participation of the Owner, the Consultant, the Vendors and the Contractors. The Owner plays the most important role in spelling out the objectives, setting out the priorities and time schedules and ensures timely flow of funds. In line with the recent trend, MAHAGENCO would implement the proposed project by Engineering, Procurement and Construction (EPC) concept. Two (2) EPC contracts shall be proposed, namely, for BTG package with associated civil works and the other for balance of plant (BOP) with associated civil works. This mode of implementation will ensure:

(a) Single point responsibility of the constructors of respective packages. (BTG & BOP)

(b) To maintain the timeframe normally desired by the lenders

(c) To satisfy the commercial requirement of funding agency

(d) To avoid delay normally faced in multi-agency deployment

The Owner may undertake responsibilities like monitoring and expediting the project. However, the Owner has engaged the services of Consultant to advise and assist in the review of design and engineering, quality assurance and inspection of equipment and services rendered by the EPC Contractor. The EPC Contractors in turn, would render their required services as per the intent and spirit of the specifications furnished by the Owner. The technical/engineering Consultant will prepare the specifications to meet the Owner's objectives.

14.2 PROJECT ORGANISATION OF THE OWNER

The project is proposed to be implemented under the overall direction of the Chief General Manager and in this assignment; senior executives of different disciplines and the Planning & Projects Department will assist him. The Planning and Projects Department assisted by other technical and commercial departments and supported by the Consultants would be responsible for the project from its inception till all relevant clearances are obtained, financial packages are tied up and other preliminary work are completed. The Planning and Projects Department assisted by the Consultants will, thereafter, take-up the implementation of the project. They will be involved in various activities of the preliminary stage so that the changeover from the preliminary to the implementation stage becomes smooth. This department will be assisted by a senior executive who would be supported by a team of experienced engineers from various disciplines, such as, Civil, Mechanical, Electrical and Instrumentation.

In specialized areas, the Planning & Projects Department would also be assisted by the Estate, Legal, Industrial Relations, Security, EHS, Purchase and Finance Departments in the process of execution of the project. Their roles, in brief, would be as follows.

The Estate Department would take-up the work of acquisition of land for ash pond, resettlement of affected population, if any, co-ordination with the local bodies and Government Departments of Land Revenue Department, P.W.D. and other statutory bodies. All legal matters arising out of land disputes and other activities would be tackled by the Legal Department. Industrial Relations Department would assist in achieving good public relation and peaceful labour situation, which, in turn, will facilitate speedy implementation of the project. A senior official of the Purchase Department would be specially deputed to coordinate with EPC Contractors in procurement of cement, steel, cables and miscellaneous standard items required for the

project. EPC Contractor would deploy Security Department's personnel from the date of receipt of the building materials at site.

Besides, engineers in Testing and Operation & Maintenance Departments would be recruited at the appropriate time during construction and pre commissioning stages of various plant and equipment.

14.3 PROJECT EXECUTION

The project is envisaged to be executed on EPC concept in two different packages covering (a) the main power block comprising steam generators and steam turbine generators along with associated auxiliaries and civil works and (b) the Balance of Plant (BOP) package, auxiliary systems including coal handling package, ash handling system, plant water system, electrical plant and equipment, instrumentation and controls and respective civil works. The interface boundary of two (02) EPC Contractor's scope shall be well defined to avoid any mismatch. The civil works and erection including enabling facilities shall also be well defined to ensure completeness of the work.

The principal objective of the project execution team to be formed by the Project Authority are to overview the design, procurement, construction and commissioning of the power station within the scheduled time and cost, ensuring high availability of the generating equipment.

Guarantees will be given for maximum continuous output and heat rate performance for the unit. Scope of the contract will be defined in the project specification. The project timescale is 51 months zero date, date of Letter of Award (LOA) of BTG Package. Contractors under technical supervision by turnkey executor and their equipment suppliers will carry out the construction of the power station. Responsibility for the management of EPC contracts will be with turnkey executor.

The EPC contract would cover the following related activities:

(a) The entire enabling works comprising leveling and grading of the project site, labour hutments, construction water and power supply to plant and labour hutments, temporary fire hydrant system, in-plant road network, drainage, sewerage system etc. as required.

(b) The main contract for the supply and installation of the respective mechanical, electrical and instrumentation and control equipment, testing commissioning and performance test to establish the quoted guarantee figures.

The basic design parameters and the scope firmed up in the EPC specifications along with their implications on the cost of the project and the implementation schedule would form the basic guideline.

EPC Contractors would group the total project work into various system-based work packages. The grouping would be done in a manner so that the interfaces and terminal points are clearly and conveniently defined, to minimize interlinking/interface problems. This aspect would be adequately projected in the L_1 network to be prepared by the EPC executor.

While the civil, mechanical, electrical and instrumentation packages would be covered under the EPC contracts mentioned above, all actions would be taken to keep the target as scheduled. EPC executor would supervise progress of activities by the contractors, their resources and ability to adhere to the quality control continuously. Arrangements would also be made for timely delivery of drawings and working manuals to the respective contractors. EPC executors to indicate the status of all the above activities on fortnightly/monthly basis shall generate progress reports.

14.4 PROJECT MONITORING, CO-ORDINATION & CONTROL

14.4.1 Project Monitoring Information System

Respective supervising engineers of EPC Contractors and the owner would physically monitor progress of each activity at every stage. All detailed information would be passed on to the Central Monitoring Cell of Project Authority to keep track of the work progress. Similarly, costing of individual items would be monitored and recorded with the help of computer and software.

Central Monitoring Cell would monitor the progress and report to the senior executives for information and necessary action.

14.4.2 Co-ordination

Regular meetings would be held at site among the representatives of the EPC executors, respective contractor engaged at work site, the Consultants and the Engineers of Projects Department to review the progress of each activity. In these meetings, slippages in progress would be identified and corrective measures taken. The problems arising out of site and material constraints would be promptly sorted out. The meetings would also be attended to by one of the senior executives of the company to facilitate on-the-spot decisions. Minutes of meetings would be circulated among all concerned for necessary follow-up action.

Co-ordination meetings between the Consultants and the senior executives of the Owner would be held regularly for major decisions in regard to planning, designing of various plant and equipment, execution procedures, manpower deputations, industrial relations, security, etc. Steps would be taken to ensure regular interactions between the EPC executors, the Consultants and Projects Department to finalize interface engineering.

14.4.3 Reporting

Various reports would be generated in regard to the physical and financial progress of the project on monthly, quarterly and yearly basis for forwarding to the various government departments, financial institutions as well as for internal use. The reports would be prepared manually and/or in computerized forms as necessary. Daily progress of the major items of work, along with their monthly targets, would be reported to the project head.

14.4.4 Quality Control

Quality assurance in construction work constitutes inspection of raw materials, adherence of appropriate construction technology, stage-wise inspection of erected items, testing, analysis of test results and suggesting adequate measures to conform to the respective codes and standards. Record keeping of the quality system adhered and regular monitoring of the same would be done to ensure long life of the plant. To carry out both destructive and non-destructive testing, the contractors would arrange for necessary testing equipment at site. Suitable storage facilities would also be arranged at the project site to ensure undesired deterioration of raw materials at site. Though the responsibility in these regards lies with the EPC executors but owner would have access to all such information.

14.4.5 Financial Control

Actual cost records would be regularly monitored against forecasts, which would be forwarded to Finance Department by the Projects Department on monthly, half-yearly and yearly basis, depending on the actual progress of delivery and erection/construction. Fund requirements would be assessed and arranged accordingly.

14.5 ROLE OF CONSULTANT

The Project Authority has engaged the services of a competent consultant to provide technical support as Owner's engineers from inception stage of the project. The Owner's engineers will, prepare the EPC bid documents, review the EPC tenders, participate in tender negotiation and prepare EPC contract documents. They will also review contractors' design and drawings, monitor Contractors' work at site and finally participate during guarantee tests. The team will comprise engineers from various disciplines viz. civil, mechanical, electrical, instrumentation, planning etc. to fulfil the above functional requirements.

14.6 PROJECT IMPLEMENTATION SCHEDULE

The project schedule has been developed with the following considerations:

(a) Zero date has been taken as the date of issue of Letter of Award to the EPC Contractor for main BTG package.

(b) Appointment of Consultant has been five (5) months prior to the 'Zero Date'.

(c) Land survey and soil investigation would be completed well in advance.

The tentative timeframe for execution of the project by EPC Contractors is expected to be as follows:

(a) The first activity to be started at site is the land development work, i.e. earth cutting and filling, compacting, levelling and grading.

(b) Providing the required construction facilities will be the next major activity requiring earnest attention for smooth execution of the project.

The work for the construction facilities like supply of water and power, construction of approach road, stores, office, etc. is scheduled to start from (+) 1st month and completed by the (+) 5th month (i.e. total 4 months).

(c) Construction of road access should be started at least four (4) months prior to 'Zero Date' so that, the road is available prior to (+) 3rd month.

(d) Foundation load data for boiler and turbine would be available within two (2) months of placement of orders.

(e) The foundation work for the boiler, and power station building is scheduled to start four (4) months after the project 'Zero Date' and would be completed in time to suit the erection schedule.

(f) All technical particulars necessary for design of miscellaneous equipment and piping would be available three (3) months after issue of order.

(g) The erection of the boiler can start by (+) 12th month after placement of order and the erection can be completed and boiler light up done by (+) 45th month.

(h) The erection of the turbo-generator can start by (+) 24th month after placement of order and that erection can be completed by (+) 48th month.

(i) Time envisaged between boiler light up and turbine synchronization is three (3) months.

(j) Further three (3) months period has been kept between synchronization and commercial operation. The first unit is thus expected to be synchronized by 48th month and commercial operation in 51st month.

(k) It has also been assumed that the manufacture and delivery schedule of all other systems can be made to suit the erection and commissioning time for the turbine.

The above schedule of EPC Contractors may undergo changes as per their requirement.

15.0 PROJECT COST ESTIMATE AND FINANCIAL ASPECTS

15.1 BASIS OF ESTIMATES

The project is planned to be implemented under two comprehensive engineering, procurement & construction (EPC) contracts comprising Boiler Turbine Generator Package and Balance of Plant package. In the estimates given hereunder itemized cost for various packages are shown a margin may be added to the estimate to arrive at the EPC price for above two packages. In the present estimate, this has not been considered as the EPC price is largely dictated by market forces and other commercial considerations. The Project cost is estimated on the basis of following assumptions:

(a) Land

The area designated for power plant would require some grading. The required cutting and filling is assumed to ensure appropriate drainage from the plot and adjoining areas.

Land cost is included in the estimates.

(b) Main Equipment

The cost of Steam Generator, Steam Turbine & Generator including their auxiliaries and associated equipments and piping has been estimated based on information available from recently finalized order for similar equipments.

(c) Taxes, Duites, Insurance etc.

For plant and equipment taxes, duties, insurance etc. are considered as below:

(i) Ocean freight and marine insurance @ 6.5% on F.O.B. price has been considered for imported items.

(ii) Customs duty on imported item and excise duty on indigenous suppliers are not leviable in view of Mega Power Project status.

(iii) Port handling charge would be @ 1% on C.I.F. value. Another 2.5% is considered towards inland transportation and transit insurance.

(iv) Weighted average sales tax @ 5% for indigenous items has been taken on FOR price.

(v) Freight and insurance for indigenous items @ 2.5% on F.O.R. cost.

(vi) Based on above average tax (including Ocean freight, port handling, inland transportation and transit insurance for imported items; Sales tax, Packing and forwarding, Freight and transit insurance on indigenous items) is considered 8.75%.

(vii) Entry tax, Octroi etc., if any, have not been included. However, works contract tax is included.

(viii) The service tax leviable has been considered in the individual price components.

(d) Auxiliary Plants & Equipment under BOP Package

All auxiliary plants and equipment other than mentioned above have been considered to be procured from reputed indigenous vendors by BOP Contractor. However, some of the components may be imported as necessary by BOP Package Contractor.

(e) Power supply to the pump house would be at 11 kV level from the local EHV sub-station.

(f) Buried/M.S. pipe (of AWWA specification) has been considered for circulating cooling water system. For evaporative cooling of circulating cooling water, Natural Draft wet-type Cooling Tower using clarified water as make-up would be deployed.

Cost of Natural Draft Cooling Tower and other equipment of plant water system have been estimated from the budgetary offer of a typical vendor.

(g) Fuel

Washed coal is considered to be available from Machhakata mine blocks in Orissa, being developed by MAHAGENCO & Gujarat State Electricity Corporation Limited and is planned to be transported to the power plant by railway network. The coal handling plant capacity @ 1200 TPH has been adopted for the station (GCV of worst coal 3500 Kcal/kg).

It is assumed that coal would be supplied in size of (-) 300 mm.

In-plant coal storage of about thirty (30) days' requirement has been considered within plant boundary.

(h) Ash Disposal

Fly ash from the furnace would be extracted, stored in dry form and disposed in dry or high concentration slurry form. Both bottom and fly ash from the plant is considered to be disposed to the existing Ash Pond located at Velhale nearly 10 Km from the site. It is expected that a portion of fly ash generated from the station will find local market as

fill material in cement plant in adjoining areas, construction of road etc.

(i) Electrical System

400 kV switchyard with adequate number of bays has been shown. MAHATRANSCO would install this switchyard and evacuate the power from the generating station as per their planning.

(j) Environmental

Stack emission	:	One chimney of 275 m height with on-line gas monitoring system has been considered.
Desulphurization	:	Considering the low sulphur content in the fuel, no FGD unit need to be installed. However, a space provision is kept.
Effluent	:	Waste water from different processes of the station would be collected in a guard pond where it will be treated and recycled for use in less priority areas viz. dust suppression and dust extraction systems of CHP, ash handling, service water for washing and cleaning, afforestation etc. Attempt has been made to attain zero discharge.

(k) Time Schedule

Commercial operation of the unit from zero date i.e. the date of Letter of Award for main equipment would be 51 months.

(l) Manpower

Manpower requirement during construction are Departmental personnel 200 and Contractors' personnel 3000. Total manpower of 200 personnel for O&M, administration and finance is envisaged. Another 100 contract personnel is envisaged in other non plant areas.

(m) The following points have been considered while estimating the cost of the project:

(i) Scopes under different estimates are generally as per the details indicated in this report and preliminary design parameters.

(ii) Rates of civil works are generally based on the cost data of on-going projects in the region.

(iii) All cost data are based on prices offered for similar projects namely Koradi Expansion Project being the latest one.

(iv) Cost of spares for mechanical and electrical equipment is considered @ 3% of ex-works supply price.

15.2 PROJECT COST ESTIMATE

The estimated capital expenses for the proposed 1 x 660 MW unit on the above basis have been detailed in **ANNEXURE XVI** at the end of this section. This works out to Rs. 4548 crores (without Mega Power Project

status) including Interest During Construction (IDC). A debt to equity ratio of 80:20 is considered. The debt would be financed by Indian Financial Institutes and the equity would be arranged by MAHAGENCO/State Government. The debt portion will attract an overall interest @ 12% p.a. and the working capital loan would be available at an interest rate of 12%.

On the basis of above, the capitalized project cost including interest during construction and margin money (Rs 33.2 crores) works out to Rs.4548 crore**.**

15.3 ESTIMATION OF COST OF GENERATION

The main objective of this sub-section would be to estimate and analyses the capital cost of the proposed project so as to be in a position to estimate the cost of generation applicable for the project.

The major assumptions are as follows:

(a) The project would be implemented by MAHAGENCO availing loan from Power Finance Corporation (PFC) / Rural Electrification Corporation (REC) and Indian Financial Institutes and the equity would be sourced from MAHAGENCO's own fund/State Govt. Equity portion would attract a return @ 14%.

(b) Interest during construction on long term loan estimated @ 12% p.a. The IDC will be capitalised. Working Capital Loan shall also attract an interest rate of 12% p.a.

(c) The as-delivered cost of coal is estimated at Rs.1967 per MT including transportation cost of coal assumed.

(d) The delivered cost of Fuel Oil would be Rs.33000/- per KL.

(e) No escalation has been considered on the cost of inputs or in project cost.

(f) The Plant Load Factor considered @ 85% with annual working hours @ 7446

(g) The auxiliary consumption including long distance pumping of water is taken @ 6.5%.

(h) O & M expenses including insurance are considered @ Rs.11.84 Lakhs per MW with an escalation of 4% per annum.

(i) Depreciation to be provided @ 3.0% on Straight Line Method (SLM). To repay the term loan, the balance quantity to be considered as advance against depreciation till the loan is repaid.

(j) A return on investment @ 14% of capital outlay has been considered.

(k) Cost of generation has been calculated as per the norms of CERC.

On the basis of above, the estimated cost of generation works out as follows:

Cost of Generation (@ 85% PLF)

1st year of full generation	:	Rs.3.25 per kWh
25 years' Levelised Tariff (with 12.4% discount rate)	:	Rs.3.27 per kWh

The detail estimation of tariff computation is furnished in **ANNEXURE XVII**.

ANNEXURE I

ALL – INDIA REGIONWISE POWER SCENARIO (PEAK DEMAND / PEAK MET)

Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Requirement (MU)	Energy Availability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
Northern								
April 2009 – March 2010	37,159	31,439	5,720	15.4	253,803	224,447	29,356	11.6
Western								
April 2009 – March 2010	39,609	32,586	7,024	17.7	258,551	223,153	35,398	13.7
Southern								
April 2009 – March 2010	32,082	29,053	3,029	9.4	220,557	206,525	14,032	6.4
Eastern								
April 2009 – March 2010	13,963	12,885	1,078	7.7	88,040	84,054	3,986	4.5
North-Eastern								
April 2009 – March 2010	1,760	1,445	315	17.9	9,349	8,315	1,034	11.1

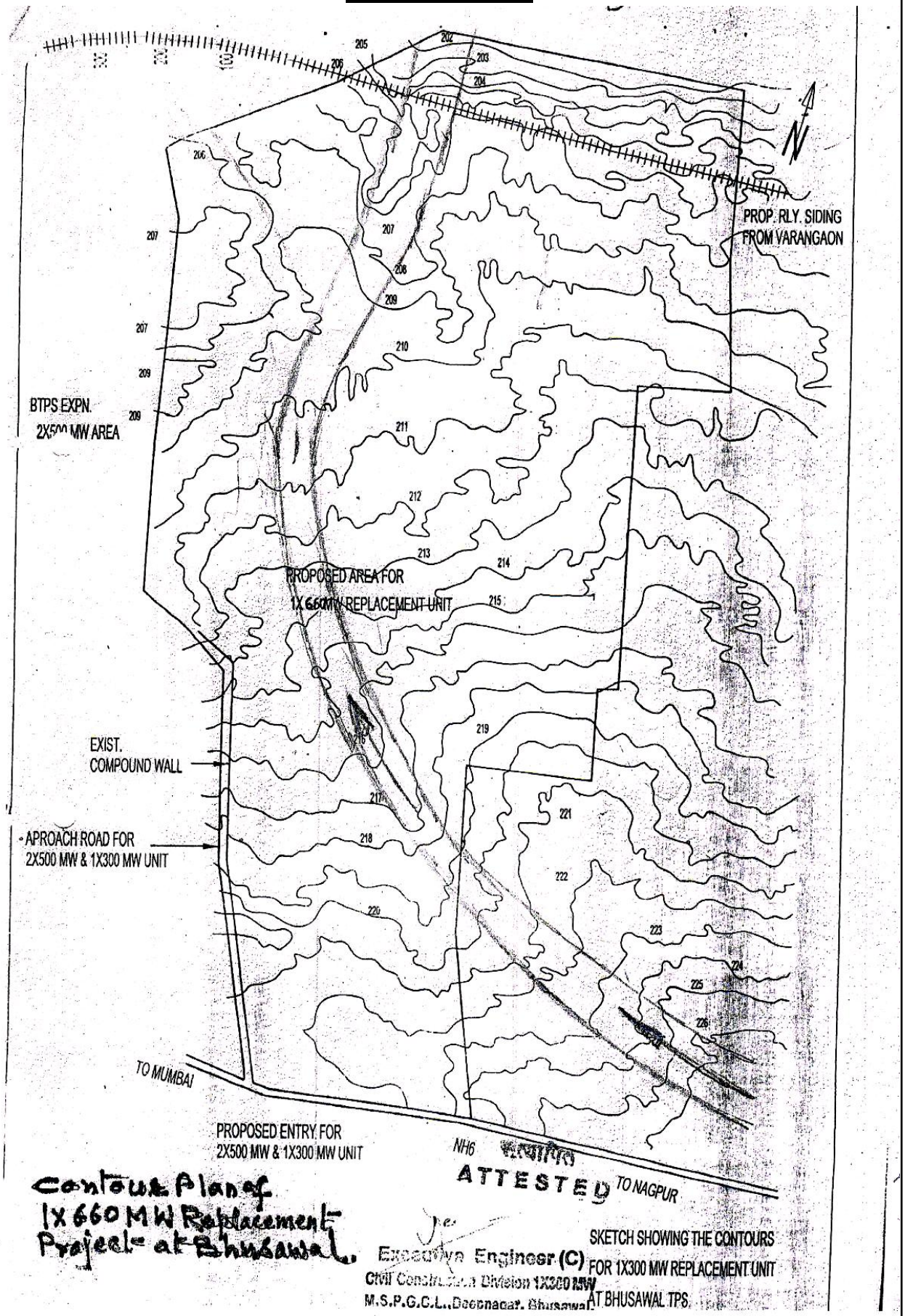
Note: Both peak met and energy availability represent the net consumption (including the transmission losses). Net export has been accounted for in the consumption of importing States.

ANNEXURE II

INSTALLED CAPACITY OF POWER UTILITIES IN THE WESTERN REGION AS ON 31.03.2010

Sector	Hydro	Thermal				Nuclear	R.E.S (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	5480.50	16357.50	1804.72	17.28	18179.50	0.00	354.48	24014.48
Private	447.00	4810.00	2805.50	0.20	7615.70	0.00	4276.26	12338.96
Central	1520.00	6978.00	3533.59	0.00	10511.59	1840.00	0.00	13871.59
Total	7447.50	28145.50	8143.81	17.48	36306.79	1840.00	4630.74	50225.03

ANNEXURE III
CONTOUR PLAN



ANNEXURE III-A
INDEX MAP

ANNEXURE IV

CLIMATOLOGICAL TABLE OF BHUSAWAL

Sr. No.	Month	Rain Fall In (MM)	Ambient Temperature °C Max	Ambient Temperature °C Min
1.0	Jun 08	16.51	42.90	37.00
2.0	Jul 08	54.51	36.00	22.50
3.0	Aug 08	77.979	40.60	20.00
4.0	Sept 08	240.03	39.80	16.0
5.0	Jan 09	3.048	29.00	18.00
6.0	May 09	10.15	47.80	22.20
7.0	Jun 09	99.568	42.30	24.50
8.0	Jul 09	198.628	37.20	23.50
9.0	Aug 09	97.79	35.00	19.50
10.0	Sep 09	51.562	39.70	24.50
11.0	Oct 09	95.504	34030	17.00
12.0	Nov 09	138.43	35.50	16.50
13.0	Dec 09	22.352	31.00	19.30
14.0	Mar 10	5.588	47.00	18.40
15.0	May 10	5.588	48.70	22.70
16.0	Jun 10	90.17	42.90	37.00
17.0	Jul 10	272.54	38.00	23.00
18.0	Aug 10	126.238	39.80	15.00
19.0	Sep 10	174.498	33.30	20.50
20.0	Oct 10	23.904	36.00	13.00

ANNEXURE V

ANALYSIS OF RAW WATER

Quality Inter to WTP	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH	8.32	8.78	8.20	8.10	8.11	7.80	8.20
Conductivity (µmhos / cm)	450	350	350	300	350	350	350
Total Hardness (ppm)	135	134	116	119	112	155	160
Chlorides as Cl (ppm)	36	58	54	30	18	35	40
Silica SiO_2 (ppm)	18	14	12	13	12	14	14

ANNEXURE VI

CONSUMPTIVE OF WATER REQUIREMENT

SR. NO.	DESCRIPTION	UNIT		REMARKS
1.0	**DM WATER REQUIREMENT**			
1.1	Heat Cycle Make-up (Note-1)	m^3/hr	19	
1.2	Make-up requirement for closed cycle cooling water system (CCWC)	m^3/hr	2	
1.3	Chemical Feed System	m^3/hr	2	
1.4	Hydrogen Generation & H.P,L.P Dosing System	m^3/hr	6	
1.5	Boiler Filling	m^3/hr	**	
1.6	Deaerator Filling	m^3/hr	**	
1.7	Regeneration Requirement:			
1.7.1	Condensate Polishing Unit (CPU)	m^3/hr	4	
1.7.2	DM Plant	m^3/hr	5	
	Total DM water Required	**m^3/hr**	**38**	
2.0	**FILTERED WATER REQUIREMENT**			
2.1	Filtered Water Required For DM Plant (Item 1above)	m^3/hr	38	
2.2	Filter Back Wash			
	(a) For DM Plant	m^3/hr	3	
	(b) For Non-DM Plant	m^3/hr	107	
2.3	Potable water Requirement			
	(a) For Plant	m^3/hr	10	
	(b) For Colony	m^3/hr	30	

SR. NO.	DESCRIPTION	UNIT		REMARKS
2.4	Make-up to A/C Softening Plant	m^3/hr	4	
2.5	Make-up to Ventilation System in various Plant Buildings	m^3/hr	21	
2.6	Distribution to various Plant Buildings for Cleaning and Washing	m^3/hr	10	
2.7	Make-up to Ash Handling Plant For sealing	m^3/hr	85	
2.8	CHP Ground Reservoir for Equipment cooling	m^3/hr	17	
2.9	DG Set	m^3/hr	**	
2.10	Air Pre-Heater Washing	m^3/hr	**	
2.11	CT Make-up Requirement			
	(a) Cooling Tower Evaporation Loss(E) (1.73% of CT flow(=79596 m^3/hr))	m^3/hr	1365	
	(b) Cooling Tower Drift Loss(D) (0.08% of CT flow(=79596 m3/hr))	m^3/hr	63	
	(c) Cooling Tower Blow Down (B) (B+D+E)/(B+D))=COC=4.37~5	m^3/hr	341	
2.12	Desludging and Back wash requirement of Side Stream Filtration Unit	m^3/hr	177	
	Total Filtered Water Required	m^3/hr	**2271**	
3.0	**RIVER WATER REQUIREMENT**			
3.1	Total River Water Required For Filtered Water Plant(Item 2 above)	m^3/hr	2271	

SR. NO.	DESCRIPTION	UNIT		REMARKS
3.2	Make-up to Ash Handling System(Considering Ash Water Recovery)	m^3/hr	125	
3.3	Design Margin Contingency & Evaporation	m^3/hr	50	(Including Losses Occurring in the reservoirs)
	Total River Water Required	m^3/hr	**2446**	
4.0	**WASTE WATER GENERATION**			
4.1	Condensate Polishing Unit(CPU)	m^3/hr	4	(Routed to Guard Pond)
4.2	DM Plant	m^3/hr	5	(Routed to Guard Pond)
5.0	**WASTE WATER REUSE PLAN**			
5.1	Water to be sent to service water storage tank(Over Head)	m^3/hr	100	(From Guard Pond)
5.2	Gardening	m^3/hr	50	(From Guard Pond)
5.3	Coal Handling Plant/System:			
5.3.1	Make-up to CHP Dust Suppression/ Dust Extraction and Service Water Requirements	m^3/hr	70	(From Guard Pond)
5.4	Total Sludge directed to ash sludge sump from filtration unit(Note 2)	m^3/hr	338	
5.5	Make-up to Ash Handling System (Considering Ash Water Recovery)(Note 3)	m^3/hr	160	

SR. NO.	DESCRIPTION	UNIT		REMARKS
	NOTES			
	1.0 As Heat Cycle Make-up would be within 1 % of TMCR, the same has been taken as 1% for Plant Water Balance though makeup would be 3% of BMCR			
	2.0 Desludging requirement of PTP of DM & Non-DM, Side Stream Filtration Unit, Ash Plant Clarifier is Catered from gravity filter back wash effluent			
	3.0 Proposed system for AHP.BA lean slurry & FA HCSD			
	4.0 ** Occasional Use			
	5.0 Intermittent requirements have been indicated on continuous weighted average basis. Flow requirements for occasional use not considered in water balance calculations and the same shall be catered from the stored water in respective reservoirs			
	6.0 The estimates will be reviewed during detailed engineering stage based on vendor input information			

ANNEXURE VII

ANALYSIS OF COAL

SR. NO.	DESCRIPTION	UNIT	DESIGN COAL	WORST COAL
1.0	**PROXIMATE ANALYSIS**			
1.1	(a) Fixed Carbon	%	28.83	25.50
1.2	(b) Volatile matter	%	26.61	21.56
1.3	(c) Moisture	%	10.80	12.00
1.4	(d) Ash	%	33.76	41.20
1.5	(e) Total	%	100.00	100.00
1.6	(f) HHV	%	3731 (AR)	3500
2.0	**ULTIMATE ANALYSIS**			
2.1	(a) Carbon	%	40.34	35.87
2.2	(b) Hydrogen	%	2.61	2.66
2.3	(c) Sulphur	%	0.80	0.90
2.4	(d) Nitrogen	%	0.97	0.72
2.5	(e) Oxygen	%	10.64 (diff)	8.35 (diff)
2.6	(f) Moisture	%	10.80	12.00
2.7	(g) Ash	%	33.76	41.20
2.8	(h) Hard Groove index	%	55.00	50
3.0	**ASH CHARACTERISTICS**			
3.1	(a) Initial Deformation temp	IT	1350	1160
3.2	(b) Hemispherical Temp H = W/2	HT	1400	+1400
3.3	(c) Fusion Temp.	FT	1400	+1400

SR. NO.	DESCRIPTION	UNIT	DESIGN COAL	WORST COAL
4.0	**ASH CONSTITUENTS**			
4.1	A-Si 0_2	%	57.2 – 63.8	
4.2	A-Al_20_3	%	26.7 – 31.8	
4.3	B-Fe_20_3	%	2.0 – 7.2	
4.4	B-CaO	%	1.1-1.6	
4.5	B-MgO	%	0.4-1.0	
4.6	B-Na_2O	% (0.12 As per GSECL)	NA	
4.7	B-K_2O	% (0.4 As per GSECL)	NA	
4.8	A-TiO_2	%	1.0-1.5	
4.9	P_2O_5	%	0.2-0.8	
4.10	SO_3	(As per GSECL)	Trace	
4.11	Base / Acid Ratio	(0.12 As per GSECL)	NA	
4.12	Fe_2O_3 CaO Ratio	(1.15 As per GSECL)	NA	
4.13	Alkalies		0.7-1.5	

Note: All calculations are based on coal having design GCV of 3500 Kcal/Kg.

ANNEXURE VIII

ANALYSIS OF LIGHT DIESEL OIL (LDO)

Sr. No.	Parameters		Valve
1.0	Specification	:	IS-1460 (Latest Revision)
2.0	Acidity (Inorganic)	:	Nil
3.0	Ash Content	:	0.02% (max.) by weight
4.0	Flash Point (Pensky-Martens, closed)	:	66 °C
5.0	Pour Point (Winter)	:	12 °C
	Pour Point (Summer)	:	18 °C
6.0	Kinematic Viscosity at 38 °C	:	2.5 to 15.7 Centistokes
7.0	Sediment by weight	:	0.10% (maximum)
8.0	Water content by volume	:	0.25% (maximum)
9.0	Sulphur by weight	:	1.8% (maximum)
10.0	Carbon Residue (Rams bottom) by weight	:	1.5% (maximum)
11.0	Gross Calorific Value	:	10,000 Kcal/kg.
12.0	Specific gravity	:	0.85 at 15 °C

ANNEXURE IX

ANALYSIS OF HEAVY FUEL OIL (HFO)

Sr.No.	Parameters		Valve
1.0	Specification	:	IS-1593 (Latest Revision) Heavy Grade (HVFO)
2.0	Acidity (Inorganic)	:	Nil
3.0	Ash Content	:	0.1% (maximum) by weight
4.0	Gross Calorific Value	:	10,000 Kcal/kg. Approx.
5.0	Flash Point (Pensky-Martens, closed)	:	66 °C (minimum)
6.0	Kinematic Viscosity at 50 °C	:	370 Centi-stokes (maximum)
7.0	Sediment by weight	:	0.25% (maximum)
8.0	Water content by volume	:	1.0% (maximum)
9.0	Total Sulphur	:	4.5 (maximum)
10.0	Density (gm/ml at 15 °C)	:	0.95
11.0	Pour Point (°C max.)	:	50 °C
12.0	Vanadium content (ppm)	:	70 (Typical)
13.0	Sodium + Potassium (ppm)	:	40 (Typical)
14.0	Specific heat	:	0.48 Kcal/kg.

Note: Values indicated against Sl. 10, 11, 12 & 13 are typical and not covered under IS-1593.

ANNEXURE X

BRIEF TECHNICAL FEATURES OF MAIN PLANT & EQUIPMENT

SR. NO.	DESCRPTION	UNIT	DETAILS	
1.0	**TURBINE GENERATOR & AUXILIARIES**			
1.1	Type		Single reheat multi cylinder tandem compound, Condensing Steam Turbine directly driving a 3000 rpm, 2-pole, 50 Hz, synchronous Generator.	
1.2	Nominal Capacity		660,000 KW at 306 K (33 °C) Condenser cooling water temperatures.	
1.3	Normal Operating Frequency Range	Hz	47.5 to 51.5	
1.4	Inlet Steam Parameters		**Main Steam**	**Hot Reheat**
1.4.1	Pressure	Kg/cm^2 (a)	247	*
1.4.2	Temperature	°C	565	593
1.4.3	Steam flow at MCR (approx.)	T/hr	2100	*
1.5	Exhaust Pressure		82.51 mm of Hg (abs.)	
1.6	Steam Extractions		CRH + 5 to 7 Nos. stages from HP, IP and LP turbines for condensate/feed water heating (depends on manufacturer).	
1.7	Type of governing		Electro-hydraulic governing with fire resistant fluid.	

SR. NO.	DESCRPTION	UNIT	DETAILS
1.8	Turbine HP-LP by-pass system		Capacity 60% of BMCR (or lower capacity commensurate with minimum main steam flow corresponding to sustained rated main steam temp.)
1.9	Condensing Equipment		Shell and tube type, surface condenser, of single flow design operating on re-circulating cooling water with evaporative Cooling Towers.
1.10	Regenerative feed heating arrangement		Three / four stages of LP heaters (U-tube design). One spray-cum-tray type Deaerator, Two / three stages HP heaters.
1.11	Boiler feed water pumps		2 x 50% of BMCR capacity Steam Turbine driven BFP & 1x30 % of BMCR electric motor driven, horizontal, centrifugal BFP.
1.12	Condensate extraction pumps		3 x 50% capacity vertical, centrifugal CAN type construction, motor driven.
1.13	Generator		780,000 KVA output at 0.85 power factor (lagging) 3 pH, 50 Hz and * kV voltage.
2.0	**STEAM GENERATOR & AUXILIARIES**		
2.1	Type		Pulverized fuel, once through, two-pass / tower type, semi-outdoor type, and dry bottom, coal-fired unit preferably with tangential firing and with associated auxiliaries suitable for both constant pressure and sliding mode operation.

SR. NO.	DESCRPTION	UNIT	DETAILS	
2.2	Nominal Capacity		2100 Tones/Hr	
2.3	Nominal Outlet Steam Parameters at BMCR		**Main Steam**	**Hot Reheat**
2.3.1	Pressure	Kg/cm^2 (a)	255	*
2.3.2	Temperature	°C	568	596
2.3.3	Steam flow (approx.)	T/hr	2268	*
(a)	Steam temp. Control range		40-100% BMCR or better.	
(b)	Super heater/Re-heater temperature control		Attemperation and tilting burner control.	
2.4	Nominal Air Heaters Capacity		2 x 60% of BMCR.	
2.5	Draft Fans		(a) 2 x 60% capacity axial flow Forced Draft (FD) Fans with blade pitch control with VFD.	
			(b) 2 x 60% capacity axial Induced Draft (ID) blade pitch control fans with variable frequency drive.	
			(c) 2 x 60% capacity P.A. Fans.	
2.6	Pulverizing Mills		Slow speed large bowl or ball and race type in **N+2 configuration.	
2.7	Coal Firing System		Direct suspended firing with state-of-the-art low NO_X burners giving stable fire between 40-100% MCR or better	
2.8	Start-up/auxiliary fuel		Light Diesel Oil for cold start and for support (capacity up to 10%BMCR).	

SR. NO.	DESCRPTION	UNIT	DETAILS
			Heavy Fuel Oil (HFO) for flame support up to 40 % of BMCR.
2.9	Ash removal		
2.9.1	Bottom Ash		Extraction and disposal in semi-wet form.
2.9.2	Fly Ash		In dry condition through vacuum and by pressurized air conveying for ultimate disposal from silos by truck for possible utilization or disposal in High Concentration Slurry mode to the ash disposal area.

NOTE:

1.0 * Vendor to specify. To be reviewed during detailed engineering stage based on vendor input.

2.0 **N-denotes the number of mills required to reach boiler MCR with design coal and 85% mill loading.

ANNEXURE XI

SALIENT FEATURES OF AUXILIARY PLANT & EQUIPMENT

SR. NO.	DESCRPTION	UNIT	DETAILS
1.0	**PLANT WATER SYSTEM**		
1.1	RAW WATER STORAGE TANK		
1.1.1	Type		Earthen bund construction
1.1.2	Capacity	Hrs.	One day's storage (24)
1.2	DM PLANT		
1.2.1	Type		Indoor
1.2.2	Control Room		Indoor
1.2.3	Number of Streams	Nos.	Two (02) (1 W + 1 S)
1.2.4	Capacity	m^3/hr	60 each.
1.2.5	Operation		PLC based from control room.
1.3	DM WATER STORAGE TANKS		
1.3.1	Type		Vertical cylindrical steel tank with inside rubber lining.
1.3.2	Capacity	m^3	750 each.
1.3.3	Numbers	Nos.	Two (02)
1.4	CONDENSATE STORAGE TANK		
1.4.1	Type		Vertical steel tank with inside rubber lining.
1.4.2	Capacity	m^3	500 (Tentative)
1.4.3	Numbers	Nos.	One (01)
1.5	COOLING WATER CIRCUIT		
1.5.1	Cooling Tower		

SR. NO.	DESCRPTION	UNIT	DETAILS
(a)	Type		Natural Draft
(b)	Number	Nos.	One (01)
(c)	Cooling Water Quality		Filtered water
(d)	Total circulating water flow	m^3/hr	78,900 (Tentative)
(e)	Design cooling range	°C	43 to 33 i.e. 10 °C
(f)	Approach	°C	5
1.5.2	Cooling Tower make-up Pumps		
(a)	Type		Horizontal, Centrifugal
(b)	Fluid Handled		Filtered Water
(c)	Capacity	m^3/hr	2240 (Tentative)
(d)	Number	Nos.	Three (2W+1S)
1.5.3	Circulating Cooling Water Pumps		
(a)	Type		Concrete Volute.
(b)	Fluid Handled		Filtered water
(c)	Capacity	m^3/hr	39,500 each (Tentative)
(d)	Number	Nos.	Three (03) (02 working + 01 standby)
1.5.4	Circulating Cooling Water Pumps (Alternate Offer)		
(a)	Type		Conventional type (Vertical Pit , Mixed flow type)
(b)	Fluid Handled		Filtered water
(c)	Capacity	m^3/hr	26,300 each (Tentative)
(d)	Number	Nos.	Four (04) (03 working + 01 standby)
1.5.5	Auxiliary Cooling Water Pumps		
(a)	Type		Vertical wet pit installation.

SR. NO.	DESCRPTION	UNIT	DETAILS
(b)	Flow	m^3/hr	6500 (Tentative)
(c)	Fluid		Filtered Water
(d)	Number	Nos.	Two (02) (01 working + 01 standby]
1.5.6	Auxiliary DM Closed Cycle Cooling Water Pumps		
(a)	Type		Horizontal volute casing, indoor.
(b)	Flow	m^3/hr	2500 (Tentative) for TG side & 550 (Tentative) for SG side
(c)	Fluid		DM water
(d)	Number		Three (03) Nos. (02 working + 01 standby) for TG side & Two (02) Nos. (01 working + 01 standby) for SG side
1.5.7	Plate Type Heat Exchanger		
(a)	Primary Coolant		DM water
(b)	Secondary Coolant		Cooling water
(c)	Plate Material		AISI 316
2.0	**COAL HANDLING PLANT**		
2.1	Conveying System		
2.1.1	Type		Twin stream conveying system.
2.1.2	Capacity	Tons/hr	1200
2.2	Crushers		
2.2.1	Type		Ring granulator/Impact type.
2.2.2	Number	Nos.	Four (04) (02 working + 02 standby)
2.2.3	Input coal size	mm	(-) 300
2.2.4	Output coal size	mm	(-) 20
2.3	Vibrating Screen		

SR. NO.	DESCRPTION	UNIT	DETAILS
2.3.1	Type		Electric driven eccentric type / Roller screen type.
2.3.2	Number	Nos.	Four (04) (02 working + 02 standby)
2.4	Stacker-cum-Reclaimer		
2.4.1	Type		Electric-driven rail-mounted unidirectional having slewing and adequate lifting arrangement.
2.4.2	Stacking Capacity	TPH	1200
2.4.3	Reclaiming Cap	TPH	1200
2.4.4	Number	Nos.	One (1)
2.4.5	Coal size	mm	(-) 20
3.0	**SOLID WASTE HANDLING SYSTEM EQUIPMENT**		
3.1	ASH HANDLING SYSTEM		
3.1.1	Basic Design Parameters	:	Max. Bottom Ash generation 55 Tons per hour including AHP & ECO hopper ash. Maximum Fly Ash generation – 128 Tons/hr (Considering 70% of ESP FA in total ash under worst condition)
(a)	Type		Wet extraction and disposal for Bottom Ash and dry extraction and dry/HCSD disposal of fly ash.
(b)	Bottom Ash cleaning		Intermittent (2 Hr min of operation per shift)

SR. NO.	DESCRPTION	UNIT	DETAILS
(c)	Fly Ash cleaning		Continuous through HCSD system. However FA evacuation by vacuum – pressure system shall be 4 Hrs.40 min including purging time.
3.1.2	Fly Ash Handling System		
(a)	Intermediate Surge Hopper / Buffer Hopper		
(i)	Type		MS construction
(ii)	Number	Nos.	Four (04)
(iii)	Capacity		20 minutes storage of fly ash generation for the station at design load with worst fuel.
(iv)	Outlet		One (01) for pneumatic conveying to terminal silos.
(b)	Fly Ash Terminal Silo		
(i)	Type		RCC construction
(ii)	Number	Nos.	Two (02) (01 no. shall be dedicated for HCSD system and 01 no. for dry/ moist unloading of fly ash on Truck/wagon.)
(iii)	Capacity		Twelve (12) hours storage capacity considering fly ash generation for the station at design load with worst fuel.
(iv)	Outlet		Four (04) two for wagon/truck disposal, one for HCSD slurry disposal and one for future use (for HCSD silo).

SR. NO.	DESCRPTION	UNIT	DETAILS
4.0	**MAIN AND START-UP FUEL OIL SYSTEM**		
4.1	LDO DAY-TANK		
4.1.1	Type		Vertical cylindrical M.S. construction with.
4.1.2	Number	Nos.	One (01)
4.1.3	Capacity	m^3	200
4.2	HFO DAY-TANK		
4.2.1	Type		Vertical cylindrical M.S. construction with bed coil and suction heater for HFO tank.
4.2.2	Number	Nos.	One (01)
4.2.3	Capacity	m^3	400
5.0	**AUXILIARY EQUIPMENT**		
5.1	TURBINE HALL EOT CRANE		
5.1.1	Capacity		
(a)	Main Hook	Tons	130
(b)	Auxiliary Hook	Tons	40
(c)	Number	Nos.	Two (02)
5.1.2	Elevators		
(a)	Type		Cabin type, driven by coil rope drum, electric drive
(b)	Location & Number		Boiler Area - 2 Powerhouse - 2 Stack - 1 Terminal Ash Silo - 1
5.2	FIRE PROTECTION SYSTEM		
5.2.1	Fire Hydrant System		
5.2.2	Type		Pressurized piping network both under-ground and over ground

SR. NO.	DESCRPTION	UNIT	DETAILS
			kept pressurized by hydro-pneumatic tank and jockey pump etc. with hydrant valves as per the requirements of Tariff Advisory Committee (TAC) of Insurance Association of India.
5.2.3	Hydrant Pumps		Three (03) nos. of 410 m^3/hr capacity, (2 electric motor driven + 1 DG driven).
5.3	AIR COMPRESSOR		
5.3.1	Type		Oil free, dry screw, water cooled, horizontal, two-stage, direct driven, rotary screw, continuous duty type
5.3.2	Number	Nos.	Six (06) (IA-03 & PA-03)
5.3.3	Free air capacity at normal pressure and temperature	Nm^3/min	55
5.3.4	Rated discharge pressure	kg/cm^2(g)	8.5
5.3.5	Location		Indoor
5.3.6	Assumed inlet air temp.	°C	45 (max.)
5.3.7	Air Receiver		One (1) per compressor.
5.3.8	Air Drying Plant		Refrigerant type with Non-cyclic version, fully automatic, Continuous duty, Indoor Skid mounted type Air Dryer for each Instrument Air Compressor with 110% capacity of the compressor capacity
5.4	TURBINE OIL PURIFICATION UNIT		
5.4.1	Type		Bowser a centrifugal or

SR. NO.	DESCRPTION	UNIT	DETAILS
			coalescer.
5.4.2	Capacity		20% per hour of total oil in TG network.
5.5	CONDENSATE POLISHER		
5.5.1	Type		Ion Exchange type.
5.5.2	Capacity		100% of condensate flow with by-pass. Four (04) units of mixed bed exchange (3W + 1S).
5.6	ON-LOAD CONDENSER TUBE CLEANING SYSTEM		
5.6.1	Type		Continuous, sponge rubber ball type with ball recirculation arrangement.
5.6.2	Capacity		Ball recirculation pump with drive, ball collectors and regulators, automatic ball sorters, ball collecting strainers, debris filters, piping, valves etc.

ANNEXURE XII

BRIEF TECHNICAL FEATURES OF ELECTRICAL EQUIPMENT

SR. NO.	DESCRPTION	UNIT	DETAILS
1.0	**GENERATOR**		
1.1	Type		Two-pole cylindrical rotor, rotating field with static / brushless exciter.
1.2	Capacity		660 MW, at 0.85 p.f. (lag)
1.3	Generating Voltage	kV	21
1.4	Speed	rpm	3000
1.5	Cooling		Stator winding – DM water rotor winding - Hydrogen Stator Core - Hydrogen.
1.6	Insulation		Class-F with temperature rise limited to Class-B.
2.0	**GENERATOR NEUTRAL GROUNDING EQUIPMENT**		
2.1	Type		Metal-enclosed cubicle
2.2	Components		Disconnecting link, grounding trans-former and resistor.
2.3	Type of N.G. Transformer		Dry, AN type
2.4	Resistor element		Cast-iron
3.0	**GENERATOR BUS DUCT**		
3.1	Type		Isolated phase, conductor and enclosure-aluminium, insulators-porcelain.
3.2	Voltage	kV	21

SR. NO.	DESCRPTION	UNIT	DETAILS
3.3	Current rating		25,000 A main run, 1600 A tap-off run
3.4	BIL	kVp	1255
4.0	**TRANSFORMERS**		
4.1	Generator Transformer		
(a)	Capacity		3x1Ph 270 MVA
(b)	Voltage ratio		420 kV/ 21 kV.
(c)	Cooling		OFAF
(d)	Tap changer		Off Load: ±10% in steps of 2.5%
(e)	Neutral Grounding		Effectively earthed
4.2	Unit Transformer		
(a)	Quantity	Nos.	Two (2)
(b)	Capacity		35 MVA each (Min. Rating)
(c)	Voltage ratio		21/11.5 kV
(d)	Cooling		ONAN/ONAF
(e)	Tap changer		OLTC. **:** ±10% in steps of 1.25%
(f)	Neutral Grounding		Low resistance grounded.
4.3	Station Transformer		
(a)	Quantity	Nos.	Two (2)
(b)	Rating		45MVA
(c)	Voltage ratio		400/11.5 kV
(d)	Cooling		OFAF
(e)	Tap changer		OLTC. **:** ±10% in steps of 1.25%
(f)	Neutral Grounding		Low resistance grounded.
4.4	MV Transformers		
4.4.1	Unit Auxiliary Transformer(UAT)		
(a)	Type		Oil filled with outdoor service.
(b)	Rating		12.5 MVA for each UAT

SR. NO.	DESCRPTION	UNIT	DETAILS	
(c)	Voltage ratio	kV / V	11 kV/3.45 kV	
(d)	Cooling		ONAN/ONAF	
(e)	Vector Group		Dyn11	
(f)	Tap changer		Off-circuit: Range ±5% @ 2.5	
4.4.2	Station Auxiliary Transformer(SAT)			
(a)	Type		Oil filled with outdoor service.	
(b)	Rating		12.5 MVA for CHP 7.5 MVA for Fire/Raw water, Water intake 9MVA for AHP	
(c)	Voltage ratio	kV / V	11 kV/3.45 kV	
(d)	Cooling		ONAN/ONAF	
(e)	Vector Group		Dd0	
(f)	Tap changer		Off-circuit: Range ±5% @ 2.5	
4.5	LT Auxiliary Transformer			
(a)	Type		Dry type	
(b)	Rating		Not exceeding 2500 kVA	
(c)	Voltage ratio	kV / V	11 kV/433 V	
(d)	Cooling		AN (Dry)	
(e)	Tap changer		Off-circuit: Range ±5% @ 2.5	
5.0	**11 & 3.3 KV SWITCHGEAR**			
5.1	Type		VCB/SF6	
5.2	Enclosure		Metal enclosed indoor drawout type.	
5.3	Rated voltage	kV	11 kV	3.3 kV
5.4	BIL		75 kVp/28 kV rms	40 kVp/10 kV rms
6.0	**415 V EQUIPMENT**			

SR. NO.	DESCRPTION	UNIT	DETAILS
6.1	415 V SWITCHGEAR		
(a)	Type		Air break
(b)	Enclosure		Metal-enclosed indoor draw out type.
6.2	MCC & DB (AC & DC)		
(a)	Type		Metal-enclosed indoor draw-out type with Air circuit breakers and motor starter units.
(b)	Components		Fuse Switch, contactors, control fuses, thermal overload relays.
(c)	Voltage		415 V for ACDB, 220 V for DCDB.
7.0	**DC SYSTEM**		
7.1	Battery		
(a)	Type		Ni-Cd and Plante Lead Acid
(b)	System Voltage	V	220
(c)	Cell voltage for float charging		2.2V/cell for Ni-Cd 1.42V/Cell for Plante lead acid
(d)	Emergency load duration		1 hour
7.2	Charger		
(a)	Type		Air-cooled, solid-state
(b)	Service		Float and float-cum-boost charge
8.0	**ELECTRIC MOTORS**		
8.1	Voltage	V	AC : (a) 11000 V for 1000kW and above (b) 3300 V for above 160 kW upto 1000 kW.

SR. NO.	DESCRPTION	UNIT	DETAILS
			(c) 415 V, 3 phase for motors of rating up to 160 KW.
		V	DC : 220
9.0	**DIESEL GENERATOR**		
9.1	Type		4-stroke, water-cooled, direct-injection, Turbo-charged with after-cooler.
9.2	Speed	rpm	1500
9.3	Capacity	kVA	1500
9.4	Voltage	V	415 V, 3 pH, 50 Hz
9.5	System		3 phase, 3 wire ungrounded
9.6	Insulation		Class H insulated with Temperature rise limited to Class B
9.7	Exciter		Brushless

ANNEXURE XIII

CONTROL SYSTEM REQUIREMENTS FOR PLANT AUXILIARIES

Sr. No.	Auxiliary System / Plant	Control System	Human Machine Interface	DDCMIS Interface
1.0	Plant Auxiliaries System			
1.1	DM Cooling Water System for Boiler & Turbine	DCS based	DCS HMI	DCS Panels at unit control equipment room.
1.2	CT pump	DCS based	DCS HMI	DCS Panels at unit control equipment room.
1.3	DM transfer water	PLC based	Local operating panel. DCS Monitors in central control room	Hardwired connectivity
1.4	Compressed Air System – Instrument Air & Service Air Compressors & Driers	Proprietary for Compressors+ PLC based common panel	Local Control Panel of Compressor & DCS HMI (monitoring only) and Hardwired Interface (for control)	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC.
1.5	Mill Reject Handling System	PLC based	Mimic based Local Control Panel & DCS HMI (monitoring only)	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC. (Optional) or hardwiring

Sr. No.	Auxiliary System / Plant	Control System	Human Machine Interface	DDCMIS Interface
1.6	Fuel Oil Pressurizing & heating System	DCS Remote Input/Output based	Local Control Panel & DCS HMI (Operation & monitoring)	Remote Processing Panels at F.O. Pump house control room. Ethernet OFC Link.
1.7	Circulating Water System and Auxiliary Cooling Water System	DCS RI/O based	Local Operator's Station & DCS HMI (Operation & monitoring)	Remote Processing Panels at CW/ACW Pump house control room. Ethernet OFC Link.
1.8	Miscellaneous pumps	DCS RI/O based	Local Operator's Station & DCS HMI (Operation & monitoring)	Remote Processing Panels at Miscellaneous Pump house control room. Ethernet OFC Link.
1.9	Condenser on-load Tube Cleaning System	PLC based	Local Control Panel & DCS (monitoring only)	Hard wired.
1.10	Automatic Self-cleaning Strainer Control	PLC based	Local Control Panel & DCS (monitoring only)	Hard wired.
1.11	Condensate Polishing Unit	PLC based	Local Control Panels & HMI stations. DCS HMI (monitoring only)	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC.

Sr. No.	Auxiliary System / Plant	Control System	Human Machine Interface	DDCMIS Interface
1.12	HP/LP Chemical Dozing system	Proprietary	Local Control Panels. DCS HMI (Control Interface)	Hard wired.
2.0	Off Site Plant & Auxiliaries			
2.1	Ash Handling Plant	PLC based	Local Control Panels & HMI stations. DCS HMI (monitoring only)	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC.
2.2	Raw water, Pre-treatment Plant	PLC based	Local Control Panels & HMI stations. DCS HMI (monitoring only). Dual Redundant soft link connection from Pre-treatment Plant to DM Plant is required for monitoring and control from DM Plant Operating station	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC. .
2.3	Coal Handling Plant	PLC based	Local Control Panels & HMI stations. DCS HMI (monitoring only). For Wagon Tippler and stacker re-claimer there should be separate PLCs.	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC.

Sr. No.	Auxiliary System / Plant	Control System	Human Machine Interface	DDCMIS Interface
2.4	Fuel Oil Unloading & Storage	PLC / Relay based	Local Control Panels. DCS HMI (monitoring only)	Hard wired connection should be provided for level signals of HFO/LDO day tank.
2.5	Demineralization plant	PLC based	Local Control Panels & HMI stations. DCS HMI (monitoring only). Pre-treatment plant to be connected to DM plant for control & monitoring.	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC.
2.6	Switchyard SCADA & SAS	Proprietary	Local Control Panels & HMI stations. DCS HMI (monitoring only)	Dual Redundant gateway – Modbus/ Ethernet OFC link OPC.
2.7	Fire Detection And Protection System	PLC Based.	Central Control Panel & HMI Station. One no. main panel & One no. Repeater panel shall be provided	Hardwired.
2.8	Air Conditioning System	PLC Based	Local Control Panel & HMI Station	NO
2.9	Ventilation System	Relay Based	Local Control Panel	NO

Sr. No.	Auxiliary System / Plant	Control System	Human Machine Interface	DDCMIS Interface
2.10	DG Set	Microprocessor Based	Local Control Panel	Hardwired
2.11	ETP & Waste Water Treatment Plant	PLC Based	Local Control Panel & HMI station	Dual Redundant PLC gateway – Modbus/ Ethernet OFC link OPC
2.12	Ozonization for CW Treatment Plant	Proprietary	Local Control Panels. DCS HMI (Control Interface)	Hard wired.

ANNEXURE XIV

SALIENT FEATURES OF MAJOR CIVIL WORKS

Sr. No.	Item	Description	Foundation	Superstructure	Cladding
1.0	Power Generating Block				
1.1	Power House	120 m x 48 m	open foundation with RC raft	Structural Steel Frame with RC Slabs.	Brick Masonry
1.2	Boiler	-	- do -	-	-
1.3	Mill House	63 m x 15 m	- do -	Structural Steel Frame with RC Slabs.	Brick Masonry (Partial)
1.4	Major equipment foundations, viz. TG, BFP, Draft Fans, Transformer, etc.	-	- do -	RC Pedestal	-
1.5	Chimney	275 m high	- do -	RC shell with Steel Flue.	-
1.6	ESP Control Building	17 m x 50 m	- do -	RC Frame & Slab.	Brick Masonry
2.0	Switchyard	400 m x 350 m			
3.0	Plant Water System				

Sr. No.	Item	Description	Foundation	Superstructure	Cladding
3.1	Raw water Pump House	Pump house on Raw water.	open foundation with RC raft & walls	RCC Frame and RC Slab..	Brick Masonry
3.2	CW Pump House	Pump sumps, pump house and electrical annex.	- do -	- do -	Brick Masonry
3.3	Water Pre-treatment	Clarifiers/Settlers, Storage Tanks, Pump House, Filters	- do -	Tanks in RC, Pump House with RC Frame and RC Slabs.	Pump House in Brick Masonry
3.4	DM Plant	Acid/ Alkali Tanks, Neutralizing Pit.	- do -	RC Frame with RC Slabs.	Brick Masonry
3.5	Natural Draft Cooling Tower	120 m dia.	RC Shell Structure	-	-
4.0	Coal Handling Plant				
4.1	Railway System	12.5 Km incl. marshalling	RC Sleepers	N.A.	N.A.
4.2	Crusher Houses	36 m x 30 m	RC Base Raft	Structural Steel Frame with floor gratings.	RCC Floor Slab and Roofing.
4.3	Transfer Houses	3 Nos.	- do -	- do -	-

Sr. No.	Item	Description	Foundation	Superstructure	Cladding
4.4	Conveyor Galleries length	600 m	RC Base Raft for Trestles	Structural Steel with Pre-cast Floor.	Sheeting
4.5	Pent House	1 No.	RC Construction	-	-
5.0	Ash Handling Plant				
5.1	Bottom Ash Hopper	-	RC Raft	-	-
5.2	Bottom Ash Silo	1 No. RC/Steel Silo	- do -	RC Frame with RC Wall & Floor.	-
5.3	Fly Ash Silos	2 Nos. RC/Steel Silos	- do -	RC Frame with RC Wall, Floor and Roof.	-
5.4	Ash Pipe Bridge & Trestles	-	RC Spread Footings	Structural Steel.	-
6.0	Misc. Buildings				
6.1	Fuel Oil Pump House	Single-storied	RC Frame with RC Slab	RC Frame with RC Slab.	Brick Masonry
6.2	Fire Station	Single storied	spread foundation	- do -	- do -
6.3	Permanent Store	Single storied	- do -	RC Col. Truss with sheeting	- do -
6.4	Canteen	Single storied	- do -	RC Frame with RC Slab	- do -

Sr. No.	Item	Description	Foundation	Superstructure	Cladding
6.5	Gate House Complex	Single storied	- do -	Brick Masonry Structure	- do -
6.6	D.G. & Compressor House	Single storied	- do -	RC Frame with RCC Slab	- do -
6.7	Administrative Building	Single storied	RC Footing.	-do-	-do-
6.8	Medical Centre (Plant)	Single storied	spread foundation	- do -	- do -

NOTE: aspect of foundation shall be reviewed after getting soil investigation report.

ANNEXURE XV

LIST OF BASIC EQUIPMENT/ INSTRUMENT FOR ENVIRONMENTAL MONITORING & TESTING

Sr.No.	Equipment /Instrument
1.0	Respirable Dust Sampler
2.0	Stack Monitoring Kit
3.0	Spectro-Photometer
4.0	Single Pan Balance
5.0	pH Meter
6.0	BOD Incubator
7.0	Air Oven
8.0	Water Distillation Assembly
9.0	D.O. Meter
10.0	Orsat Apparatus
11.0	Kjeldahl Nitrogen Assembly
12.0	Gas Liquid Chromatograph
13.0	Standard Laboratory Equipment and Appliances
14.0	Continuous weather monitoring station (for monitoring of wind speed, wind direction, air temperature, R.H. solar radiation and rainfall)
15.0	Atomic Absorption Spectrophotometer

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
A	**BOILER TURBINE GENERATOR (BTG) PACKAGE**				
1.0	**BTG MECHANICAL**				
1.1	Boiler & Auxiliaries including , ESP,Chemical Feed System,Coal mills,HP piping , Fuel oil handling system, Mill reject handling system,lift at Boiler etc.. Along with structural supply platfom, ladders etc Imported Component Indegeneous Compnents	410	616		1026
1.2	Turbine & Generator Set and its Auxiliaries,including HP/LPbypass, BFPs, CPU,,OCTCS,EOT Cranes,lift,etc.	274	410		684
1.3	CW & ACW System inculding pumps motars, valves & Specialities, Piping upto Cooling Tower Forebay		27		27
1.4	Sump Pumps, Miscellaneous Hoists etc. within the Periphery of BTG building		4		4
1.5	Air Conditioning & Ventilation System		22		22
1.6	Fire Protection System pertaining to BTG Area.		8		8
1.7	SWAS.		3		3
	TOTAL BTG MECHANICAL (1.1 TO 1.7) EX-WORKS	**684**	**1090**		**1774**
2.0	**BTG ELECTRICAL**				
2.1	Generator and its Auxiliaries I.E. Excitation System, AVR, SVPT, NGT with loading Resistor, Generator Protection and Control, Monitoring, Synchronising etc				Included in A(1.2) above
2.2	Generator Transformer.Stattion Transformers, Unit Transformers,11KV/3.3 KV Aux.Transformers,3.3KV/415V LT Transformers		66		66
2.3	Generator Bus Duct (IPBD)		9		9
2.4	11 KV & 3.3 KV Switchgear, Segregated Phase Bus Duct (Unit Switchgear & Station Switchgear) and ABT panels (44 kA, 3 Sec)		12		12
2.5	LT Switchgear, MCC, ACDB, DCDB, Fuse DB etc. (pertaining to BTG)		5		5
2.6	HT/LT and Control cables, Instrumentation & Special Cables, if any		9		9
2.7	Battery and Battery charger (Pertaining BTG and also for Station), UPS System etc		9		9
	TOTAL BTG ELECTRICAL (2.1 TO 2.7) EX-WORKS		**110**		**110**

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
3.0	**BTG CONTROL & INSTRUMENTATION**				
3.1	Station C&I DCS (With PADO, Maintenance Management System, LVS ,MIS):		26		26
3.2	Integral Controls (BMS,ATRS ETC)		14		14
3.3	Package Control Systems /PLCs		5		5
3.4	Other Packages		5		5
	TOTAL BTG C & I (3.1 TO 3.4)		**50**		**50**
4.0	TOTAL BTG MECHANICAL, ELECTRICAL, C&I (A1 + A2 +A3) Ex-Works/FOB cost	**684**	**1250**		**1934**
5.0	Custom Duty, CVD, SD freight, insurance etc on finished goods Imported @24% on 50% of total Imported component	82			
6.0	EXCISE DUTY @ 10.3% on Indegenious Components & 50% Import Components		164		
7.0	Sales Tax / VAT @ 2%		28		
8.0	Packing, Forwarding , Transport & Transit Insurance @ 2.5% ON (4.0 + 6.0+7.0)		36		
9.0	Total Taxes Including Packing Forwarding and Transit Insurance Etc.ETC.	**82**	**228**		**310**
10.0	ERECTION TESTING & COMMISSIONING @ 8% ON (4.0)				**155**
11.0	**TOTAL BTG E&M COST(4.0 +9.0+10.0)**				**2399**
12.0	**BTG CIVIL**				
12.1	Boiler Foundations, ESP Foundations,Mill Foundations, Flue gas & air duct foundationsTG &Aux. Foundations, Power House Foundations along with earth mat, all fire barrier walls RCC pavingincluding plinth protection of all buildings,ravel filling in transformer yard , Rail track in Transformer yard & track for stator lifting,land development,etc			158	
12.2	Power house super-structure & all structural steel work in BTG area			100	
12.3	Pipe & cable rack foundations,,Pipe & cable trenches			20	

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
12.4	C.W. Pumps / ACW Pump House including covered approach channel and forebay, gates and screen, maintenance facilities, switch gear / MCC rooms, C.W. pipes including their supports foundations (C.W Channel upto 5 meterfrom NDCT)			20	
12.5	All roads in BTG Area,Storm Water drainage System in BTG area etc			10	
12.6	Other works like gas storage building, minor grading, foundations etc			5	
	BTG CIVIL (12.1 TO 12.6)			**313**	**313**
13.0	**Taxes on civil works**			**16**	**16**
14.0	**TOTAL BTG CIVIL**			**329**	**329**
15.0	**TOTAL BTG PACKAGE COST MECHANICAL,ELECTRICAL, C&I,CIVIL (11.0+14.0)**				**2728**

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
B	**BALANCE OF PLANT (BOP) PACKAGE**		**E&M**	**CIVIL**	
1.0	**WATER SYSTEM (Raw Water, Pre Treament & Post Treatment, ETP, STP,Rain Harvesting etc)**				
1.1	Mechanical including piping		67		
1.2	Electrical		13		
1.3	C & I		5		
1.4	**SUB TOTAL (1.1+1.2+1.3)**		**85**		**85**
1.5	Civil			28	
1.6	**TOTAL(1.4+1.5)**				**113**
2.0	**COAL HANDLING SYSTEM**				
2.1	Mechanical		100		
2.2	Electrical		27		
2.3	C & I		5		
2.4	**SUB TOTAL (2.1+2.2+2.3)**		**132**		**132**
2.5	Civil			30	30
2.6	**TOTAL(2.4+2.5)**				**162**
3.0	**ASH HANDLING SYSTEM**				
3.1	Mechanical (Including Ash Disposal Lines upto Ash Bund)		40		
3.2	Electrical		15		
3.3	C&I		5		
3.4	**SUB TOTAL (3.1+3.2+3.3)**		**60**		**60**
3.5	Civil			15	
3.6	**TOTAL(3.4+3.5)**				**75**
4.0	**COMPRESSED AIR SYSTEM**				
4.1	Mechanical		5		
4.2	Electrical		2		
4.3	C & I		1		
4.4	**SUB TOTAL (4.1+4.2+4.3)**		**8**		**8**
4.5	Civil			2	2
4.6	**TOTAL(4.4+4.5)**				**10**
5.0	**FIRE PROTECTION & DETECTION SYSTEM**				

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
5.1	Mechanical		6		
5.2	Electrical		1		
5.3	C & I		1		
5.4	**SUB TOTAL (5.1+5.2+5.3)**		**8**		**8**
5.5	Civil			1	1
5.6	**TOTAL(5.4+5.5)**				**9**
6.0	**FUEL OIL TRASFERING SYSTEM**				
6.1	Mechanical		4		
6.2	Electrical		1		
6.3	C & I		1		
6.4	**SUB TOTAL (6.1+6.2+6.3)**		**6**		**6**
6.5	Civil			1	1
6.6	**TOTAL(6.4+6.5)**				**7**
7.0	**CRANES & HOIST, ELEVATORS FOR BOP AREA**				
7.1	Mechanical		2		
7.2	Electrical		1		
7.3	C & I		1		
7.4	**SUB TOTAL (7.1+7.2+7.3)**		**4**		**4**
7.5	Civil			1	1
7.6	**TOTAL(7.4+7.5)**				**5**
8.0	**Chem. Lab, Co2, N2, H2 Cylinders, Dosing, Painting, Pollution Control And Monitoring System, T.O. Purification Unit. Thermal Insulation, H2 Generation**				
8.1	Mechanical		6		
8.2	Electrical		1		
8.3	C & I		1		
8.4	**SUB TOTAL (8.1+8.2+8.3)**		**8**		**8**
8.5	Civil			2	2
8.6	**TOTAL(8.4+8.5)**				**10**
9.0	Any Other Electricals inculding DG Set		4		
10.0	NDCT			63	
11.0	CHIMNEY			22	

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
12.0	LAND DEVELOPMENT			20	
13.0	PIPE-CUM-CABLE RACK			5	
14.0	OTHER MISC. ITEMS INCL. ARCHITECTURAL WORKS			10	
15.0	**SUB-TOTAL BOP (Mech+Elect+C&I)**		**315**		
16.0	**SUB-TOTAL BOP (Civil)**			**200**	
17.0	**TOTAL BOP PACKAGE EXCLUDING TAXES**				**515**
18.0	EXCISE DUTY @10.3% ON E&M COST		32		**32**
19.0	SALES TAX / VAT @ 2% on E&M COST		7		7
20.0	PACKING, FORWARDING, TRANSPORT & TRANSIT INSURANCE @ 2.5%		9		9
21.0	TAX FOR CIVIL WORKS			10	10
22.0	ERECTION, TESTING AND COMMISSIONING COST 8% OF E&M COST (14.0)		25		25
23.0	**TOTAL BOP MECHANICAL, ELECTRICAL, C & I AND CIVIL (17.0 TO 22.0)**				**598**
C	**OTHER WORKS (EXCLUDED FROM BTG / BOP)**				
1.0	Soil Investigation,Study & Survey			16	
2.0	Other land for access cooridor ,ashpipe lines, water pipe lines etc			15	
3.0	Railways (13 KM) @ Rs2.75 CR/KM			36	
4.0	ROB			16	
5.0	Road outside boundry(4 KM)			5	
6.0	Boundry wall			2	
7.0	Township & colony			72	
8.0	Construction water supply			2	
9.0	**SUB TOTAL OTHER CIVIL WORKS (1to8)**			**164**	
10.0	Tax on Civil Works			8	
11.0	Land Cost (108.07 H)			25	
12.0	**OTHER CIVIL WORKS INCLUDING TAXES**			**197**	
13.0	Corporate Social Responsibility (CSR)			25	
14.0	Switchyard		160		
15.0	Construction Power Supply		2		
16.0	Locomotives (3 Nos of 650 HP each)		10		
17.0	Bullozers (2 Nos)		3		

PROJECT COST ESTIMATE

		IMPORTED	INDEGENIOUS		TOTAL (IMPORTED + INDEGENIOUS)
			E&M	CIVIL	
SR. NO.	PARTICULARS	RS. CR.	RS. CR.	RS. CR.	RS. CR.
18.0	SUB -TOTAL OTHER WORKS E&M (14.0 to 17.0)		175		
19.0	SUB-TOTAL OTHER WORKS- E&M INCLUDING TAXES		202		
20.0	SUB-TOTAL OTHER WORKS -CIVIL (12+13)			222	
21.0	TOTAL OTHER WORKS (19.0+20.0)				424
22.0	Extra work not specifically mentioned (10% of total)			0	42
23.0	TOTAL COST OF OTHER WORKS				466
D	TOTAL COST(BTG+BOP+OTHER WORKS)				3792
E	PRE OPERATING EXPENSES				44
F	INTEREST DURING CONSTRUCTION (IDC)				712
G	ESTIMATED PROJECT COST				4548

Input Parameters	Units	Values
Plant Data		
Installed Capacity	MW	660
Derated Capacity	MW	660
PLF	%	85%
Aux Power Consumption	%	6.50%
Station Heat Rate	kcal/kWhr	2130
Captive Consumption	kWhr / p.a.	0
Fuel Data		
GCV of Fuel	kcal/kg	3800
Fuel Cost	Rs / Tn	2028.3
Fuel / Water Cost escalation	%	2.0%
Fuel inventory	Days	60
Secondary fuel oil		
1st year consumption	ml/kWh	2.5
Thereafter	ml/kWh	1.5
Cost of secondary fuel	Rs/kL	33000
Escalation of fuel oil cost	%	4%
Project Data		
Plant cost including land cost	Rs Mn	37920
Preoperative expenses	Rs Mn	436.08
Construction/commissioning/stabilization period	Months	51
O&M Cost		
O&M Cost (% of capital cost)	%	3.07%
O&M Escalation	%	5.72%
Fixed Component of O&M	%	3.07%
Variable Component of O&M	%	0.00%
Grid Tariff		
Present grid tariff	Rs / kWhr	3.27
Escalation	%	0.00%
Cross subsidy	Rs / kWhr	0
Metering charges	Rs / kWhr	0
Power that can be exported annually	Mn Units	4594.93
Basic Financing Pattern		
Equity		20%
Return on equity		14.00%
Loan		80%
Interest on loan		12.00%
Loan Repayment period	Quarters	43

Loan Grace period (Considering two quarters from COD of June 2015 it will be Dec 2015 so three quarters of the financial year 2015-16)	Quarters	3
Working Capital		
Receivables	Days	60
O&M expenses	Days	30
Spares inventory as% of capital cost	%	1.00%
Escalation for spares		6.00%
Margin Money	%	10%
Interest on WC loan	% p.a.	12.00%
Depreciation		
Land and Land development		0%
Factory buildings		3.60%
Plant and machinery		3.60%
Miscellaneous fixed assets		3.60%

Interest During Construction							
		2012	2013	2014	2015	2016	
		Apr to Mar	Apr to Mar	Apr to Mar	Apr to Mar	Apr to Jun	Jul to Sep
Particulars	Quarters	1	2	3	4	5	6
Preferred equity deployment	%	10.00%	30.00%	30.00%	20.00%	10.00%	0.00%
% of total project cost		1.972%	5.915%	5.915%	3.943%	1.972%	0.000%
		896.60	2689.80	2689.80	1793.20	896.60	0.00
Total Plant Cost disbursement	%	10%	30%	30%	20%	10%	0%
Plant Cost disbursement INR	Rs Mn	3835.61	11506.82	11506.82	7671.22	3835.61	0.00
Total cumulative %		10%	40%	70%	90%	100%	0%
Total cumulative INR		3835.61	15342.43	26849.26	34520.47	38356.08	0.00
Interest on previous loan	Rs Mn		881.70	2045.55	3172.72	1020.62	
Loan drawn	Rs Mn	2939.01	8817.02	8817.02	5878.02	2939.01	0.00
Cumulative Loan Drawn	Rs Mn	2939.01	11756.03	20573.06	26451.07	29390.08	0.00
Expenditures	Rs Mn	3835.61	12388.53	13552.37	10843.93	4856.22	0.00
Margin Money for WC	Rs Mn	0.00	0.00	0.00	0.00	0.00	337.45
Equity Total	Rs Mn	896.60	3586.40	6276.20	8069.40	8966.00	0.00
Loan for the year	Rs Mn	2939.01	9698.73	10862.57	9050.73	3959.62	337.45
Loan Total	Rs Mn	2939.01	12637.73	23500.31	32551.04	36510.67	337.45
Loan INR	Rs Mn	2939.01	12637.73	23500.31	32551.04	36510.67	337.45
Loan Accumulated (eoq) INR	Rs Mn	2939.01	12637.73	23500.31	32551.04	36510.67	36848.12
Expenditures in current year	Rs Mn	3835.61	12388.53	13552.37	10843.93	4856.22	0.00

Project Cost Estimate		
	Units	
Plant Cost	INR Mn	37920.00
PreOperative expenses	INR Mn	436.08
Total Plant Cost (without IDC & Margin Money for WC)	INR Mn	38356.08

Summary of Project Finance		
Project Capital Expenditure Cost including land, equipments and preoperative expenses	Rs Mn	38356.08
Interest during construction	Rs Mn	7120.59
Total project Cost	Rs Mn	45476.67
Equity	Rs Mn	8966
Loan	Rs Mn	35866

Annual Charges & Estimation of Cost of Generation

Particulars	Year	Mar-16	Mar-17	Mar-18	Mar-19	Mar-20	Mar-21	Mar-22	Mar-23	Mar-24	Mar-25	Mar-26	Mar-27	Mar-28	Mar-29	Mar-30	Mar-31	Mar-32	Mar-33	Mar-34	Mar-35	Mar-36	Mar-37	Mar-38	Mar-39	Mar-40
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Annual Charges																										
Fixed Charges																										
Interest on loan	Rs Mn	3285.96	4107.45	3669.32	3231.19	2793.07	2354.94	1916.81	1478.68	1040.55	602.43	164.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Return on Equity	Rs Mn	941.43	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24	1255.24
Depreciation	Rs Mn	1035.61	1380.82	1380.82	1380.82	1380.82	1380.82	1380.82	1380.82	1380.82	1380.82	1380.82	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90
Advance against depreciation	Rs Mn	0.00	715.80	735.26	735.26	735.26	735.26	735.26	735.26	735.26	735.26	735.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operation & Maintenance (O&M)																										
O&M expenses	Rs Mn (5.72% esc)	873.11	1230.73	1301.13	1375.56	1454.24	1537.42	1625.36	1718.33	1816.62	1920.53	2030.38	2146.52	2269.30	2399.11	2536.34	2681.41	2834.79	2996.94	3168.37	3349.60	3541.19	3743.75	3957.89	4184.28	4423.63
Income tax payable	Rs Mn	64.34	96.03	97.85	99.00	100.17	101.35	99.80	100.98	102.18	660.84	692.27	631.22	647.28	663.74	680.61	697.89	734.42	752.55	771.10	790.08	809.49	829.33	849.61	870.33	891.48
Interest on working capital	Rs Mn	404.94	405.06	422.46	440.70	459.82	485.77	506.90	529.05	552.28	576.63	608.70	635.61	663.85	693.46	724.52	757.11	798.64	834.67	872.46	912.13	953.75	1005.55	1051.57	1099.87	1150.57
Total fixed charges	Rs Mn	6605.40	9191.13	8862.08	8517.77	8178.61	7850.80	7520.19	7198.36	6882.95	7131.75	6866.97	5491.50	5658.57	5834.44	6019.60	6214.55	6446.00	6662.30	6890.07	7129.94	7382.57	7656.77	7937.21	8232.62	8543.81
Energy Charges																										
Fuel																										
GCV of fuel	kcal/kg	3800	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00	3800.00
Cost of fuel	Rs/Tonne	2068.84	2110.21	2152.42	2195.47	2239.38	2284.16	2329.85	2376.44	2423.97	2472.45	2521.90	2572.34	2623.79	2676.26	2729.79	2784.38	2840.07	2896.87	2954.81	3013.90	3074.18	3135.67	3198.38	3262.35	3327.59
Average Plant gross heat rate	kcal/kWhr	2130	2130.00	2130.00	2130.00	2130.00	2230.00	2230.00	2230.00	2230.00	2230.00	2330.00	2330.00	2330.00	2330.00	2330.00	2330.00	2430.00	2430.00	2430.00	2430.00	2430.00	2530.00	2530.00	2530.00	2530.00
Annual cost of primary fuel	Rs Mn	4274.16	5812.85	5929.11	6047.69	6168.65	6587.42	6719.17	6853.55	6990.62	7130.43	7599.19	7751.17	7906.20	8064.32	8225.61	8390.12	8925.21	9103.72	9285.79	9471.51	9660.94	10259.68	10464.87	10674.17	10887.65
Annual cost of secondary fuel	Rs Mn	304.08	252.99	263.11	273.64	284.58	295.96	307.80	320.11	332.92	346.24	360.09	374.49	389.47	405.05	421.25	438.10	455.62	473.85	492.80	512.51	533.01	554.33	576.51	599.57	623.55
Annual cost of fuel	Rs Mn	4578.23	6065.84	6192.22	6321.33	6453.23	6883.38	7026.97	7173.67	7323.54	7476.67	7959.27	8125.66	8295.66	8469.37	8646.86	8828.22	9380.84	9577.57	9778.59	9984.02	10193.95	10814.01	11041.38	11273.74	11511.20
Total variable charges	Rs Mn	4578.23	6065.84	6192.22	6321.33	6453.23	6883.38	7026.97	7173.67	7323.54	7476.67	7959.27	8125.66	8295.66	8469.37	8646.86	8828.22	9380.84	9577.57	9778.59	9984.02	10193.95	10814.01	11041.38	11273.74	11511.20
Total annual charges	Rs Mn	11183.63	15256.98	15054.31	14839.10	14631.84	14734.18	14547.16	14372.03	14206.49	14608.42	14826.24	13617.16	13954.23	14303.81	14666.46	15042.77	15826.84	16239.86	16668.66	17113.96	17576.52	18470.78	18978.59	19506.35	20055.02
Unit cost of generation																										
Fixed Charges	Rs / kWhr	1.92	2.00	1.93	1.85	1.78	1.71	1.64	1.57	1.50	1.55	1.49	1.20	1.23	1.27	1.31	1.35	1.40	1.45	1.50	1.55	1.61	1.67	1.73	1.79	1.86
Variable Charges	Rs / kWhr	1.33	1.32	1.348	1.376	1.404	1.498	1.529	1.561	1.594	1.627	1.732	1.768	1.805	1.843	1.882	1.921	2.042	2.084	2.128	2.173	2.219	2.353	2.403	2.454	2.505
Electricity duty	Rs / kWhr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cess	Rs / kWhr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	Rs / kWhr	3.25	3.32	3.28	3.23	3.18	3.21	3.17	3.13	3.09	3.18	3.23	2.96	3.04	3.11	3.19	3.27	3.44	3.53	3.63	3.72	3.83	4.02	4.13	4.25	4.36
Levelised Tariff	Rs / kWhr		3.27																							

Projected Profitability Statement

Particulars	Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Generation																										
Percentage of year available for generation	%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Capacity Available for generation		100%																								
Total generation	Mn units	3685.77	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36	4914.36
Aux consumption	Mn units	239.58	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43	319.43
Total units usable	Mn units	3446.19	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93
Power available to export	Mn units	3446.19	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93
Units available for wheeling	Mn units	3446.19	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93
Cost of generation																										
Cost of fuel / water	Rs Mn	4578.23	6065.84	6192.22	6321.33	6453.23	6883.38	7026.97	7173.67	7323.54	7476.67	7959.27	8125.66	8295.66	8469.37	8646.86	8828.22	9380.84	9577.57	9778.59	9984.02	10193.95	10814.01	11041.38	11273.74	11511.20
O&M expenses	Rs Mn	873.11	1230.73	1301.13	1375.56	1454.24	1537.42	1625.36	1718.33	1816.62	1920.53	2030.38	2146.52	2269.30	2399.11	2536.34	2681.41	2834.79	2996.94	3168.37	3349.60	3541.19	3743.75	3957.89	4184.28	4423.63
Interest on term loan	Rs Mn	3285.96	4107.45	3669.32	3231.19	2793.07	2354.94	1916.81	1478.68	1040.55	602.43	164.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest on working capital	Rs Mn	404.94	405.06	422.46	440.70	459.82	485.77	506.90	529.05	552.28	576.63	608.70	635.61	663.85	693.46	724.52	757.11	798.64	834.67	872.46	912.13	953.75	1005.55	1051.57	1099.87	1150.57
Wheeling charges , if any	Rs Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cross subsidy and metering charges	Rs Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Annual cost of generation and wheeling	Rs Mn	9142.24	11809.09	11585.14	11368.78	11160.35	11261.51	11076.04	10899.73	10732.99	10576.26	10762.65	10907.80	11228.81	11561.93	11907.71	12266.74	13014.27	13409.17	13819.42	14245.75	14688.90	15563.31	16050.84	16557.89	17085.40
Savings																										
Grid tariff	Rs / kWhr	3.25	3.32	3.28	3.23	3.18	3.21	3.17	3.13	3.09	3.18	3.23	2.96	3.04	3.11	3.19	3.27	3.44	3.53	3.63	3.72	3.83	4.02	4.13	4.25	4.36
Annual wheeling of power	Mn units	3446.19	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93	4594.93
Tariff for wheeled power	Rs / kWhr	3.25	3.32	3.28	3.23	3.18	3.21	3.17	3.13	3.09	3.18	3.23	2.96	3.04	3.11	3.19	3.27	3.44	3.53	3.63	3.72	3.83	4.02	4.13	4.25	4.36
Income from wheeled power	Rs Mn	11183.63	15256.98	15054.31	14839.10	14631.84	14734.18	14547.16	14372.03	14206.49	14608.42	14826.24	13617.16	13954.23	14303.81	14666.46	15042.77	15826.84	16239.86	16668.66	17113.96	17576.52	18470.78	18978.59	19506.35	20055.02
Total Annual Savings	Rs Mn	2041.39	3447.89	3469.17	3470.32	3471.49	3472.67	3471.12	3472.30	3473.50	4032.16	4063.59	2709.36	2725.42	2741.88	2758.75	2776.03	2812.57	2830.69	2849.24	2868.22	2887.63	2907.47	2927.75	2948.47	2969.62
Profit before depreciation and tax	Rs Mn	2041.39	3447.89	3469.17	3470.32	3471.49	3472.67	3471.12	3472.30	3473.50	4032.16	4063.59	2709.36	2725.42	2741.88	2758.75	2776.03	2812.57	2830.69	2849.24	2868.22	2887.63	2907.47	2927.75	2948.47	2969.62
Less depreciation	Rs Mn	1035.61	2096.62	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90
Profit Before Tax	Rs Mn	1005.77	1351.27	1353.09	1354.24	1355.41	1356.59	1355.04	1356.22	1357.42	1916.08	1947.51	1886.46	1902.52	1918.98	1935.85	1953.13	1989.66	2007.79	2026.34	2045.32	2064.73	2084.57	2104.85	2125.57	2146.72
Less income tax/MAT	Rs Mn	112.65	151.34	151.55	151.68	151.81	151.94	151.76	151.90	152.03	632.31	642.68	622.53	627.83	633.26	638.83	644.53	656.59	662.57	668.69	674.95	681.36	687.91	694.60	701.44	708.42
Distributable profit	Rs Mn	893.13	1199.93	1201.54	1202.57	1203.60	1204.65	1203.27	1204.32	1205.39	1283.77	1304.83	1263.93	1274.69	1285.71	1297.02	1308.60	1333.08	1345.22	1357.65	1370.36	1383.37	1396.66	1410.25	1424.13	1438.30
Add depreciation	Rs Mn	1035.61	2096.62	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90
Increase in Working Capital	Rs Mn	3037.08	0.98	145.02	151.99	159.31	216.24	176.08	184.60	193.55	202.96	267.20	224.32	235.26	246.76	258.85	271.56	346.14	300.19	314.98	330.53	346.87	431.64	383.48	402.50	422.51
Net cash accrual	Rs Mn	-1108.33	3295.57	3172.60	3166.66	3160.37	3104.49	3143.27	3135.81	3127.92	3196.90	3153.71	1862.51	1862.32	1861.85	1861.06	1859.94	1809.84	1867.93	1865.57	1862.74	1859.40	1787.92	1849.67	1844.53	1838.70
Cumulative cash accrual	Rs Mn	-1108.33	3295.57	6468.17	9634.83	12795.19	15899.69	19042.96	22178.76	25306.68	28503.58	31657.29	33519.80	35382.12	37243.98	39105.04	40964.98	42774.82	44642.75	46508.32	48371.05	50230.45	52018.37	53868.05	55712.58	57551.27

Debt Service Coverage Ratio													
Particulars		Years	1	2	3	4	5	6	7	8	9	10	11
Profit After Tax		Rs Mn	1199.93	1201.54	1202.57	1203.60	1204.65	1203.27	1204.32	1205.39	1283.77	1304.83	1263.93
Depreciation		Rs Mn	1035.61	2096.62	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08
Interest on Loan		Rs Mn	4107.45	3669.32	3231.19	2793.07	2354.94	1916.81	1478.68	1040.55	602.43	164.30	0.00
Repayment of Loan		Rs Mn	912.77	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	2738.30
Debt Service Coverage Ratio			1.26	0.95	0.95	0.95	0.94	0.94	0.94	0.93	0.94	0.94	1.23
Average DSCR			1.00										

Working Capital requirement

Particulars	Inventory Days	Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Fuel	60	Rs Mn	949.81	968.81	988.19	1007.95	1028.11	1097.90	1119.86	1142.26	1165.10	1188.41	1266.53	1291.86	1317.70	1344.05	1370.93	1398.35	1487.54	1517.29	1547.63	1578.58	1610.16	1709.95	1744.15	1779.03	1814.61
Secondary fuel	60	Rs Mn	67.57	42.17	43.85	45.61	47.43	49.33	51.30	53.35	55.49	57.71	60.01	62.41	64.91	67.51	70.21	73.02	75.94	78.97	82.13	85.42	88.84	92.39	96.08	99.93	103.93
O&M	30	Rs Mn	97.01	102.56	106.66	110.93	115.37	119.98	124.78	129.77	134.96	140.36	145.98	151.82	157.89	164.20	170.77	177.60	184.71	192.09	199.78	207.77	216.08	224.72	233.71	243.06	252.78
Receivables	60	Rs Mn	2263.92	2265.99	2386.09	2512.55	2645.72	2785.94	2933.59	3089.07	3252.80	3425.19	3606.73	3797.89	3999.17	4211.13	4434.32	4669.34	4916.81	5177.41	5451.81	5740.75	6045.01	6365.40	6702.77	7058.01	7432.09
Capitalized spares		Rs Mn	3.79	4.02	4.26	4.52	4.79	5.07	5.38	5.70	6.04	6.41	6.79	7.20	7.63	8.09	8.57	9.09	9.63	10.21	10.82	11.47	12.16	12.89	13.66	14.48	15.35
Total		Rs Mn	3374.53	3375.51	3520.53	3672.52	3831.83	4048.08	4224.16	4408.76	4602.31	4805.26	5072.46	5296.78	5532.04	5778.81	6037.66	6309.22	6655.36	6955.55	7270.53	7601.05	7947.92	8379.57	8763.04	9165.55	9588.05
Bank Credit		Rs Mn	3037.08	3375.51	3520.53	3672.52	3831.83	4048.08	4224.16	4408.76	4602.31	4805.26	5072.46	5296.78	5532.04	5778.81	6037.66	6309.22	6655.36	6955.55	7270.53	7601.05	7947.92	8379.57	8763.04	9165.55	9588.05
Margin Money	10%	Rs Mn	337.45																								
Working Capital		Rs Mn	3374.53	3375.51	3520.53	3672.52	3831.83	4048.08	4224.16	4408.76	4602.31	4805.26	5072.46	5296.78	5532.04	5778.81	6037.66	6309.22	6655.36	6955.55	7270.53	7601.05	7947.92	8379.57	8763.04	9165.55	9588.05
Increase in working capital		Rs Mn	3037.08	0.98	145.02	151.99	159.31	216.24	176.08	184.60	193.55	202.96	267.20	224.32	235.26	246.76	258.85	271.56	346.14	300.19	314.98	330.53	346.87	431.64	383.48	402.50	422.51

Schedule of repayment of term loan

				2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Particular	Years		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Rupee Loan	Quarterly payment	912.77																	
Grace quarters	3																		
Opening Balance				36510.67	35597.90	31946.83	28295.77	24644.70	20993.63	17342.57	13691.50	10040.43	6389.37	2738.30	0.00	0.00	0.00	0.00	0.00
Repayment		Q1	0.00	0.00	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	0.00	0.00	0.00	0.00	0.00
		Q2	0.00	0.00	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	0.00	0.00	0.00	0.00	0.00
		Q3	0.00	0.00	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	0.00	0.00	0.00	0.00	0.00
		Q4	0.00	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	912.77	0.00	0.00	0.00	0.00	0.00	0.00
Closing balance			0.00	35597.90	31946.83	28295.77	24644.70	20993.63	17342.57	13691.50	10040.43	6389.37	2738.30	0.00	0.00	0.00	0.00	0.00	0.00
Interest payable			0.00	3285.96	4107.45	3669.32	3231.19	2793.07	2354.94	1916.81	1478.68	1040.55	602.43	164.30	0.00	0.00	0.00	0.00	0.00
Total Rs loan servicing			0.00	4198.73	7758.52	7320.39	6882.26	6444.13	6006.00	5567.88	5129.75	4691.62	4253.49	2902.60	0.00	0.00	0.00	0.00	0.00
Total repayment			0.00	912.77	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	2738.30	0.00	0.00	0.00	0.00	0.00
Total interest			0.00	3285.96	4107.45	3669.32	3231.19	2793.07	2354.94	1916.81	1478.68	1040.55	602.43	164.30	0.00	0.00	0.00	0.00	0.00

Depreciation under Companies Act

Particular	Year			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Rate		Value																									
As per Companies Act (SLM)																												
Book Value of assets		Rs Mn	38356.08	38356.08	38356.08	36259.46	34143.38	32027.30	29911.22	27795.14	25679.06	23562.99	21446.91	19330.83	17214.75	16391.85	15568.94	14746.04	13923.14	13100.24	12277.34	11454.44	10631.53	9808.63	8985.73	8162.83	7339.93	6517.03
Land and land development	0%	Rs Mn																										
Factory buildings		Rs Mn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plant and machinery	3.60%	Rs Mn	38356.08	1035.61	1380.819	1380.819	1380.819	1380.819	1380.819	1380.819	1380.819	1380.819	1380.819	1380.819	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017	822.9017
Advance against depreciation				0.00	715.80	735.26	735.26	735.26	735.26	735.26	735.26	735.26	735.26	735.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accumulated debt repayment				912.77	4563.83	8214.90	11865.97	15517.03	19168.10	22819.17	26470.23	30121.30	33772.37	36510.67		0.00	0.00	0.00	0.00									
Accumulated depreciation				1035.61	2416.43	3797.25	5178.07	6558.89	7939.71	9320.53	10701.35	12082.17	13462.98	14843.80	15666.70	16489.61	17312.51	18135.41	18958.31	19781.21	20604.11	21427.02	22249.92	23072.82	23895.72	24718.62	25541.53	26364.43
Debt repayment				912.77	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	3651.07	2738.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total depreciation		Rs Mn		1035.61	2096.62	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	2116.08	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90	822.90
Total debt repayment	35866																											
Total booked depreciation during repayment	14843.80																											
AAD during repayment period	7333.14																											
Total depreciation during repayment	22176.95																											
90% of asset value	34520.47																											
Balance depreciation to be recovered	12343.53																											
Balance years	15																											
Annual depreciation after repayment	822.9017																											