TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

DETAILED PROJECT REPORT

1 X 660 MW SUPERCRITICAL ENNORE TPS EXPANSION PROJECT, ERNAVUR VILLAGE, ENNORE, TAMIL NADU

JULY 2019
(Rev 0)

DESEIN PRIVATE LIMITED
CONSULTING ENGINEERS
DESEIN HOUSE, GREATER KAILASH-II
NEW DELHI–110048

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PROJECT HIGHLIGHTS

1.	Project	:	1x660 MW Supercritical Ennore Thermal Power Station Expansion Project		
2.	Promoters	:	Tamil Nadu Generation and Distribution Corporation Limited		
3.	Plant Capacity	:	660 MW		
4.	Plant Configuration	:	1 x 660 MW		
5.	Location	:	Ernavur Village, Ennore, Tamil Nadu		
		:	Latitude : $13^0 12' 02.87''$ N		
		:	Longitude : $80^0 18' 29.26''$ E		
		:	Nearest Town : Chennai : 20 km		
		:	Nearest National Highway : NH - 5 : 05 km		
		:	Nearest Railway Station: Kathivakkam : 2 km		
		:	Nearest Airports : Chennai : 38 km		
		:	Nearest Sea Port : Ennore		
6.	Site Elevation	:	Height above MSL : 9.5 m		
7.	Seismic Zone	:	Zone III as per IS:1893		
8.	Land Requirement	:	Within existing Ennore Thermal Power Station (on the southern side).		
				Description (Within the Power Plant)	**Acres**
			a)	Main Power Block & Auxiliaries	24
			b)	Switchyard	2
			c)	Water Storage & Facilities, Cooling Tower etc.	18
			d)	Coal Storage & Handling Facilities.	12
			e)	Ash Dump Area	Existing
			f)	Staff Colony	Existing
			g)	Green Belt	14

			h)	Miscellaneous	14
				Sub Total	**84**
				Description (Outside the Power Plant)	**Acres**
			i.	Corridor for water pipeline	3
			ii.	Corridor for pipe conveyor system	3
				Sub Total	**6**
				Grand Total	**90**
9.	Climatological Data	:	i)	Max. mean temperature	41.5°C
			ii)	Min. mean temperature	17.3°C
			iii)	Wet bulb temperature	23.9°C
			iv)	Average Relative Humidity	74%
			v)	Annual Rainfall	1215.3 mm
			vi)	Wind Direction (Jan to March)	West & North West
				April to October	South and South West
			viii)	Mean wind speed	6.6 km/hr
10.	Source of Water (Distance from site)	:	Bay of Bengal (3 Km)		
11.	Water Requirement	:	7113 m^3/hr		
12.	Plant Cooling System	:	Closed cycle cooling system using Natural Draft Cooling Tower.		
13.	Primary Fuel & Source	:	Domestic Coal from Talcher & Mahanadi coal fields./ Chandrabila Coal block and Imported coal from Indonesia / South Africa / Australia.		
14.	Support Fuel & Source	:	HSD/HFO from nearest refinery/oil depots.		
15.	Coal GCV				
	Domestic Coal	:	2800 Kcal/kg		
	Imported Coal	:	5642 Kcal/kg		
	(i) Best Coal (100%	:	5642 Kcal/kg		

	imported coal)		
	(ii) Design Coal (70% imported & 30% domestic coal)	:	4789 Kcal/kg
	(iii) Worst Coal (50% Domestic & 50% Imported)	:	4221 Kcal/kg
16.	Coal Requirement Station Heat Rate 2317 kcal/kwh at 85% PLF	:	
	i. 100% imported Coal	:	2.02 MTPA
	ii. 70% imported & 30% domestic coal	:	2.38 MTPA
	iii. 50% imported coal & 50% domestic coal	:	2.70 MTPA
17.	Support fuel (HFO/LDO)	:	5782 KL/Year @ 1ml/kwh
18.	Transportation :		
	i. Coal	:	From Indian & Imported coal fields to Ennore port by Ship and port to site by pipe conveyor.
	ii. Support fuel	:	By Road Tankers
19.	Steam Generator	:	Steam Generator will be of super-critical pressure parameters, balanced draft furnace, once through, single reheat, radiant, dry bottom type, suitable for outdoor installation designed for firing pulverized coal as main fuel.
20.	Steam Turbine Generator	:	The Steam Turbine will be single shaft, multi-cylinders, tandem compound single reheat, regenerative, condensing unit directly coupled to AC Generator giving a continuous rated output at generator terminals.
21.	Control System	:	Distributed Digital Control & Management Information System
22.	Chimney	:	One (1) no. of Single Flue RCC Stack of 275 meter high.
23.	Power Evacuation	:	400 kV GIS

24.	Project Completion Schedule	:	36 months from ózero dateô(33 months commissioning & 3 months commercial operation) For FGD provision additional 6 months		
			Best coal (100% Imported)	Design coal (70% Imported & 30% Domestic)	Worst coal (50% Imported & 50% Domestic)
25.	Total Project EPC Cost (Estimated) (Rs)	:	4892.75 Crores	4892.75 Crores	4892.75 Crores
26.	Cost Per MW (Estimated) (Rs)	:	7.41 Crores	7.41 Crores	7.41 Crores
27.	Levellised Tariff at 85% PLF (Rs)	:	5.36 /KWhr	5.32 /KWhr	5.32 /KWhr

1.0 INTRODUCTION

The electric power grid for the Southern Region of India comprises the states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. With rapid industrialization, successful rural electrification and large scale use of electricity for the irrigation purpose, the demand of electricity has registered a significant growth and steep increase in the southern region. Also, it is expected that the ongoing liberalization of country's economic policy would accelerate the industrial growth which would further increase the power demand.

Earlier in Tamil Nadu state, the power generation along with power transmission and distribution was being managed by the erstwhile Tamil Nadu Electricity Board (TNEB). As mandated by Indian Electricity Act 2003 TNEB was bifurcated to form separate entities as Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) in the field of power generation & distribution and Tamil Nadu Transmission Corporation Limited (TANTRANSCO) for transmission of power, which are subsidiary of TNEB Ltd.

As such, the Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) has assumed the lead role of power generation in Tamil Nadu State.

To meet the growing demand of electricity, Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) established by Government of Tamil Nadu under the Indian Electricity Act 2003 is planning to develop 1 X 660 MW Supercritical Ennore Thermal Power Station Project at Ernavur village, Ennore, Tamil Nadu.

In this direction, M/s TANGEDCO has engaged M/s DESEIN PRIVATE LIMITED, Consulting Engineers for the preparation of Detailed Project Report

of 1 X 660 MW Ennore Supercritical Thermal Power Station Expansion Project. This Report is based on Central Electricity Authority (CEA) guidelines, Tamil Nadu Electricity Regulatory Commission (TNERC) norms and MoEF for basic EIA.

The Detailed Project Report is prepared based on Govt. of India guidelines and CERC norms. The scope covers the following:-

a) Capacity and size of the unit(s).
b) Location of the plant ï layout plans.
c) Basic plant requirements, e.g., land, fuel, water etc.
d) Source and availability of fuel and water.
e) Description of salient features of mechanical and electrical equipment and auxiliary systems; design consideration for civil and structural engineering work.
f) Power Evacuation facilities.
g) Consideration of environmental aspects (the work would, however, not cover EIA study as required by the Ministry of Environment & Forests).
h) Cost estimates up to the station bus including break-up under major heads and phased expenditure in line with GOI guidelines based on the major inputs received from TANGEDCO.
i) Financial analysis / estimated cost of generation as per the GOI norms and as acceptable to F.Is. / Banks.
j) Time schedule for project implementation.
k) Execution and management.

1.2 EXECUTIVE SUMMARY

The current availability of power for TANGEDCO from all sources excluding PPA, Wind, Solar, Bio mass and Co-generation is roughly 10500 MW. During 2011-12 Tamil Nadu was facing severe power shortage. During the year 2011-2012, the power shortfall of nearly 2000 to 2500 MW was experienced in state of Tamil Nadu against the availability of 10,500 MW including private & central power generation. In order to overcome the prevailing power shortages and expected growth rate of 8% in future, it is necessary to augment the power generation capacity in the State of Tamil Nadu.

Giving due consideration to above, in order to mitigate the power deficit in the state of Tamil Nadu, it is necessary to go for the capacity addition by installing new projects. In order to reduce the period of setting up a new power station, it is preferred to take up expansion project where the land is available and other important inputs like coal and water can be made available easily and hence existing infrastructure can be best utilized for up-coming project.

TANGEDCO is already having 3 x 110 MW / 2 x 60 MW totaling to 450 MW installed coal based TPS installed during 1970 to 1975 at Ernavur village, Ennore, Tamil Nadu. All the units have been decommissioned on 31.3.2017.

For replacing all the units of the existing Ennore Thermal Power Station (450MW) with a new Coal fired 1x660 MW Supercritical ETPS Replacement thermal unit in the Government of Tamil Nadu order GOTN Letter (Ms) No.45 Energy dated 30.3.2012. The DPR works and MoEF clearance works for the project is under progress. The Coal handling and Sea water requirement for the future replacement unit is planned with this Expansion project. Also to meet the new MoEF norms adequate land is being marked between the two projects for installation of FGD, for Desulphurization and DeNO$_x$. It is planned in such a way that, both units will have common handling facilities for limestone and Gypsum the byproduct of wet limestone FGD.

The proposed 1 X 660 MW Supercritical Ennore TPS site is within the boundary of existing Ennore TPS at Ernavur village, Ennore, Tamil Nadu. Nearest railway station from this project site is Kathivakkam at a distance of about 2 km. The latitude and longitude of the proposed site are 13^0 12ø02.87øN and $80^0$18ø29.26øE respectively. The proposed site is suitable in respect of techno-commercial aspects including adequacy of space, proximity to rail / road connections, space for power evacuation system and adequate water availability for running unit. The proposed site is also environmentally compatible as compared to other locations considered in the region.

Liberalization policy of Govt. of India in power generation by the enactment of Electricity Act 2003 has taken place. Electricity Act 2003 does not indicate special requirement like clearance from concerned statutory or non statutory authorities for setting up the thermal power plant. As per GOI guidelines for setting up of power project various inputs / statutory / non statutory sanctions like Land availability, Water availability, Coal availability, Environmental clearance, Airport Authority clearance for chimney height, CRZ clearance, Pollution Control Board etc. are to be obtained. TANGEDCO has already obtained statutory clearances and entered into MOU with M/s MMTC for supply of imported coal for this project as detailed in Chapter-2.

In the proposed project, 84 acres of land is available within the existing ETPS for the project main plant and auxiliaries. The land for water pipeline corridor and pipe conveyor system is excluded from the above area. The area required for locating the Sea Water Intake system is about 3 acres available in ETPS camp area and the land required for locating the Pipe conveyor system is about 3 acres available inside the NCTPS and the right of way permission has been obtained from PWD for laying the conveyor in the water ways. The area for the ash dyke is already available for the existing plant, will be used for disposing the wet bottom ash regularly and 50% dry fly ash in case of

emergency. **There is no need of land acquisition for this project**. There is no rehabilitation or resettlement issued involved in this project.

The proposed 1 x 660 MW unit will require about 7113 m^3/hr of sea water which will be sourced from Bay of Bengal. The intake point from Bay of Bengal is at a distance of 3 Km from project site. The above water quantity is sufficient for condenser cooling water as well as plant water requirements.

Plant is designed for operation with:

i. 100% imported coal (Best Coal).
ii. 70% imported coal + 30% domestic coal (Design Coal).
iii. 50% imported coal + 50% domestic coal (Worst Coal).

Blended Coal (50% Domestic + 50% Imported) requirement per annum at plant load factor of 85% will be 2.70 million tonne which is the maximum requirement in the plant. Coal will be transported from coal mine to Ennore port by ship and from Ennore port to site by pipe conveyor.

Secondary fuel (HSD) will also be supplied by the Road Tankers.

The proposed plant will comprise of supercritical boiler, condenser, turbine and generator with all accessories. The capacity of steam generating unit will be selected to ensure enough margin over the requirement of turbine and will be designed for satisfactory and continuous operation with different types of available coals.

Selection of type of boiler has been discussed in Chapter - 4.0. It is proposed to have one unit of 660 MW capacity with supercritical technology and pulverized coal fired boiler.

Technical features outlining the salient parameters of the main plant and equipment are discussed in the Chapter - 5.0. The state-of-the-art technology will be deployed for auxiliaries and sub-systems to ensure safe and continuous operation of the units with minimum unscheduled outages.

The steam generator will be semi outdoor, once through, radiant reheat, dry bottom and balanced draft unit .of super-critical parameters, designed for firing pulverized coal as prime fuel. Steam generator will be sized for 2100 TPH at 256 Kg/cm² (a), super heater outlet steam pressure, 568 ^{0}C steam SH temperature and 593 ^{0}C reheat temperature.

Steam turbine of 660 MW unit will be three / four cylinder, 3000 RPM, multistage, tandem compound, single reheat condensing reaction unit with uncontrolled extractions for regenerative cycle.

The Generator will be directly coupled, horizontal shaft cylindrical rotor continuously rated at rated power factor of 0.85 lagging, 3 phase 50 Hz. The generator will be provided with brushless excitation as per manufacturerôs standard. The state-of-the-art technology will be deployed for auxiliaries and sub-systems to ensure safe and continuous operation of the units with minimum unscheduled outages.

SCR shall be installed in the steam generator to limit the NOx emission to 100 mg/ Nm3.

Wet limestone based FGD is proposed to be installed in the plant to limit the SOx emission to 100 mg/Nm3

The design coal used for the power plant will be blended imported: Indian coal (Ratio 70:30). The coal will be received through ship at Ennore Port Transported throôbelt conveyors will be passed throôcrushers and crushed

coal will be sent throô& pipe conveyor to ETPS. Capacity of the coal handling plant will be 2 x 1000 TPH for two shifts operation based on blended coal of 50:50 ratio (worst condition). Crushed coal, stacking, reclaiming & feeding systems have been envisaged. The stockpiles of the two types of coal will have capacity for seven (7) days when domestic & imported coal mixed at 50:50 ratio. Coal handling system is discussed in Chapter - 6.1.1 of the report.

Fly ash generated is proposed to be handled in dry form. Bottom and coarse ash will be extracted and disposed off in wet condition throôscraper feeder and clinker grinders to the existing ash pond. Fly ash utilization will be as per MOEF guidelines for the manufacture of cement, bricks & building material etc. In emergency cases fly ash if any will be disposed off in slurry form to ash dyke. Ash handling system is discussed in Chapter - 6.1.2 of the report.

Water will be drawn from Bay of Bengal at a distance of about 3 Km from project site. Sea water will be drawn throôinfiltration wells from deep sea throô pipes up to the forebay under gravity from the fore bay the water will be pumped to the plant throôpipe lines. The sea water will be clarified, RO ï Permeate and de-mineralized for the power plant water use. Circulating water system will be closed circuit cooling system using natural draft cooling tower. Only make up water will be drawn from source (sea). Clarified and filtered water will be used for cooling tower makeup. Natural draft cooling tower is proposed in view of low O&M Cost. Plant water system is discussed in Chapter - 6.1.3 of the report.

The electrical system will be equipped with adequately sized equipment with required redundancy to ensure uninterrupted operation of power plant. Power generated from proposed plant will be evacuated at 400 kV voltage level to TANGEDCO sub-station. Electrical equipment and systems are discussed in Chapter - 6.2 of the report.

The proposed station envisages the state-of-the-art Distributed Digital Control & Management Information System (DDCMIS) which will integrate various closed loop sub-systems, open loop sub-systems, monitoring and information sub-systems 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 Chapter ï 6.3 of the report, instrumentation and control philosophy is dealt in adequate detail.

Civil engineering aspects envisaged are given in the Chapter ï 6.4. Existing staff colony to be available extent for accommodating the staff required for the project activities of the power plant will be used.

The plant layout for the proposed plant has been developed keeping in view the optimum utilization of land, wind rose pattern of the area, accessibility by road, locations of the facilities best suited from the point of operation of plant in most economic and convenient way. The Plant layout is discussed in Chapter - 7.0 of the report.

To minimize emission of Suspended Particulate Matter (SPM) from boiler flue gases, Electrostatic Precipitators (ESPs) of high efficiency of the order of 99.98 % and of adequate size will be provided at exit end of each boiler to bring down SPM emission level less than 30mg/Nm^3. Waste water from the plant will be properly treated before re-use and/or disposal. One (1) no. of Single Flue RCC stack of 275 meter high will be provided. The entire environmental aspects have been discussed in Chapter - 8.0.

Facilities will be developed for execution of the project. Manpower requirement of about 0.5 person / MW has been envisaged for O&M of the proposed station. This may undergo revision as per developersô practices. The training requirement of senior officerôs supervisory / monitoring staff for O & M is also envisaged.

The schedule of commissioning of the unit will be 42 months from zero date, .including the commissioning of FGD and SCR.

It is proposed to finance the project such that Capital structure is built up of Equity Capital 20% & Loan Capital 80%. Total Project including land cost, non-EPC cost with interest during construction for Design Coal is estimated at 6380.81 Crores i.e. Rs 9.67 Crores / MW. Levelised tariff at 85% PLF is Rs 5.32 / kwh.

2.0 DEMAND ANALYSIS AND JUSTIFICATION

2.1 Power Demand and Supply Analysis

"Power sector Report" as per CEA website gives the details of power supply position. The details at IXth plan end, Xth plan end, XIth plan end and April 2012 – August 2012 for All India is given in **Table - 2.0** and for Southern region and Tamil Nadu are given in Table 2.1.

Table 2.0

Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Availa-bility (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
IXth Plan End	78441	69189	-9252	-11.8	522537	483350	-39187	-7.5
Xth Plan End	100715	86818	-13897	-13.8	690587	624495	-66092	-9.6
XIth Plan End	130006	116191	-13815	-10.6	937199	857886	-79313	-8.5
April 12 ï March 13	15955	137543	-16014	-10.1	995500	908574	-86926	-8.7

Table - 2.1

Description	Unit	Southern Region		Tamil Nadu	
		March'13	April 2012 – March'13	March'13	April 2012 – March'13
Peak Demand	MW	39870	40695	12389	12606
Peak Availability	MW	33852	35034	10556	11053
Peak surplus/ deficit	MW	-6038	-5661	-1833	-1553
Peak surplus/ deficit	%	-15.1	-13.9	-14.8	-12.3
Energy Requirement	MU	26303	281828	80090	92150
Energy Availability	MU	21525	238034	6491	76009
Energy surplus/ deficit	MU	-4778	-43794	-1599	-16141
Energy surplus/ deficit	%	-18.2	-15.5	-19.8	-17.5

According to Table 2.1, during April 12 ï March 13, Southern Region has peaking shortage of 5661 MW i.e. (-)13.9 % & Energy shortage of 43794 MU i.e. (-) 15.5% and Tamil Nadu state has peaking shortage of 1553 MW i.e. (-) 12.3% & shortage of 16141 MU i.e (-)17.5 %. At All India level the peaking shortage is 10.1% & Energy deficit is (-) 8.7% respectively.

Installed capacity of All India level, Southern Region and Tamil Nadu State as on 31.03.2013 is given in Table - 2.2.

Table-2.2

All India

Sector	Hydro	Thermal				Nuclear	RES** (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	27395.00	49560.50	5215.32	602.61	55378.43	0.0	3569.92	86343.35
Private	2595.00	29995.38	6985.50	597.14	37578.02	0.0	22286.26	62459.24
Central Sector Share	9426.40	42055.00	6702.23	0.00	48757.23	4780.00	0.00	62963.63
Total	**39416.40**	**121610.88**	**18903.05**	**1199.75**	**141713.68**	**4780.00**	**25856.14**	**211766.22**

RES** = Renewable Energy Sources

Southern Region

Sector	Hydro	Thermal				Nuclear	RES** (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	11353.03	11382.50	555.70	362.52	12300.72	0.00	1343.63	24997.38
Private	0.00	2760.00	4047.50	576.80	7384.30	0.00	10753.15	18137.45
Central Sector Share	0.00	9640.00	359.58	0.00	9999.58	1320.00	0.00	11319.58
Total	**11353.03**	**23782.50**	**4962.78**	**939.32**	**29684.60**	**1320.00**	**12096.78**	**54454.41**

Tamil Nadu State

Sector	Hydro	Thermal				Nuclear	RES** (MNRE)	Total
		Coal	Gas	Diesel	Total			
State	2137.20	3570.00	523.20	0.00	4093.20	0.00	118.55	6348.95
Private	0.00	250.00	503.10	411.66	1164.76	0.00	7385.05	8549.81
Central Sector Share	0.00	2959.37	0.00	0.00	2959.37	524.00	0.00	3483.37
Total	**2137.20**	**6779.37**	**1026.30**	**411.66**	**8217.33**	**524.00**	**7503.60**	**18382.13**

Tables - 2.3 shows the details of peak load and energy requirement of Eastern, Western and Northern Region as per 17th Electric Power Survey a publication of CEA. As the peak demand and energy requirement of the Western Region, Northern Region and Southern Region are mainly involved, as such for the power demand and supply analysis of the above said three Regions have been considered.

Table-2.3

Peak load and Energy Requirement at Station Bus Bar

YEAR	Western Region		Northern Region		Southern Region	
	Peak Load (MW)	Energy Require-ment MKWH	Peak Load (MW)	Energy Require-ment (MKWH)	Peak Load (MW)	Energy Requirement (MKWH)
2009-10	41898	268307	41131	256859	34715	219001
2010-11	44427	281220	44496	275171	37434	235582
2011-12	47108	294860	48137	294841	40367	253443
2016-17	64349	409805	66583	411513	60433	380068
2021-22	84778	550022	89913	556768	80485	511659

Source: *17th electric power survey*

From the Table-2.3 it will be seen that peak load requirement will be on a rising trend. Considering Utilization factor of 70%, Western Region will require 91927 MW by year 2116-17 and 121111 MW by year 2021-22, Northern Region will require 95118 MW by year 2016-17 and 128447 MW by year 2021-22, similarly Southern region will require 86333 MW by year 2016-17 and 114979 MW by 2121-22,

To bridge the gap between demand and supply, generation of additional capacity is required. The proposed project has been considered for the effective utilization of existing infrastructure and water. Further, the proposed TPS will have the advantage of economy of scale in reducing the cost of generation by adopting Supercritical Technology.

2.2 Government Policy for Power Generation/Requirement of input/ clearance

Liberalization policy of Govt. of India in power generation by the enactment of Electricity Act 2003 has come in force. The Act consolidates the laws relating to generation transmission, distribution, trading, and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies etc.

As per Clause-7 of the Act 2003 ñAny Generating Company may establish, operate and maintain generating station without obtaining licence under this Act if it complies with technical standards relating to connectivity with the gridò

M/s TANGEDCO being a generating company is logically in the right direction to install the proposed project.

2.2.1 Requirement of Input/Clearances

Electricity Act 2003 do not indicate special requirement like clearances from the concerned statutory or non-statutory authorities for setting up thermal power plant. However, clause 10 (3) stipulates that generating company will:

a) Submit technical details regarding its generating station to appropriate commission (i.e. CERC/SERC) and the Authority (i.e. CEA).

b) Co-ordinate with Central Transmission Utility or State Transmission Utility as the case may be for transmission of electricity generated by it.

2.2.1.1 **As per GOI guidelines for setting up of power project, various Statutory/Non-statutory inputs are to be tied-up.**

Relevant requirements & status thereof are as follows:

S. No.	Requirements	Status
1.	Approval of Competent Authority	TANGEDCO has obtained the approval from Govt. for setting up of this project vide Energy (32) Department Lr. (MS) No. 44, Energy dated 30.03.2012.
2.	Incorporation of the Company	TANGEDCO is a subsidiary of TNEB Ltd., wholly owned company by Govt. of T.N. TANGEDCO has been registered under Company Act 1956 for Generation & distribution of power as per Indian electricity Act 2003.
3.	Land Availability	84 acres of land is available within the existing ETPS boundary for main power plant and its facilities. About 6 acres land available for pipe conveyor and water pipeline corridor. There is no need for land acquisition for this project.
4.	Water Availability	The net water requirement for 1 X 660 MW power plant has been assessed as 7113 m^3/hr. (which includes plant water as well as cooling water). Water source for the power plant is Bay of Bengal.

S. No.	Requirements	Status
5.	Coal Availability	Coal Requirement for 1 X 660 MW capacity has been assessed as 2.02 mtpa for 100% Imported Coal, 2.38 mtpa for 70% Imported & 30% Domestic coal, 2.70 for 50% Imported coal & 50% Domestic coal
6.	Environment Clearance	As per MoEF notification, the project falls under category óAô The expert appraisal committee of MoEF cleared the project in the meeting held on 03.06.2012, and EC was granted up to 2.6.2019. Fresh EC is applied as the projects EC expired. Final MoEF clearance is expected shortly.
7.	Pollution Control Board Clearance	TNEB clearance has been obtained from the Govt. of Tamil Nadu vide G.O. (4D) N.01 dated 15.11.2012.
8.	CRZ Clearance	CRZ clearance has been obtained for this project for setting up power plant in coastal region during 2008.
9.	Airport Authority Clearance for Chimney Height	Civil Aviation (AAI) clearance obtained for installing a one (1) no. of 275 meters high single flue RCC Chimney.
10.	Evacuation and Absorption of power	The power will be evacuated at 400 KV voltage level. Necessary steps for evacuation of power will be taken up by TANTRANSCO separately. Hence a power evacuation is not considered in EPC Scope.

S. No.	Requirements	Status
11.	Ash utilization plan	Ash utilization will be as per MoEF guidelines. Prospective users of fly ash like cement, bricks, and concrete block manufacturers will be identified for utilization of 100% fly ash. Further bottom ash will be disposed into the existing ash pond.
12.	Approval by State Regulatory Commission/ Central Regulatory Commission	Approval of SERC for tariff fixation within the State and CERC for sale of electricity to other States if any will be obtained at appropriate stage.
13	Gypsum from wet FGD	Gypsum coming as by product from the wet limestone FGD system to be installed will be utilized by the cement companies in the state. Final agreement on the supply of gypsum will be made only after the generation of gypsum from the plant.

3.0 BASIC REQUIREMENT

3.1 Infrastructure Requirements

For the establishment of a power project a number of basic inputs such as land, fuel, water etc. are required. Site selection of power station is primarily governed by the following basic considerations:-

a) Availability of suitable and adequate land

b) Rail / road accessibility

c) Availability of fuel and proximity to source

d) Availability of water and proximity to source

e) Proximity to the grid for evacuation of power

f) Environmental aspects

The most important criteria for selection of site for TPS is availability of land with least R&R issues, fuel availability and its transportation, water availability within a reasonable distance and the acceptability from the environmental considerations.

3.2 Site Selection and Features of the Site

The basic requirement for establishing the project was studied in the backdrop of available infrastructural facilities and the requirement of developing of facilities to ensure compatibility and adequacy of system by TANGEDCO for setting up power plant.

Site selection team comprising officials of TANGEDCO visited the potential sites in Tamil Nadu for identifying the most suitable site for setting up Thermal Power Project of 660 MW capacity.

Based on the site selection teamôs assessment and careful study of the features of the sites, the proposed site at Ennore was found suitable for establishing the power plant. In order to reduce the period of setting up a new power station, it is preferred to take up expansion project where the land is available and other important inputs like coal and water can be made available easily.

The nearest town is Chennai at a distance of about 20 km and railway station is Kathivakkam at a distance of about 2 km. Chennai Airport is about 38 km away. The grid coordinates of the proposed power plant site are at Latitude $13^0$12ô02.87ò N and Longitude $80^0$18ô29.26ò E. Plant site level about 9.5 m above Mean Sea Level (MSL).

Location map is as per **Annexure - 3.1.**

Climatological data is as follows:

Maximum Mean Temperature	41.5^{o}C
Minimum Mean Temperature	17.3 ^{o}C
Wet Bulb Temperature	23.9 ^{o}C
Annual Relative Humidity	74%
Annual Rainfall	1215.3 mm
Wind Direction (Jan to March)	West & North West
April to October	South & South west
Mean wind speed	6.6 kmph

a) **Land**

In the proposed project, 84 acres of land is available within the existing ETPS for the project main plant and auxiliaries. The land for water pipeline corridor and pipe conveyor system is excluded from the above area. The area required for locating the Sea Water Intake system is about 3 acres available in ETPS camp area and the land required for locating the Pipe conveyor system is

about 3 acres available inside the NCTPS and the right of way permission has been obtained from PWD for laying the conveyor in the water ways. The area for the ash dyke is already available for the existing plant will be used for disposing the ash in case of emergency. There is no need of land acquisition for this project.

Detailed land requirement is provided below in Table 3.2.

Table - 3.1

Land Requirement Details

S. No.	Details	Area in acres
(A)	**Inside Power Plant boundary**	
i.	Main Plant & Equipment	24
ii.	Switchyard	2
iii.	Water storage & facilities, cooling Tower etc.	18
iv.	Coal Storage & handling facilities	12
v.	Ash Dump Area	Existing
vi.	Staff Colony	Existing
vii.	Green Belt	14
viii.	Miscellaneous (Includes FGD)	14
	Sub Total	**84**
(B)	**Facilities outside the plant boundary**	
i.	Corridor for Water pipeline	3
ii.	Corridor for Pipe Conveyor	3
	Sub Total	**6**
	Grand total	**90**

Site has differential levels and require filling to maintain the desired grade level of +9.50 MSL. Suitability of foundation designs will be based on soil investigation results.

b) **Rail & Road Accessibility**

i) **Railway Accessibility**

The nearest railway station is Kathivakkam on Chennai - Howrah main trunk line of Southern Railway. The distance between the project site and Kathivakkam railway station is 2 km.

ii) **Road System**

Site is well connected to Chennai City and National Highway No. 5 is about 5 kms from the site. The road will be suitably developed. No problem is envisaged in accessibility and transportation of heavy equipment to site by road.

c) **Fuel Availability & Transportation**

i) Coal requirement

The coal requirement for the power plant based on Station Heat Rate of 2317 kcal/kwh, is estimated as 2.70 mtpa with blended GCV of coal as 4221 kcal/kg (worst coal):

- Coal required per hr. : 362.28 tonnes
- Per day : 8695 tonnes
- Annual coal requirement at 85% PLF : 2.70 million tones

ii) Coal availability

The availability of domestic coal is envisaged from Talcher and Mahanadi Coal Fields, Orissa.

TANGEDCO will approach to Ministry of Coal for allocation of coal.

TANGEDCO will also import coal from foreign sources.

iii) Coal Transportation

Coal from coal fields to Ennore port by Ship and port to site by pipe conveyor.

iv) Secondary Fuel

Start-up fuel will be Light Diesel Oil (LDO) for start up of boiler and support fuel will be HFO, will be brought to site in tankers through road.

d) **Availability of Water**

Raw Water requirement has been assessed as 7113 m^3/hr which will be sourced from Bay of Bengal at a distance of about 3 Km from project site.

Suitable intake system will be developed at a location as may be suggested by N.I.O, Goa. TANGEDCO has planned to draw sea water from suitable location from Bay of Bengal as per the NIO study report throô submerged piped buried in the sea bed. The water collected under gravity in the fore bay will be pumped to the plant site throôunderground pipe lines. On line boosting stations will be provided as per requirement.

In line with the MoEF guidelines for new Thermal Power Stations, it is proposed to adopt closed circuit cooling water system deploying cooling towers and draw only make up water requirement from the source.

e) **Power Absorption**

Power generated from proposed plant will be evacuated at 400 kV voltage level. TANGEDCO/TANTRANSCO will take necessary steps for the evacuation of power.

f) **Environmental Aspects**

The Power Plant will be developed based on the guidelines of the State Environmental Authorities and that of MOEF. Suitable provisions will be incorporated in the design of buildings, structures, and selection of equipment so that there are no adverse effect of emissions, noise, and contamination of soil, water and air. One (1) Nos. of single flue 275 meter high RCC stack will be provided for the generating unit as per the guidelines.

TANGEDCO will approach MoEF / Environment Impact Assessment Authority for obtaining TOR for conducting EIA studies and report will be submitted for environmental clearance.

4.0 TECHNOLOGY AND UNIT RATING

4.1 Unit Rating

The 1 x 660 MW STPP is proposed to be established by TANGEDCO.

The plant configuration is selected to achieve:

i) Economy of scale to achieve least per MW installed cost.

ii) Better efficiency of large sized boiler and steam turbine and lower overall heat rate.

iii) Lower land requirement.

iv) Economical O&M cost aspects

v) Lower staff requirement and accordingly colony size.

vi) Higher net saleable power on account of higher efficiency and lower auxiliary power consumption.

To achieve better efficiency of the plant and more competitive tariff, higher size, one (1) unit of 660 MW will be installed.

4.2 Use of Supercritical Technology

The large capacity plants of single unit rating of 660 MW and above generally adopt supercritical parameters i.e. pressure 256 kg/cm^2 (a) and main steam / reheat steam temperature as 568^{0}C / 596^{0}C respectively at the boiler outlet. The higher steam cycle parameters result in improved plant efficiency.

The main advantages of adopting unit size of 660 MW and above with supercritical parameters are brought out below:

i. From Plant Performance Point of View

- Reduction in coal consumption.
- Reduction in ash generation.
- Reduction in effluent gasses to atmosphere.
- Reduction in suspended particulate matters to environment.

ii. From Operation Point of View

- Better heat rate at full load as well as partial load.
- Lesser percentage of auxiliary consumption, hence increase in net power export.
- Lesser startup time and hence less consumption of startup fuel and power.
- Quicker load following capabilities i.e. better response to load rise / fall.
- Boiler drum is eliminated hence no need of level control.
- More favourable for frequent start / stop, even for two-shift operation.
- Lesser requirement of service system like compressed air, water etc. because of reduction in number of units.

iii. From Plant Upkeep Point of View

- Lesser requirement of manpower for the operation & maintenance.
- Lesser number of equipment to maintain, hence lesser inventory.
- Increase in cost due to expensive materials to withstand higher pressure and temperature is off-set for reduction in size of balance of plant as well as number of units.

5.0 TECHNICAL FEATURE OF THE STEAM GENERATOR & TURBINE

5.1 Steam Generator and Auxiliaries

The supercritical plant (SCP) technology is being adopted by number of Independent Power Producers & Utilities in India with 660 MW and 800 MW unit sizes. The main plant equipment will comply with the requirements including the Turbine heat rate as specified in the Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 issued vide notification dated 20.08.2010.

The steam generator will be of supercritical technology designed for firing mixture of Imported & Indian coal (ratio 70:30) by weight as primary fuel, balanced draft furnace suitable for semi-outdoor installation.

Steam generator will be designed to meet the Indian Boiler Regulation (IBR) requirement. Wherever IBR is not specific, ASME or equivalent reputed international code will be used.

Steam and water system will essentially comprise of steam separator, evaporator, down comers, water walls, superheater, re-heater, de-superheater, economizer, valves, fittings, piping, insulation, supporting hangers, instrumentation etc.

The furnace will be designed to withstand pressure regimes without permanent deformations and will be made of gas tight welded membrane walls, with required openings for wall blowers, observation ports, access doors and instruments.

The furnace walls will either be spiral wound and vertical tubes or vertical rifle tubes as per the manufacturerôs design. The furnace will have bottom hopper

with stainless steel seal plates suitable for connection to an ash hopper. A suitable sealing arrangement (Seal Trough) shall be provided for connecting to Boiler and BAH. Dry bottom Ash hopper with scrapper, clinker grinder for connecting to sea water mixing and wet ash disposal to the existing pond.

SCR will be installed in the steam generator to limit NOx emission as per MOEF guidelines. Ammonia handling system shall be part of the system and ammonia shall be sprayed in flue gas in SCR.

The water / steam separators will be arranged at the evaporator outlet and will be so sized to ensure adequate steam separation. The water / steam mixture will be fed into the separators by connecting pipe work which will enter around the circumference at an inclined angle to ensure mixture moving spirally downwards and the water / steam separation is done by means of applied centrifugal force. The water will be led downwards to the collecting vessel and the steam escapes centrally upwards to the connections towards the first superheater stage.

The superheater and re-heater will be designed to maintain superheat and reheat steam temperatures at superheater and re-heater outlet over the entire steam temperature control range.

The attemperators are to be of spray type fitted with an inner removable lining. RH temperature control is by means of damper control of the flue gases or gas recirculation.

The economizer will be of non-steaming and bare tube type. The tube banks will be of inline arrangement.

1. Air and Flue gas Draft System

The Draft system comprises of two (2) sets of FD fans each set rated for 60% of BMCR capacity. The FD fans will be radial impulse type with inlet vane control arrangement or axial reaction type with hydraulic variable blade pitch control arrangement offering a favorable efficiency for regulation purpose. Two (2) Induced Draft (ID) Fans each rated at 60% of BMCR flow will be double suction radial (with wear liner) with speed control arrangement through variable speed hydraulic coupling or axial blade pitch control type for regulation. 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.

Boiler will be equipped with two (2) nos 60% capacity primary air fans with cold primary air system; thus, it will be possible to reduce the capacity of Primary Air Fans (PAF) compared with hot primary air system. The fans will be complete with lube oil system, regulators and all other accessories required for continuous operation

Air heaters of two tri-sector type as per manufacturerôs design. Additionally, two steam heated air preheaters will be provided on the up stream of secondary section of air preheater.

2. Pulverized Fuel Preparation System

For firing high mixture of ash content abrasive coal and imported coal, pulverizers of slow speed large capacity bowl mills will be provided having low auxiliary power consumption and relatively high life expectancy of grinding parts and armour plating.

Considering the grinding fineness required, it is suggested to equipping the mill with rotating classifiers having speed adjustment to control grinding fineness. The firing system will employ latest state of the art burners and permit load variation from 30 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.

3. Secondary Fuel Oil 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.

HSD for boiler start up (upto 7.5% of BMCR) and Heavy Fuel Oil (HFO) for low load operation and flame stabilization (upto 30% of BMCR), as necessary, will be provided. High Energy Arc (HEA) ignitors will be provided to ignite the fuel oil.

4. Soot Blowing System

Fully automatic, sequentially controlled, microprocessor based steam soot blowing system, complete with provision for individual operation of any soot blower pair, operation and facility to by pass any soot blower, will be provided. The system will have short retractable rotary wall blowers for the furnace and long retractable rotary blowers for the superheater, reheater and economizer.

5. Electrostatic Precipitators

It is proposed to install high efficiency electrostatic precipitators having an efficiency that will limit the outlet emission to 50 mg/Nm^3 while the

boiler is operating at its BMCR, firing worst coal having maximum ash content.

The electrostatic precipitators will have a number of parallel gas streams (at least four), 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 (8) hours. The hoppers will have heating arrangements to prevent ash sticking to the sloping sides and down pipes. Level indicators will be provided to indicate and trip the ESP in case of high ash levels in the ash hoppers which may jeopardize the safety of ESP otherwise.

6. Flue Gas De-sulphurising system (FGD)

Wet Limestone based FGD plant is proposed to be installed to limit Sox emission as per MOEF guidelines. In line with this requirement lime handling system, absorber, gypsum handling system, effluent recycling and disposal system are proposed to be installed.. 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 desulphurised flue gases back to the chimney with provision for bypassing the FGD system.

7. Auxiliary Boiler

To meet the auxiliary steam requirement for cold start of one unit when any other unit is not available, a startup auxiliary boiler of 120 T/Hr capacity, 19 Kg/Sq cm (g), 350°C will be provided. Auxiliary boiler will be suitable to generate rated parameters with HSD. Auxiliary boiler will be connected to auxiliary PRDS system suitably.

5.1.2 Technical Data: Boiler and Auxiliaries

The steam generator will be designed to achieve the maximum continuous rate (BMCR) of 2100 TPH with an appropriate control margin. The steam generator performance data at BMCR and firing design coal (70% imported & 30% domestic coal) are listed below:

The data mentioned below is indicative only. However, the boiler should be capable of firing imported to domestic coal in proportion of 50:50 (worst coal) & 100% imported coal.

Boiler Parameters (Typical for 660 MW unit)

Particulars	Units	Parameter
SH Steam flow	tph	2100
SH Outlet Pressure	$Kg/cm^2(a)$	256
SH Temperature	°C	568
RH Steam flow	tph	1600
RH Pressure	$Kg/cm^2(a)$	46.48
Temperature at RH outlet	°C	593
Temp. at Economiser inlet	°C	294

Gas temp. at APH outlet	°C	140
SH temp. Control		By spray
RH temp. Control		As per manufacturer's practice
Safety valves		As per IBR
FD fans	Nos./Type	2 Nos. Radial / Axial, Variable Blade pitch control
ID fans	Nos./Type	2 Nos. Radial / Axial; Variable speed with hydraulic coupling.
P A Fans	Nos./Type	2 Nos. Radial / Axial variable blade pitch control
Soot blowers		Rotary and long/short retractable

5.2 Steam Turbine and Auxiliaries

5.2.1 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 & operational flexibility.

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

- High-pressure (HP) section
- Intermediate-pressure (IP) section
- Low-pressure (LP) section

5.2.1.1 **Turbine**

The turbine will have one HP, one double flow IP or HP-IP combined and one / two 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.

5.2.1.2 **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.

5.2.1.3 **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.

5.2.1.4 **LP Turbine**

The LP-turbine will comprise of 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.

5.2.1.5 Gland Steam Sealing System

A fully automatic gland sealing steam supply system will be provided for the TG Set. 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.

5.2.1.6 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.

5.2.1.7 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 either shaft driven main oil pump or AC & DC powered oil pumps as per manufacturerôs design. 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.

5.2.1.8 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 minimise fire hazards. The system will comprise of:

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.

d) A control fluid purifying unit will be provided for the turbo-set for purifying atleast 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.

5.2.1.9 Lube Oil Purification System

A suitably sized centrifuge type turbine oil purification plant will be provided as an auxiliary of the proposed turbo-generator set to condition the turbine oil continuously to remove the water and other impurities.

In addition, a common turbine oil storage unit comprising one clean oil tank, one dirty oil tank, one purifier unit with necessary pumps, vent fans etc. will be kept. This would also receive the refill of turbine oil from outside. The purification plant will be complete with oil purifiers,

storage tanks, filters, and necessary pumping sets and vent fans.

5.2.1.10 Governing / Regulation Systems

The turbine will have throttle or nozzle controlled type governing. The steam turbine generator unit will be equipped with an digital 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.

5.2.1.11 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.

5.2.1.12 Bearings and Couplings

The turbine rotors will be designed with a single bearing system to minimize the impact of foundation distortions on bearing stresses, bending stresses acting on the trunnions. The combined journal and thrust bearing at the rear of the HP turbine comprises a self-adjusting journal bearing and a thrust bearing to accept the unbalanced residual thrust. The other journal bearings will also be of the self-adjusting type. Bearing temperatures will be monitored by thermocouples located directly under the white-metal lining of the bottom shell in the journal bearings and in two diametrically opposed pads in the thrust bearing.

The individual turbine shafts will be rigidly coupled together by means of integral flanges.

5.2.1.13 HP - LP Bypass Station

60% H.P. and L.P. 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 HP bypass station will be connected to the main steam line and discharges the steam to cold reheat line. The main steam will be de-superheated by means of boiler feed water injection. 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 de-superheated 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, without venting steam in to atmosphere.

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

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

5.2.2 Steam Condenser

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

5.2.2.1 Design Features

The condenser will be a double-flow box-type surface condenser with divided 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 forms an integral part of it.

The steam dome, shell and hotwell are steel fabrications, as are the water boxes. The condenser will be supported on the springs 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.

5.2.2.2 Air Extraction

The unit will comprise of (2x100%) 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 pumps is selected) mounted on a common shaft. Vacuum pumps will be sized as per latest HEI requirements.

5.2.2.3 Condensate Pumps

Each 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 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.

5.2.3 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 the regulation of BFP speed by regulating the drive turbines in case of TDBFPs and through regulation of Hydraulic coupling for MDBFP.

5.2.3.1 HP & LP Heaters

Regenerative feed heating cycle will consist of LP heaters, one drain cooler, deaerator and banks of HP heaters. The number of LP & HP heaters will be based on the optimisation of feed heating cycle.

Feed water will be heated in feed water heaters by uncontrolled turbine extraction steam from turbine inter-stage tap-offs and cold reheat line. The deaerator will normally be operated under variable pressure on extraction steam from the crossover pipe, between IPT and LPT modules. 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 additionally de-superheating zone.

5.2.3.2 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 in condensate & HP Heater drains. The minimum capacity of the Deaerator will be 6 minutes of BFP runs 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.

5.2.4 Boiler Feed Pumps

The unit will comprise of 2 x 50% Turbine driven and 1 x 50% electric motor driven boiler feed pumps, with booster pumps mounted on a common shaft. Each pump will be designed to give parameters to suit the 50% steam generator requirements of unit. The motor driven pump will be located on ground floor and 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 upto 185 deg. C (tentative).

The boiler feed pumps will be of horizontal, centrifugal type with stiff shaft design. The boiler feed pumpôs 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 recirculation 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 the standby motor driven feed pump under conditions like tripping of the running BFPs and/or discharge header pressure low etc.

Hydraulic coupling will be utilised to achieve speed control of motor driven pump. Provisions will be made for warm up to standby pump, if required. The turbine driven pumps will be connected with their drive turbines and the turbine exhausts will be connected to the main condenser.

5.2.5 Technical Data: Steam Turbine & Auxiliaries

The data indicated below is typical for 660 MW units:

Description	Unit	Parameter
Type	-	Tandem compounded
Number of cylinders	-	3 / 4
Type of governing	-	Digital Electro Hydraulic
Speed	RPM	3000

Rated output (continuous)	KW	660,000
Steam pressure before Emergency stop valve	$kg/cm^2(a)$	247
Steam temperature before emergency stop valve	Deg.C	565
Reheat steam inlet pressure	$kg/cm^2(a)$	45.57
Reheat steam temperature	Deg C	593
Steam flow required for 660 MW, 0% makeup, 32^0 cooling water temp.	t/hr	1953
Rated pressure at exhaust of LP turbine	ata	0.1
Rated quantity of circulating water to condenser	m^3/hr	74,000 (approx)
Temp rise of circulating water	Deg.C	10

Typical Heat and Mass flow Diagram is as per **Annexure – 5.1**

6.0 DESCRIPTION OF BALANCE OF PLANT

6.1 Mechanical System

6.1.1 Coal Handling System

6.1.1.1 Design Parameters

a) Domestic Coal will be received from Talcher and Mahanadi coal blocks, Odisha. The coal will be transported from coal mines to Ennore port by ship and from port to proposed site by pipe conveyor.

b) The coal handling plant (CHP) will be designed to operate throughout the year with blended coal (50% Domestic + 50% Imported) having average gross calorific value of 4221 kcal/kg. Coal quality parameters (indicative) are given in **Annexure – 6.1**.

c) Considering gross plant station heat rate of 2317 k.cal/kwh, the coal consumption for the plant works out at full load with GCV of blended coal (50% Domestic + 50% Imported) as 4221 Kcal/kg as:

Coal consumption in tonnes

i. Per hour = $\frac{1 \times 660 \times 2317}{4221}$

= 362.29 tonnes

ii. Per day = 8694.96 tonnes

iii. Per year at 85% PLF = 2.6976 million tonnes

Say 2.70 million tonnes per annum

Some coal may be lost in transit / windage loss & during storage etc. however, plant will not work on full load on 24 hours sustained load basis. Consequently, coal handling plant will be rated on the basis of requirement of about 8695 tonnes/day. The CHP system capacity will be taken as 1000 tph per stream (2x1000) TPH based on 1 shift operation.

It is proposed to use a mix of imported coal and indigenous (domestic) coal in the ratio of 70: 30 .The mixing of two types of coal will be carried out at ETPS premises (In Plant Coal Handling System) by reclaiming through Rotary Discharge Machines (paddle feeders) on to tunnel conveyor (one working & one standby) from two different stockpiles built by a common overhead travelling tripper near JNT-1. The mixing process will be completed during conveyance from JNT-1 to SG Bunkers through discharge points.

It is proposed to make two different stockpiles of coal as received from NCTPS through use of tripper conveyor BCN-8 whereas at the same time reclaim two types of coal by use of rotary discharge machines since two circuits are independent of each other. The material flow diagram at JNT-1 shall be referred.

It is proposed to make two separate stockpiles of imported coal and indigenous coal over the tunnel conveyor BCN-9 A/9B by use of a tripper conveyor BCN-8. The coal stockpiles shall have shed over it.

The stockpile for imported coal will be 375 m long, 15 m high and 44 m wide whereas the stockpile for indigenous coal will be180m long. The stacking of both types of coal will be made by the same Tripper Conveyor BCN-8 at 2000 TPH. The reclamation for imported coal will be done by rotary discharge machine 0 to 1000 TPH with variable flow type (1 working and 1 stand-by) on either conveyor BCN-9A/9B at 700 TPH. It is proposed to use a separate rotary

discharge machine (1 working and 1 stand-by) on tunnel conveyor BCN-9A/9B for indigenous coal to reclaim @ 300 TPH. So all together there shall be four (4) rotary discharge machines for imported coal and four (4) R.D.M. for indigenous coal i.e .two RDMs for each type of coal for each tunnel conveyor.

The indigenous coal will be reclaimed @ 300 TPH and the imported coal will be reclaimed @700 TPH on tunnel conveyor BCN-9A /9B so that total carrying capacity will be 1000 TPH at JNT-1 .The capacity of conveyor BCN-9A / 9B will be 1000TPH in reclamation. Thus it is expected during onward conveyance of reclaimed coal at 70% and 30% of imported and indigenous type respectively will eventually lead to proper mixing till it reaches the SG Bunkers.

The tunnel for conveyors BCN - 9A / 9B shall have diaphragms walls for protection against water seepage into the tunnel.

It is proposed to have capacity of all the eight (8) rotary discharge machines as 1000 TPH adjustable to 300 TPH for indigenous and 700 TPH for imported coal so that in case of unavailability of either type of coal the plant can be run by reclaiming 1000 TPH of the coal available. Also if required the mixture ratio can be varied to 50% each through variable drive of R.D.Machines.

It is proposed to have cover (shed) over coal stockpile for entire length which will ensure that dry coal is available during monsoon. The shed shall have water sprinkler system as well as fire protection provision to cover entire area within the shed.

The stockpiles of the two types of coal will have capacity for 7 (Seven) days when mixed at 50: 50 ratio.

The redundancy in tunnel conveyor and rotary discharge machines shall eliminate any provision of emergency reclaim hoppers with tunnel conveyor.

No activity (permanent civil construction) shall be allowed between the stockpile and the existing compound wall cum project boundary. Please refer the No Activity Zone as shown in the Plot Plan.

At present, the coal from North Chennai Thermal Power Station (NCTPS) yard is transported through Rail Wagons to ETPS. It is now proposed to transport the coal through a set of Belt Pipe Conveyors thereby eliminating spillage of coal, dependency on Railways and ensuring pollution free atmosphere.

The Coal Handling System at NCTPS has been designed to convey coal from Talcher Coal Mines of Mahanadi Coal Field, Orissa. The coal is shipped through Paradeep Port to Ennore Port. From Ennore Port, the coal is transported to NCTPS through 4000TPH capacity Open Trough Belt Conveyors External Coal Handling System of NCTPS. This Coal is transported to Junction Tower No. JNT-61 located inside NCTPS premises through series of belt conveyors.

The design capacity of existing NCTPS conveyors up to JNT-61 is 4000 TPH .Out of 4000 TPH coal, 2000 TPH has to be tapped for ETPS and the tap off point shall be BCN-52 conveyor discharge chute replacing the Sector Gate with flow divider (Diverter Gate) and suitable modification in the chute. The coal received here is uncrushed coal and coal size ranges from 150 mm to (-) 300 mm. The total requirement of coal for proposed 1 x 660 MW unit is about 8640 tonnes per day and is likely to increase to 17280 tonnes per day when the future unit is installed.

The proposed New Coal Transportation System for conveying coal from Crusher House at NCTPS to JNT-1 at ETPS will be through two (2) nos.

1000TPH capacity Pipe Conveyors NPC-104 A and NPC-104 B .The system will normally be operative for 4 hours per day with both streams and 8 hours per day with single stream at present for 660 MW unit .This system will work for 7.5 hours per day with both streams when the future unit of 660 MW is installed. In case of any shut down for routine maintenance work in any of the two pipe conveyors, when both the 660 MW units are in operation, , the other pipe conveyor will operate for 8 hours and 15 hours per day respectively. Normally, the pipe conveyors shall convey crushed coal, either imported or indigenous, to the stockpile through the tripper conveyor BCN-8.The feeding of crushed coal (mixture of imported and indigenous coal) to the bunkers shall be by reclamation from the stockpile only.

6.1.1.2 Coal Handling Plant Auxiliaries

Inline Magnetic Separator (for tramp metal separation), metal detector, Belt weighers, Suspended Electromagnets etc. have been incorporated at suitable locations. Sampling system at suitable location shall be provided.

For CHP Buildings viz. Transfer Towers / Crusher House, Manual Hoists/ Electric Operated Hoist are envisaged for handling cum maintenance purpose for equipment.

For Dust Control, Dry Fog Type Dust Suppression System is proposed for coal transfer points and also for Coal Bunkers for Unit-1 thruôUnit-3.For Coal Stockpiles, Plain Water Spray System via Sprinklers is envisaged.

For Crushers, each crusher shall be provided with Vibration isolation system & Vibration Monitoring System.

Vibration Isolation System shall also be provided for conveyor drives located at floors having elevations more than 15 m.

Tunnel Ventilation System using fresh dry filtered air supply type system is envisaged for ventilation of underground tunnels / underground portion of Transfer Towers,

Six (6) dozers (5W + 1 S) with Coal blade shall be provided for stockpile compaction / dosing/operations etc for Stockpile # 1/2/3/4/5/6.

PLC system shall be provided for operation & control of CHP. Similarly each ROM / Paddle feeder shall be provided with PLC system for its operation & control for working suitably in conjunction with its yard belt.

For main CHP Control Room, Split type window A.C. unit shall be provided in addition to ceiling fans. Exhaust fans for Battery Room, Electric House of Stacker cum Reclaimer Machine are envisaged. Unitary type Pressure Ventilation System is proposed for each MCC Room for above CHP.
Flow Diagram of Coal Handling Plant is given in **Annexure - 6.2.**

6.1.2 Ash Handling Plant

6.1.2.1 The ash handling system for will be designed to meet the following requirements:-

a)	Coal consumption at full load per hour	:	362.29TPH
b)	Ash content (for blended)	:	26%
c)	Ash generated	:	94.20 TPH
d)	Bottom ash generated 20%	:	18.84 TPH
e)	Coarse ash generated 10%	:	9.42 TPH
e)	Fly ash generated 80%	:	75.36 TPH

6.1.2.2 **System Description**

Ash formed due to combustion of pulverized coal in the steam generator will be collected as bottom ash in the bottom ash hopper, coarse ash in economizer, APH & duct hoppers and fly ash in ESP and stack hoppers.

Bottom ash will be collected in the bottom ash hopper and conveyed to ash slurry sump through scrapper feeder chain conveyors and jet pumps. The ash slurry conveyed to ash slurry sump will be further conveyed to ash disposal area by means of Ash Slurry Pumps.

Coarse ash will be automatically extracted and conveyed to the feeder ejectors located below each hopper. Necessary vacuum/momentum required for extracting the ash from the hoppers shall be created by the feeder ejectors. The coarse ash slurry thus produced shall be routed to coarse ash tank located in boiler area. The slurry collected in the coarse ash tank shall be conveyed to the proposed ash slurry sump through coarse ash slurry pumps.

Fly ash from ESP and stack hoppers will be extracted through vacuum and conveyed to fly ash silos through pressure conveying system. The fly ash will be further disposed in dry form through trucks or in wet form to ash disposal area through HCSD system.

6.1.2.3 Bottom Ash Handling System

As shown in the flow diagram, Bottom Ash (BA) will be collected continuously in a bottom ash hopper. BA hopper will be located directly below the bottom water wall header of boiler; and will have an effective storage capacity of 4 hours bottom ash generated while firing worst coal. To unload contents of the BA hopper, its feed gates will be opened by a remotely controlled/ operated four way solenoid valve. It will be ensured that full quantity of ash is removed during de-ashing cycle.

BA hopper will discharge BA into two scrapper feeder chain conveyors below the feed gate assembly. After the scrapper chain conveyor BA shall be led to clinker grinder through transition chute where ash shall be crushed to limit the ash size to 25 mm and from there led to a jet pump and subsequently to Ash slurry sump. Ash slurry sump shall convey the slurry to Ash disposal area.

Flow Diagram of Bottom & Eco Ash Handling System is given in **Annexure - 6.3.**

6.1.2.4 Coarse Ash Handling System

As shown in the flow diagram of coarse ash handling system, Coarse ash will be automatically extracted and conveyed to the feeder ejectors located below each coarse ash hopper. Necessary vacuum/momentum required for extracting the ash from the hoppers shall be created by the feeder ejectors. The coarse ash slurry thus produced shall be routed to coarse ash tank located

in boiler area of each unit. The slurry collected in the coarse ash tank of each unit will be conveyed to ash slurry sump through coarse ash slurry pumps.

The water required for feeder ejectors will be drawn from HP Water Pumps.

6.1.2.5 Fly Ash Handling System

As shown in the flow diagram of fly ash handling system, fly ash collected in various ESP and Stack hoppers will be extracted and conveyed to buffer hoppers automatically and sequentially by means of vacuum generated by mechanical exhauster and will be transported to fly ash silos by means of pressure conveying system. Adequately rated oil free rotary screw type Conveying Air Compressors will be provided to supply compressed air required for conveying fly ash from buffer hoppers to fly ash silos. One (1) buffer hopper will be provided for each vacuum stream. Adequately sized bag filters will be mounted on buffer hopper. Two (2) streams will be provided to evacuate fly ash from buffer hoppers to Fly ash silos.

Below each buffer hopper, two ash vessels will be provided to convey ash to fly ash silos.

Three (3) fly ash storage silo in RCC construction will be provided, having an effective storage capacity of storing fly ash generated in 24 hours with worst coal. The fly ash silo will be provided with four outlets; one for unloading ash in dry form into closed trucks through telescopic chute; one for unloading ash in conditioned form into open trucks through ash conditioner, one for unloading ash to mixing tanks for slurry disposal system (50% emergency wetting) and fourth outlet blind flanged for future use. The fly ash storage silo will be provided with adequately rated vent filter on silo roof.

Three (3) adequately rated mechanical exhausters will be provided (one working per stream and one common stand by) for extracting fly ash from various hoppers to buffer hoppers.

Two (2) adequately rated oil free screw compressors will be provided (one working and one standby) for supplying compressed air for conveying fly ash from buffer hoppers to fly ash silo.

Two (2) adequately rated low speed, oil free, lobe type fluidizing air blowers with heaters will be provided; one working with one common standby.

Two (2) adequately rated low speed, oil free, lobe type fluidizing air blowers with heaters will be provided for fly ash silo; one working and one standby. These blowers will be located on the operating floor of the silo.

Two (2) adequately rated oil free screw compressors with refrigerant type air driers and air receivers will be provided for supplying instrument air for various valves and cleaning of pulse jet type bag filters; One (1) working with one common standby.

Flow Diagram of Fly Ash Handling System ï ESP to Buffer Hopper Vessel is given in **Annexure - 6.4.**

Flow Diagram of Fly Ash Handling System ï Buffer Hopper to Silo is given in **Annexure - 6.5.**

6.1.2.6 Ash Disposal System

The bottom and coarse ash slurry will be collected in the common ash slurry sump. Ash slurry pumps with associated pipes and valves as shown in the flow scheme will be installed to dispose ash slurry of each unit to the ash disposal area. Ash water recovery system will be provided to recover the decanted water for re-use in ash disposal system.

Flow Diagram of Ash Water & Slurry System is given in **Annexure - 6.6.**

6.1.2.7 Fly Ash Slurry Disposal System

There will be a wet disposal system wherein ash from the hopper can be diverted to the Wetting unit and then to the air separator collector for tank for each unit. In the wetting unit slurry will be formed under the injection of HP water and from the separator, air will be suitably vented out and slurry will be drained. This wet mode FA disposal system shall have a capacity to handle 50% of the flyash generated. Concentration of fly ash slurry shall be about 30% while in cross-country transfer.

It is further to clarify that either the Silo Bye-Pass (Wet) mode will be operated OR Dry mode system up to remote Storage Silo shall be operated. Dry Mode will operate at 100% capacity while wet mode shall be designed for 50%.

There shall be four (4) series of slurry pumps (each series being multi stage) out of which two (2) series will be working, one (1) series will be working standby and one (1) series being maintenance standby. Each pump will be of identical duty conditions. At least in 1st stage shall have scoop controlled Fluid Couplings to vary the duty point within + 20% to - 40% of design duty point.

There shall be three (3) slurry pipes running cross country from slurry pump discharge to existing ash dump area (located at a distance of 6 km from the plant) out of which two (2) will be working and two (2) will remain as standby for two units. The main valve at slurry pump series discharge shall be motor operated knife gate valve shall be installed for all slurry line branch isolations including ash pond discharge points to connect the selected slurry pump discharge to the selected slurry pipe. The slurry pumps shall be capable of

delivering slurry to a dyke height (considering future raising of Dyke height) from existing grade level. All pipe/fittings & supports shall be suitable to take that load area at hydro-test condition.

Cross country slurry pipe pedestals, racks and supports are to be designed considering two slurry pipes, one sludge pipe and recovery water pipe under working condition and one slurry pipe, one sludge pipe and one recovery water pipe under hydro-test condition.

All pipe/fittings & supports shall be suitable to take that load at hydro test condition. The slurry pump discharge head shall be selected considering the soil (as per longitudinal section) along pipe route. The slurry piping shall be analysed for surge/ water hammer. Necessary protection measure shall be taken. However, backflow of slurry in pipe shall be prevented.

6.1.2.8 System Capacities

6.1.2.8.1 Bottom Ash Handling System

Bottom Ash handling system of each unit will be sized such that the bottom ash generated in 8 hours will be evacuated within 90 minutes.6.1.2.8.2 **Coarse ash Handling System**

Coarse ash collected in economizer, APH and duct hoppers in a shift of 8 hours will be evacuated in forty five (45) minutes.

6.1.2.8.3 Fly Ash Handling System

Ash collected in ESP and stack hoppers in a shift of eight (8) hours will be evacuated within 270 minutes. The capacity of the individual lines and grouping of various ash hoppers will be based on the standard vacuum pump capacity.

6.1.2.9 Ash Disposal Water System

The water required for ash disposal will be tapped from cooling tower blow down and routed to the ash water sump. The pumps required for ash disposal viz. HP water pumps, LP water Pumps, refractory cooling water pumps, seal water pump etc. will be provided.

6.1.2.10 Ash Dyke

The Ash pond area which is located about 6 km from the plant is an existing ash pond The slurry pump chain head shall be designed to enable discharge at farthest point in the dyke area up to ultimate dyke height (20 Meter, from present existing earth level).

The Ash slurry pipes will discharge into the ash pond and ash particles will settle inside the ash pond. An ash water recovery, collection and transfer system is to be provided near ash pond area. Water due to slurry disposal shall be tapped from the recovery collection system and taken to a treatment plant (inside plant boundary) for ash handling systems for reuse in ash water sump make up.

6.1.3 Plant Water System

6.1.3.1 Raw Water

Consumptive Water (Sea water) requirement of this unit will be made available at the forebay through a channel connected to intake well through underground pipeline. Stop log gate and coarse screen shall be provided at inlet and coarse screen at outlet of channel respectively.

Raw water (Sea water) analysis is enclosed in **Annexure – 6.7.**

6.1.3.2 **Water is required in a thermal power station for:**

a) Cooling Tower & Auxiliary cooling water system.
b) Water for bearing cooling and other auxiliary systems through closed loop circulation.
c) Boiler make-up.
d) Potable water for plant.
e) Services water for plant.
f) Fire fighting.
g) Ash handling.

6.1.3.3 **Composite Water Balance**

The composite water scheme is as per **Annexure – 6.8.**

The consumptive water requirement of 1 x 660 MW units is worked out as follows:

A.	**DM Water Requirement**	**Unit**	**Quantity**
-	Make-up water in power cycle 2200 x 1.5% = 33 cu.m/hr	cu.m/hr	33
-	Chemical feed	cu.m/hr	2.0
-	Stator generator	cu.m/hr	2.0
-	DM CW make-up	cu.m/hr	3.0
-	CPU regeneration	cu.m/hr	5
-	DM regeneration	cu.m/hr	2.5
	Sub total	cu.m/hr	47.5
-	Two (2) (1W+1S) MB Polisher of cap. 50 cu.m/hr with service cycle of 50 hrs. are installed.		

B.	**Permeate water requirement (RO-II)**		
-	Feed to DM plant including regeneration requirement	cu.m/hr	50
C.	**RO II module**		
-	Feed to RO II module	cu.m/hr	72
	RO-II module 2 X 100 % each with a capacity 50 cu.m/hr of permeate with recovery of 70%.		
D	**RO I permeate requirement**		
-	RO II feed	cu.m/hr	72
-	HVAC make-up	cu.m/hr	25
-	Service water/ Fire fighting	cu.m/hr	30
-	AHP seal water make-up	cu.m/hr	140
-	Potable water	cu.m/hr	10
-	FGD make-up	cu.m/hr	120
	Sub total (D)	cu.m/hr	390
E	**RO I module**		
	Feed to RO I module	cu.m/hr	1325
	RO-I module 3 X 50 % each with a capacity 200 cu.m/hr of permeate with recovery of 30 %.		
F	**DMF/ PSF**		
	Feed to DMF/PSF 3(2W+1S)100% DMF/PSF are installed	cu.m/hr	1369
G	**Clarifier**		

-	Feed to clarifier one(1) no. clarifier of cap. 1500 cu.m/hr output	cu.m/hr	1413
H	**Sea water required for PT plant**	cu.m/hr	1413
I	**CW make-up**	cu.m/hr	5700
J	**Total sea water requirement**	cu.m/hr	7113 (70cusecs)

6.1.3.4 **Pretreatment System**

Raw water will be pumped through 3 (2W + 1S) 50% pumps to clariflocculator. Ferric chloride/lime/polyelectrolyte will be dosed in the pre-treatment plant to accelerate coagulation process. The dosing system shall consist of dosing tanks, pumps with necessary piping arrangements. Sludge from the clarifiers will be taken into reject sump and will be fed to guard pond through sludge disposal pumps 2 (nos) (1W + 1S) 100%.

6.1.3.5 **Permeate Water System (RO-1)**

The clarified water from the outlet of clarifier will be stored in clarified water storage tank of capacity 2 X 2500cu.m. The clarified water will be passed through 3 sets of DMF, PSF and Cartridge filters (2W+1S) and further it will be fed to RO stage-I with the help of HP pumps 3nos.(2W+1S).

Permeate water will be stored in RO-I Permeate cum fire water tank, RO-I water will be further distributed to various areas of the plant through dedicated pump sets as follows:

a) Two (2) – (1W + 1S) 100% capacity & adequate head water pump sets to supply water to RO stage – II.

b) Two (2) - (1W + 1S) 100% capacity adequate head service water pumps to supply permeate water all over the plant building through a distribution network.

c) Two (2) ï (1W+1S) 100% pump sets of APH/ESP wash water

d) Two (2) ï (1W+1S) 100% pump sets of HVAC make-up.

e) Two (2) ï (1W+1S) 100% pump sets of Potable water.

f) Set of fire hydrent pumps/spray and Jokey pumps of adequate head and capacity will be provided for firefighting system.

g) Two (2) ï (1W+1S) 100% pump sets for AHP seal water make-up.

6.1.3.6 Permeate Water System (RO-II)

The RO-I permeate water will be fed through RO-II module and the permeate water will be stored in permeate water tank RO-II. The RO-II permeate water will be fed through Mixed bed Polisher 2(1W+1S) 50 cu.m/hr with the help of RO stage-II permeate water pumps 2(nos) (1W+1S).

6.1.3.7 Mixed Bed Polisher

The quality of water at the outlet of MB units at design flow rate shall be guaranteed as follows :

Conductivity at the outlet	:	not greater than 0.1µmho/cm @ 25^0C
pH	:	6.8-7.2
Total Silica (reactive + colloidal)	:	not to exceed 0.01 ppm as SiO_2
TOC	:	< 300 ppb

The MB outlet will be stored in two (2) ï 600 cum capacity DMWST after passing through Mixed bed polishing unit 2 nos. (1W+1S) 50 cu.m/hr.

DM water from DM water storage tanks will be transported to Condensate Storage Tank. (CST) - provided for the unit. DM water will be further used for stator cooling, hot-well make-up, chemical feed system & DMCW make up, etc For this, purpose, two (2) numbers 100 % capacity Hot well make up pumps, will be provided along with 2X100% capacity Boiler Fill pumps.

6.1.3.8 Chemical Feed System

Chemical feed system will be provided for dosing neutralizing amines such as hydrazine & ammonia in the condensate pump discharge / boiler feed suction line (low pressure feed system) to maintain the chemical concentration in the water / steam cycle within permissible limits for trouble-free operation of the plant along with oxygen dosing arrangement to control water chemistry regime.

The chemical feed system plant will be located at ground level between B - C bay.

a) **Hydrazine dosing system**

The dosing system of each unit will consist of:

i) An adequately sized solution preparation tank, and metering tank with accessories

ii) Two (2) 100 % capacity pump sets complete with suction filters, valves, specialities, and other accessories with pipe work, fittings etc as necessary. Normally, one pump set will run intermittently while the other pump set will be standby.

iii) One (1) no. hand pump for manual filling of the solution preparation tank.

b) **Ammonia dosing system**

i) An adequately sized solution preparation tank, and metering tank with accessories.

ii) Two (2) 100 % capacity pump sets complete with suction filters, valves, specialties, and other accessories with pipe work, fittings etc as necessary. Normally, one pump set will run intermittently while the other pump set will be standby.

iii) One (1) no. hand pump for manual filling of the solution preparation tank.

c) **Oxygen dosing system**

The Oxygen dosing system will consist of dedicated skids consisting of banks of oxygen cylinders for dosing at down stream of deaerator and CPU outlet line to heaters.

6.1.3.9 Condenser Cooling Water System

Closed cycle condenser cooling is envisaged with Natural Draught Cooling tower. Make-up water will be pumped to the circulating water (CW) sump through one (1) no. 100% capacity buried steel pipes, CW sump will be provided with 3 nos. (2W + 1S) CW pump sets for pumping water to condenser and will discharge back to Natural Draught Cooling Tower having cooling range of 9°C and maintaining a Cycle of Concentration of 1.3. The re-cooled water from cooling tower will be channeled to CW sump. Suitable arrangement for NaOCl dosing, to curb organic growth. The blow down will be taken to sea with the help of blow down pumps 3(nos) (2W+1S).

6.1.3.10 Bearing Cooling Water System

Demineralised water in a closed cycle is envisaged for all auxiliary equipment cooling of the power plant. This will be recooled by water, circulating on the secondary side of the plate heat exchangers.

a) 3 x 50% PHEs for TG and 2 x 100% for SG will be provided with two (2) nos (1W + 1S) ACW pumps to establish necessary pressure differential required for PHEs. These pumps will be located in CW pump house.

b) Demineralized water for make up to closed cycle BCW system will be conditioned to avoid corrosion of carbon steel materials. DM CW pump sets utilizing Demineralised water through PHEs will distribute to various coolers of unit auxiliaries under uniform pressure.

c) Makeup water to DMCW system will be made available through hot well make up pump of each unit.

6.1.3.11 Chemical Laboratory

A chemical laboratory will be provided for the day-to-day testing of fuel samples, water quality, steam quality, blow down etc.

6.1.3.12 Effluent Treatment System

The ETP shall handle various effluents generated continuously and intermittently in the power plant during normal operation. Effluent are treated as per the treatment schemes applicable to types of effluents.

The following are the primary effluents expected from various areas of power plant.

1. Oily waste:
   a) Transformer yard.
   b) Fuel Oil
      - HFO/ HSD decanting & storage area.
   c) Transformer yard.
   d) Switchyard area.

Oily waste mentioned from the above areas are collected in oily waste sump from there it will be passed through an Oil Water Seperator (OWS), in which the water will be recovered and shall be led to common collection sump along with oil less than 10 ppm. The separated oil will be collected in a drum and shall be suitably disposed off. The recovered water shall led to guard pond which shall be further used for CHP dust suppression.

2. Plant Drains.

   a) Clarifier waste.
   b) DMF & PSF waste.
   c) RO-I reject waste.
   d) RO-II reject waste.

Waste from the clarifier, DMF, PSF and RO-I shall be taken to reject sump and further it pumped to guard pond with the help of sludge disposal.

RO-II reject water shall be used for CHP & green belt development and excess will be fed directly to guard pond.

The reject water collected in the guard pond shall be discharge back to sea along with CT blow down.

3. CW blow down will be taken to sea with the help of blow down pumps Installed at CW forebay maintaining an ambient temperature

6.1.3.13 Condensate Polishing System

The condensate Polishing System will be designed to remove dissolved and suspended solids, corrosion products & other impurities from condensate during startup, normal operation and periods of condenser tube leakage to maintain the feed water and steam purity requirements of the boiler and turbine. The condensate polisher will be located in condensate feed water cycle between the condensate pump discharge and gland steam condenser.

Condensate polishing system of 2 X 50% capacity for each unit complete with all equipment including common external arrangements will be provided.

6.1.4 Compressed Air System

To cater for the plant requirements it is proposed to install required number of instrument air compressors and service air compressors of adequate capacity for the compressed air at 8.4 kg/cm^{2}g. The instrument air compressors will be oil free type, complete with HOC (Heat of Compression) type dryers and 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 is put into service. The instrument and service air headers will be interconnected in a manner that in case of emergency the service air be used for the plant instrument air.

Station service air requirement for normal cleaning purposes, atomizing air for warm-up guns and ignitors, motive power for burner drive mechanism and emergency air for air drive motors of air pre-heaters will be met from service air compressors. It is proposed to install these compressors in a separate building.

6.1.5 Ventilation and Air Conditioning Systems

Right environment for operation and maintenance of the power plant units as well as for proper functioning of the plant equipment, controls and accessories, is an important aspect, which will be given due consideration in the proposed ventilation and air-conditioning system.

6.1.5.1 Air-conditioning (AC) System

Various control rooms of the plant units having a group of sophisticated and precision control and protection devices, as well as computer rooms will be air-conditioned to have controlled environment for proper functioning of the equipment and operating personnel comfort. Various types of air-conditioning system will be provided (viz.) centralized system, package air-conditioning plants & split / window AC. The following areas will be air-conditioned:-

a) Control rooms, control equipment room / UPS room, computer room, SWAS panel room, excitation room, AVR room, relay panel room etc.

The above will be air-conditioned through a central and / or distributed chilled water system. It will consist of 2x100% capacity chilled water circulation pumps, condenser cooling water pumps, cooling towers (as needed), hermitically or semi-hermitic type chillers, cabinet type air handling units with centrifugal limit load type backward blowers with 3-way mixing valves & balancing valves etc. Cooled air will be supplied to the various areas by rectangular GI ducts and return air will be taken back through return air grills provided above the false ceiling.

b) Electrostatic precipitator control rooms.

c) Coal handling plant control room.

d) DM plant control room

e) Switchyard control room

f) Ash handling control room

g) VFD control room

h) Office area in Administrative building

The above facilities will be air-conditioned through dedicated window / split ACûs.

6.1.5.2 **Ventilation System**

a) Adequate ventilation system is considered as detailed below for the power plant machine room building, ESP control building, and other areas such as DG set room, air compressor room, A/C plant room, DM plant building, Battery rooms and various pump houses such as fuel oil pump house, DM water pump house etc to achieve:

i) Dust free comfortable working environment.

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

b) **Power plant machine room building**

Supply air system will be provided with evaporative cooling plant by a set of air washers of 2x50% capacity with cooling water coils (water supplied from an independent source). The system will include 2x50% capacity supply air fans, inlet louvers, bird screens, viscous filters, cooling coils, recirculating water system with 2x100% circulating water pump sets, 2 bank spray nozzles & flooding nozzles, eliminator plates and masonry sump tank etc for supply and distribution of cooled air at various locations. The exhaust system will consist of roof extractors (for machine room), axial flow wall mounted exhaust fans with GI ducts, dampers, grills and other accessories as necessary. The system will be designed to maintain close to ambient dry bulb temperature inside the building.

Various rooms of the power plant building such as cable spreader room, switchgear room etc will be ventilated by means of pressurized supply and exhaust fans suitably located.

c) **ESP control building**

For ventilation of this building, ambient air will be drawn through unitary air filtration unit comprising fresh air intake louver, dry type filter and cooling coils conveying water [supplied from an independent source] and supplied to the space by means of centrifugal fans through ducting, grilles, etc.

The supplied air will be exhausted through wall mounted gravity operated dampers to maintain higher over pressure (measurable) in mm water column to reduce dust and fine sand.

d) **Other buildings**

Other areas such as DG set room, air compressor room A/C plant room etc will be ventilated by means of dry system comprising axial flow fan, dry filter wherever required, cowls, ducting etc. Inside dry bulb temperature is maintained lower than ambient by about 5°C. Fire dampers will be provided on ductwork routed through electrical installation areas. Ventilation system of respective areas will be suitably interlocked with fire detection system to minimize spreading of fire.

e) The normal design criteria for the design of the ventilation system is to consider at least 10 air changes per hour for an effective volume of space 4 m from the floor level. In areas such as the machine room of the plant building TG bay, etc. where the volumes handled are very large, the system is designed by providing limit load type backward curved centrifugal DIDW blowers / fans (mounted on suitable heavy duty vibration isolators) inside an acoustically insulated room with dedicated ductwork so that all the heat generated is removed and a temperature lower than the ambient is maintained. The system envisages to maintain a temperature of 5°C lower than the ambient temperature for providing comfortable working atmosphere.

6.1.6 Fire Protection System

For protection against fire, all yard equipment and plant equipment will be protected by a combination of hydrant system, automatic sprinkler spray system (emulsifier system), fixed foam system for oil handling areas, automatic high velocity and medium velocity sprinkler spray system, auto-modular inert gas based system for control rooms apart from portable and

mobile fire extinguishers located at strategic areas of plant buildings and adequate Passive Fire Protection measures. The systems will be designed as per the recommendations of NFPA or approved equivalents in accordance with the Tariff Advisory Committee of the Insurance Association of India stipulations.

(a) In view of vulnerability to fire and its importance in the running of the power station, effective measures will be taken to tackle fire in the susceptible areas such as cable galleries, fuel oil handling areas, coal handling plant areas including transfer points, crusher houses and tunnels, etc.

(b) For containment of fire and preventing it from spreading in cable galleries, unit wise fire barriers with self-closing fire doors will be provided. In addition, all cable entries / openings in the cable galleries, tunnels, floors will be sealed with non-inflammable / fire resistant sealing materials to prevent fire propagation for at least three (3) hour. Fire protection cable coating compound over cables at switchgear entry points, power station building entry points and trays shall be provided to prevent damage from fire for at least thirty (30) minutes.

Adequate separating distances will be maintained between different process blocks and hazardous equipment. To prevent fire from spreading through ventilation & air conditioning ducts, dampers with auto closing arrangements will be provided at appropriate locations. FRLS power and control cables will be used.

Fire water pumps are installed in the filtered water pump house. In the filtered water storage tank water will be stored as dedicated dead storage for meeting firewater requirement in exigencies. The details of system are as follows:-

a) Three (3) nos. of horizontal centrifugal fire water pumps with drive motors and all other accessories as specified. The quantity and capacity indicated in the specification is only tentative and bidder to work out capacity and quantity based on TAC guidelines.

b) Three (3) nos. of horizontal centrifugal fire water pumps with compression ignition diesel engines along with all accessories required for automatic starting of diesel engine, including fuel oil system, lub oil system etc. The quantity and capacity indicated in the specification is only tentative and bidder to work out capacity and quantity based on TAC guidelines.

c) One No. RCC fire water storage tank having two compartments. Effective capacity of each compartment shall be decided based on TAC requirements. However the effective capacity of each compartment, in any case, shall ne be less than 3000 cum with all accessories as specified.

d) One (1) no. of hydro-pneumatic tank along with electric motor driven jockey pumps (1w + 1s) and compressors (1w + 1s) with drive motors. Jockey pumps & compressors shall be provided with all regular accessories.

e) Two (2) nos. of horizontal centrifugal type booster pumps (One motor driven and the other diesel engine driven) for hydrant service on higher floors of power house and boiler building.

f) Automatic high velocity sprinkler spray protection system will be provided for Generator transformers, Unit auxiliary transformers, Station service transformers, and Turbine oil storage tanks.

g) Automatic medium velocity sprinkler protection system actuated by heat detectors strategically located will be provided for cable galleries and coal handling areas such as coal conveyors, transfer points, crusher houses etc.

The ventilation system provided in cable galleries will be so interlocked with the fire alarm system that in the event of a fire, the ventilation system would be automatically switched-off.

Automatic medium velocity sprinklers will be used for protection of burner zone of each of the boilers.

h) Fuel oil tanks in the fuel oil farm area will be provided with spray water system as well as fixed foam mechanical system to extinguish accidental fires in tanks as well as outside in the dyke.

Water for foam system will be drawn from the plant hydrant system. Adequate numbers of hydrant points will be distributed near the oil tank farm area. Fire hoses fitted with couplings and nozzles will be located suitably at the oil station and kept in hose boxes.

i) Automatic inert gas based flooding type-extinguishing system will be provided for unit control room, areas independently apart from the provision of detection and fire alarm system in that area.

j) Suitable fire detection system will also be provided at cable vault rooms, unit control rooms and other MCC rooms etc to detect outbreak of fire at an early stage.

k) Adequate number of fire hydrant points will be distributed throughout the plant building, service building, coal handling plant, ash handling plant and other areas along with fire hoses fitted with couplings and nozzles and kept in the hose boxes.

In addition to the above facilities, adequate number of manual call points, as well as portable and mobile (wheel mounted) fire extinguishers of soda acid type, foam type, chemical type, and carbon-dioxide type will be provided at suitable locations throughout the plant area to meet NFPA code as well as Tariff Advisory Committee stipulations. These extinguishers may be used during the early stages of fire to prevent from spreading.

6.1.7 Coal Mill Reject Handling System

The Mill Rejects Handling System will be provided for collection of the rejects from the mills of each boiler unit and to convey to storage bunker. Each mill will be provided with collection and transportation equipment comprising of one no. Pyrite Hopper with water spray arrangement plate valves at inlet and outlet and a transport vessel connected to storage bunker.

6.1.8 Fuel Oil System

a) The fuel oil will be transported to the plant site by road tankers; and unloading pumps shall be used for unloading of oil and storing it in tanks. Before unloading the heavy fuel oil, it shall be heated by electric heaters in the road tankers as considered necessary to make it flowable. Fuel oil decanting pumphouse is also included in scope of bidder.

b) The heavy fuel oil shall be heated in the storage tanks to maintain a suitable temperature by supplying steam through floor coil heaters. The steam shall be provided from auxiliary Boiler. Heavy fuel oil tanks shall also be provided with suction heaters with steam as the heating source to heat the oil before sending it to pressuring units.

c) There shall be pipe nozzle provisions on the storage tanks in regard to heavy fuel oil recirculation from the boiler front. An adequately sized non-return valve shall be provided in each line connecting the fuel oil unloading headers and unloading pump suction header.

d) The heavy fuel oil will be pumped from the storage tanks to boilers front by pressuring units. The heavy fuel oil return from pressurizing units and burner headers will be brought back to respective storage tanks. Similarly, the High speed diesel oil will be pumped from HSD storage tank to boiler; and to hot gas generator by pressurizing units.

e) An oil water separator (to separate oil to the extent of max. 10 ppm oil left in the water) shall be provided close to the dyke area and unloading oil headers area to receive oil from the drain trenches, dyke area and unloading area. Oil from the oil water separator shall be returned back to the heavy fuel oil tanks by the help of two (2) 100 percent capacity oil recovery pumps. The water after suitable treatment shall be discharged to the surface drain.

f) All the heavy fuel oil lines, oil pumps and strainers shall be electric traced.

g) One (1) ï 200 NB (min.) heavy fuel oil unloading manifold complete with eight (8) stand pipes with flexible hoses of 8 M length [each provided with universal type couplings, isolation valves and matching pieces as required for connecting to road tankers isolation valves and caps as required for connecting to road tankers. Tapping points on the oil header shall be suitably located.

h) Heavy fuel oil road tankers shall be fitted with electric heating coils so that oil may be heated to reduce its viscosity. When the oil temperature

in tanker rises to about 50°C, oil shall be drained to the oil-unloading header. When the oil unloading header and the piping at the unloading pump suction is filled up with oil and steady oil supply is ensured, the unloading pumps shall be started.

i) One (1) 200 mm HSD unloading manifold completed with eight (8) stand pipes with flexible hoses of 8 M length each shall be provided with universal type couplings and matching pieces as required for connecting to road tankers. Tapping points on the oil header shall be suitably located. This header shall be inter-connected with rail tanker unloading header with necessary isolating valves etc.

6.1.8.1 **Oil Unloading Pump sets**

a) Two (2) - 150 cum per hour capacity or fowarding pump capacity, whichever is higher, 4 kg/cm2(g) discharge pressure, direct AC driven horizontal twin screw type heavy fuel oil unloading pump sets complete with AC electric motor drives and all other accessories as necessary. The pumps shall be steam jacketed.

b) Two (2) ï 50 cum per hour capacity, 4 kg/cm2(g) discharge pressure, direct AC driven horizontal twin screw type LDO/ HSD unloading pump sets complete with drive motor with accessories for unloading road tankers.

6.1.8.2 **Tanks & other Equipment**

a) One (1) ï 2000 KL capacity vertical cylindrical heavy fuel oil storage tanks with accessories located in the oil tank dyke area. The HFO tanks shall be insulated.

b) One (1) ï 1000 KL capacity vertical cylindrical High speed diesel oil storage tank with accessories located in the oil tank dyke area.

c) One (1) ï 500 KL (Min) capacity vertical day oil HFO tank

d) One (1) ï 100 (Min) capacity vertical day oil LDO tank.

e) The heavy fuel oil storage tanks shall be complete with floor coil heaters and fuel oil suction heaters and other accessories as necessary.

f) One (1) oil water separator along with 2 x 100 % pumps as mentioned in this specification for the fuel oil unloading and storage area shall be provided with all needed accessories.

g) One (1) drain oil tank of 10 M3 cap with 2 x 100% capacity pumpsets.

h) One (1) condensate tank of suitable capacity for main tank area.

i) Two (2) nos. drain oil pumps, each of capacity 5 M3/hr

j) Two (2) nos water pumps, each of capacity 30 M3/hr.

k) Two (2) Nos. sump pump set, each of capacity 30 M3/hr complete with all accessories of drive and mounting in FO Unloading pump house.

l) One (1) nos. pressure reducing and de-superheating station for reducing steam pressure to 4 kg/cm2.

m) One (1) drain oil tank of 2 M3 cap with 2 x 100% capacity pumpsets

6.1.9 Cranes and Hoists

In order to facilitate the handling of various equipment during erection and maintenance of the power plant, a number of cranes and hoists will be required at various locations.

Two (2) electrically operated traveling type (EOT) cranes each of 125 tonnes main hook capacity & 40 tonnes auxiliary hook capacity with lifting beam will be used for handling heavy equipment in the machine room / turbine building.

The generator stator will weigh about 440 tonnes, to avoid extra load on the turbine building columns and foundations, the generator stator will be lifted by jacking / cribbing process. For other heavy pieces to be lifted such as generator rotor, LP turbine rotor etc. The EOT cranes will be utilized.

Conventional and special type of cranes for maintenance of few important equipment of SG and TG packages, such as FD/PA/ID fans, pulverizes, air heaters, condenser water box, ESP transformer rectifier sets etc, will be provided. For various pump houses clarification plant, Filtration plant, De-mineralizing plant, Fuel oil pump house, Intake pump house, under slung cranes of adequate capacity and pendant operated cranes with electrical hoists will be provided. For circulating water pump house, a pendant operated 40/5 tonne capacity electric traveling crane will be provided.

Maintenance cranes / handling devices of suitable capacities will be considered for all other areas such as compressor house, hydrogen generating plant, coal handling plant transfer points etc. Monorails for lifting heavy motors and other equipment within the powerhouse not covered by EOT crane such as miscellaneous pumps, heat exchangers etc will also be provided. Suitable rails embedded on floor for dragging the horizontal feed water heaters to have the approach under EOT cranes will also be provided.

6.1.10 Hydrogen Generation Plant

A Hydrogen generation plant having two (2) ï 10 cum/hr capacity streams will be provided in the plant to meet the generator cooling requirements of all the units. Hydrogen gas produced from the plant will be compressed in bottles for transport to the respective unitôs hydrogen bottle racks in the machine room.

The normal hydrogen gas requirement for one unit will be about 25 Nm^3/day. Adequate nos. of hydrogen cylinders, each of capacity 7 Nm^3, will be provided for hydrogen gas storage, which will be used for normal supply of gas for makeup and filling up of generators.

Carbon dioxide is required for purging the hydrogen and air during shut down and start up respectively. Adequate Nos of CO_2 cylinders of 8.85 Nm^3 capacity will be stored at site. The oxygen gas produced as by product from the hydrogen generation plant will be released to atmosphere.

6.1.11 Elevators

One Passenger-cum-goods elevators of 3000 kg capacity for boiler connecting various boiler floors, 680 kg capacity passenger lifts / elevators for the TG hall building and one no passenger lift / elevator of 680 kg capacity each in service and administration building will be provided. Stack elevator of capacity about 400 kg rack and pinion type vertical lift complete with all accessories will be provided for stack.

6.1.12 Mechanical Work Shop

A mechanical workshop for regular maintenance, work will be provided with necessary equipment.

6.2 ELECTRICAL SYSTEMS & EQUIPMENT

6.2.1 Basic Design Concepts

The electrical system will be designed to ensure high reliability of operation and high availability of the power plant through use of proven equipment conforming to International Standards, Codes and Practices and adequate level of redundancy. The electrical systems & equipments will be specified to comply with the guide lines issued / notified by Indian Statutory Authorities viz. the Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), Indian Electricity (IE) Rules & Act, National Electrical Code (NEC), etc.

6.2 2 Generator

The 660 MW turbo generator will be directly-coupled to the steam turbine and will be a two-pole type alternator having direct hydrogen-cooled stator core & rotor and demineralised water-cooled & vacuum pressure impregnated stator winding. The generator excitation system will be brushless type with a permanent magnet generator (PMG) or Static Excitation System.

To maintain and control the generator terminal voltage under various operating conditions and external faults, a digital multi-channel automatic voltage regulator (DAVR) will be provided.

Other auxiliary systems such as seal-oil system, hydrogen / stator cooling water system, etc. will be provided, as standard.

The turbo-generator will be designed for continuous operation at VWO output of the connected steam-turbine, at rated voltage and speed.

Generator capacity	660 MW
No of Phases	3
Generator voltage	18-27 KV
Frequency	50 HZ
Permissible continuous variation in terminal voltage	± 5%
Permissible continuous frequency variation	-5% to +3%
RPM	3000
Power factor	0.85
No load short circuit ratio (saturated)	> 0.48
Permissible unbalanced loading: • Continuous, p.u. • I_2^2t, sec	 >0.08 >8
Class of insulating material	F
Permissible max. Temperature rise	As per class B
Efficiency at rated full load	>98%

6.2.3 Generator Neutral Earthing

In line with prevalent practice, high impedance earthing will be adopted for the generator winding neutral. The earthing system will be designed keeping in view the overall system capacitance to earth and the capacitive current flow during a phase to earth fault.

High impedance earthing system will comprise, a single phase distribution transformer with its primary winding connected between generator neutral and earth. The secondary of the distribution transformer will be loaded by a resistor.

6.2.4 Generator Bus Duct

The terminals of the generator would be connected to the respective generator transformer (GT) LV on the line side and to star formation &neutral earthing cubicle through Isolated Phase Bus Ducts (IPBD) of adequate short circuit withstand capability with suitably rated tap-offs to the unit transformers and Surge Protection & Voltage Transformer(SPVT) cubicle. The short circuit rating of the main run will correspond to higher of the fault current contributions from generator or transformer side while the tap-offs and delta connection will be designed for sum of the fault contributions from generator and GT side. The fault withstand time rating of the busduct will correspond with the de-excitation time of the generator. The bus duct will be natural air cooled, pressurized type and will run partly indoor and partly outdoor.

The bus duct installation would be complete with generator line side and neutral side current transformers and line side voltage transformers required for protection, metering, voltage regulation and automatic turbine run-up system. Surge protection equipments consisting of lightning surge arrestors & capacitors with suitable discharge characteristics to suit the generator basic insulation level shall be provided.

6.2.5 Generator Circuit Breaker (GCB)

A circuit breaker at generator voltage level will be provided between generator line terminals and the generator step up transformer LV terminals, in order to provide faster clearance of GT LV side faults including GT internal faults. The GCB when kept open ,will be used to derive unit start up power from the EHV grid system by back charging of GT and will also serve as the

synchronizing breaker after the unit runs upto rated speed & voltage. For external faults which can be cleared by the GT EHV breaker opening, the GCB will be kept closed to enable feeding of house loads by the generator. .Similarly, for generator internal faults or for faults of BTG system, the GCB only can be opened and the auxiliaries can be run during coasting period by keeping the GT EHV breaker closed.

The circuit-breaker shall use SF6-gas as insulating and interrupting medium. For current interruption the self-blast interrupting principle shall be applied.

6.2.6 Evacuation of Power

400 kV substation comprising indoor gas insulated switchgear (GIS) and outdoor air insulated switchyard shall be provided for evacuation of nett power generated at the plant to the grid.

A Single Line Diagram is as per **Annexure – 6.9**

6.2.6.1 400 kV GIS substation

The GIS shall have double bus configuration and will comprise following bays/ circuits.

a) One (1) Generator Transformer bay having 2 breakers
b) Four (4) Line bays
c) One (1) Bus Coupler bay
d) Two (2) Bus VTs
e) One (1) Bus Reactor bay
f) One (1) Spare bay (equipped for future GT)
g) Space for one (1) future bay

The switchgear shall be capable of future extension on both sides, without requiring a complete shutdown.

The salient requirements of 400kV GIS are given in Table ï 6.6.1. For each of the outgoing lines, precision energy metering would be provided. The metering panel would be located near the VTs such that the length of the metering cable is kept to a minimum to reduce errors in energy recording. The metering panel would have active & reactive energy meters of 0.2 accuracy class.

Table –6.2.6.1 Technical Parameters for 400 kV GIS

Sl. No.	Parameters	Ratings of 400 kV GIS
1.0	Technical Data for GIS	
1.1	Design Voltage Levels	
(a)	Nominal Voltage	400 kV
(b)	Highest system voltage	420 kV
(c)	Basic impulse level	1425 kV peak.
(d)	Switching Impulse Voltage	1050 kV peak
(e)	Fault level	63 kA rms for 1 sec.
1.2	Minimum Clearances	
(a)	Phase to Phase	4000 mm
(b)	Phase to Earth	3500 mm
(c)	Section Clearance	6500 mm
(d)	Minimum height of live point above finished grade	8000 mm
1.3	Minimum creepage distance	31 mm / kV

6.2.7 **Auxiliary Power supply**

For the 1 x 660 MW unit, two(2) x 50% capacity steam turbine driven boiler feed pumps(TDBFPs) and one(1)x 50% capacity electric motor driven boiler feed pump (MDBFP) are envisaged. Further, the cooling tower is proposed to be natural draft type.

During start up of the unit as also during outage of one of the TDBFPs, the MDBFP will be running on full load. As per CERC norms, the auxiliary power requirement of a thermal power plant having electric motor driven BFPs and natural draft cooling towers is to be considered as 8.5% of the generated power i.e. about 56 MW (70 MVA at an average power factor of 0.8) for the 1x660MW plant.

Keeping in view the GCB configuration, the plant auxiliary power consumption may be distributed between two 100% rated transformers designated as Unit transformers(UTs) connected to the generator busduct between GCB and GT . Apart from catering to 100% of plant load, the transformers will have to be sized to permit DOL starting of the highest rated plant motor, which would be the 50% capacity MDBFP motor having an expected rating around 17.5MW.

For increased reliability and availability of auxiliary power system, two sets of 11kV switchgears will be provided with interconnecting tie feeders between the two sets of switchgears.

Various auxiliaries would be supplied at the following nominal voltages depending upon their ratings and functions:

a) 11000 V ± 10%, 50 Hz ± 5%, 3 phase, 3 wire, solidly grounded AC supply for motors rated above 1500 kW.

b) 3300 V ± 10%, 50 Hz ± 5%, 3 phase, 3 wire, solidly grounded AC supply for motors rated above 160 kW and upto 1500 kW..

c) 415 V, ± 10%, 50 Hz ± 5%, 3 phase, 3 wire, solidly grounded AC supply for motors rated 160 kW and below and other L.V. services.

d) 230 V, ± 10%, 50 Hz ± 5%, 1 phase AC supply for lighting, space heating of motors and panels, single phase motors, etc.

e) 220 V, ungrounded DC supply for protection, control and indication

6.2.8 Construction Power Supply

Construction power to the tune of 2.5 to 5 MW is expected to be required during various phases of construction

Temporary construction supply at 11 kV AC will be made available at three different locations. These locations are the Power House, External Coal Handling Plant and at the Intake Sea Water System area.

6.2.9 Generator Transformers

The GT for 660 MW unit will comprise a bank of three (3) single phase oil immersed outdoor type transformers with class 'A' insulation and OFAF cooled rating of 275 MVA each. The transformers will also have ONAF and ONAN ratings of approximately 80% and 60% respectively of the OFAF rating. The low voltage side of the transformers will have isolated phase bus duct connection to the generator through the GCB, while the high voltage side will be connected to the 400 kV GIS by means of ACSR overhead conductors. Voltage ratio for the GTs will be generator rated kV/ 420/ã3. Each transformer will be provided with off- circuit taps on HV winding which will have graded insulation. The impedance of the transformer at normal tap will be chosen such as to be compatible with the switchyard and bus duct fault levels and full load regulation. The noise level of the transformer will be restricted to 85 dB in line with NEMA-TR1 standard. The HV windings of the three transformers will be connected in star with neutral brought out for solid earthing. The

secondary windings will be connected in delta. The vector group is proposed as Ynd1.

Each transformer will be provided with a lightning surge arrester on each phase. One (1) single phase transformer will be provided as standby/spare and will be suitably placed in the transformer yard.

Technical particulars of the generator transformers are as given below.

GT capacities	825 MVA, (Bank of 3 x 1 phase 275 MVA)
Ratio	(18-27)/420/ã3 kV
Frequency	50 Hz
No of windings	Two
Cooling	ONAN/ONAF/OFAF
Vector group	Ynd1
Z	15% (indicative)
OCTC	(+)5% to (-) 5% in steps of 2.5%

6.2.10 Standby Transformer (ST)

Provision of a standby startup transformer has also been envisaged to cater for the eventuality that normally GT cannot be placed and energized till completion of condenser cooling water pipeline work which takes a long time. The stand by transformer is proposed to be connected to 230kV grid supply through suitable rated EHV cables up to incoming gantry and shall be equipped with necessary EHV circuit breaker, dis-connector, earth switch& surge arrestors apart from control, metering& protection panels.

Salient technical particulars of ST are as given below

ST capacity	50 MVA(Indicative)

Voltage Ratio	230/11 kV
Vector group	YNyn0
Cooling	ONAN/ONAF
OLTC	(-) 12.5% to -7.5% in steps of 1.25%
Quantity	One

6.2.11 Unit Transformers (UT) and Auxiliary Transformers (AT)

Two unit transformers would be provided for each unit to feed unit loads. For 660 MW unit each UT will be rated for 80/100 MVA, 18-27 kV/11 kV, 3-Phase, 50 Hz, OLTC with +12.5% to -7.5 % in steps of 1.25%. The unit transformers would be ONAN / ONAF cooled with a vector group of Dyn11. The LV neutral would be earthed through a resistance so as to limit the earth fault current to about 300A.

A number of auxiliary transformers would be provided to feed the main plant & balance of plant (BOP)auxiliary loads such as CHP, AHP, raw water intake system, etc. The ATs will be rated for 11/3.3 kV, 3 phase, 50 Hz, OLTC with ONAN / ONAF cooling.

6.2.12 Service Transformers

Required number of service transformers would be provided to feed power to LV loads depending on service/ location of the loads. These transformers would be rated at not more than 2.5 MVA, dry type, 11 / 0.433 kV and 3.3 kV / 0.433 kV as required. They would supply power to the 415 V auxiliaries of the unit, Cooling water system, Water treatment plant, Ash handling system, Coal handling system etc., the neutrals of these transformers would be solidly

earthed. The transformers would be provided with + / - 5% off-circuit taps in steps of 2.5% on the HV side.

6.2.13 **HV Switchgear**

The voltage level of HV Switchgear will be 11 kV and 3.3 kV. The HV switch gear would comprise draw-out type vacuum circuit breakers housed in indoor, metal-clad cubicles and would cater to all motors rated above 160 kW up to 1500 kW (3.3 kV) and motors rated above 1500 kW (11 kV). The switch gears would be equipped with control, protection, interlock and metering features as required.

Separate 3.3 kV switchgears would also be provided for the sea water intake system, coal and ash handling systems and external coal handling system. Fast auto change over feature would be provided between two sources of supply.

6.2.14 **LV Switchgear**

415V, 3 phase, 3 wire/4 wire power for LV auxiliaries would be obtained from 3.3 kV/ 0.433 kV and 11 kV/0.433 kV service transformers. The 415V system would be a solidly earthed system. For maximum reliability, duplicate power supplies with auto changeover facility would be provided for all power and motor control centres. The 415V switch gear would be of metal enclosed design with a minimum symmetrical short circuit rating of 50 kA for 1 sec. All power and motor control centres would be compartmentalised and would be of double front execution. They would be of fully draw-out design with all circuit components mounted on a withdrawable sheet metal chassis. The circuit breakers would be of air break/MCCB/MPCB type. Motor starting would be direct-on-line. MCCBs/MPCBs shall be used instead of HRC fuses for all LV switchgear.

All LV motors would be controlled by air break, electro-magnetic type contactors provided with ambient temperature compensated, time lagged, hand reset type thermal overload relays, having adjustable setting with built-in single phase preventer and MCCBs for protection against short circuits.

6.2.15 Motors

HV & LV motors shall be energy efficient level IE 2 type as per IS 12615: 2011, F class insulated with maximum temperature rise within class Bôlimits, having IP-55 enclosure protection (with canopy for outdoor motors), designed for direct-on-line starting with as low starting current as possible. Starting current of motors will be designed so as not to pose a problem in starting or cause drop out of running auxiliaries.

The motor rating shall be arrived at considering 15% margin over the duty point input or 10% over the maximum demand of the driven equipment, whichever is higher, considering highest system frequency.

All motors shall be either totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or Closed air circuit air cooled (CACA) type. However, motors rated 3000KW or above can be Closed air circuit water cooled (CACW). CW motors can be screen protected drip proof (SPDP) type.

HV motors shall also be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 min. commencing from hot condition.

Motor torque characteristic will be such as to ensure smooth and rapid starting and acceleration of the driven equipment.

Motors rated above 30 kW will be provided with space heaters to be switched on when the motor is idle.

6.2.16 **Metering**

Microprocessor based multi-function 0.2s class energy meters with communication facilities, non-volatile memory, MMI and self-diagnostic facilities shall be provided for all, generators, HV side of GT, STs &UTs in line with notified CEA standards.

Incomers, tie feeders, outgoing transformer& motor feeders on all 11 kV and 3.3 kV station and unit switchgears will be equipped with multifunctional microprocessor based feeder management devices having protection and metering facilities along with ports for interface with plant DDC MIS system.

All other feeders will be provided with conventional indicating and metering instruments.

6.2.17 **Protection**

Electrical protection proposed for the various equipments will be generally as per guidelines indicated in Table-6.17 below:-

TABLE- 6.2.17 : PROTECTION GUIDELINES

	Generator/GT/UT Unit Protection		Two (2) sets of numerical protection relays providing 100% redundancy, continuous, self monitoring and metering and event/fault recording & communication facilities & comprising the following protections:	
			i.	Differential (87G)
			ii.	Stator Inter turn fault (87 GI)

			iii.	95-100% stator earth fault protection (64G)
			iv.	Loss of excitation (40G1 & 40 G2)
			v.	Negative phase sequence current (46)
			vi.	Reverse power (32)
			vii.	Low forward power protection (37)
			viii.	Rotor earth fault (64R)
			ix.	Over-voltage (59)
			x.	Under voltage (27)
			xi.	Generator pole slipping (90)
			xii.	Under/over frequency (81)
			xiii.	Voltage balance (60) VT fuse Fail monitoring
			xiv.	Thermal Overload (49)
			xv.	Backup impedance (21G)
			xvi.	Excitation system faults
			xvii.	Stator winding temp monitoring& protection
			xviii.	Dead machine protection (96) against accidental energization
			xix.	GCB failure
			xx.	Generator bus duct earth fault with GCB open
	Generator Transformer		i.	Differential (87 T)
			ii.	GT HV overhead connection differential
			iii.	HV standby earth-fault (51 N)
			iv.	Over fluxing (99)
			v.	Buchholz (63)

			vi.	Winding temp. monitoring & protection (49)
			vii.	Oil temp monitoring & protection (49Q)
			viii.	Pressure relief device operation
			ix.	Low oil flow
			x.	400kV breaker pole discrepancy
			xi.	400V kV breaker failure
			xii.	400kV breaker trip coil supervision.
	Unit Transformers/Stand by transformer		i.	Differential (87UT)
			ii.	HV phase over current (50/51)
			iii.	LV phase over current (51)
			iv.	LV standby earth-fault (51N)
			v	Over fluxing (99)
			vi	Transformer Buchholz (63)
			vii	OLTC Surge protection
			viii	Winding temp. monitoring & protection.
			ix.	Oil temp. monitoring & protection
			x	Pressure relief device operation
	Auxiliary Transformers		i.	HV phase Overcurrent (50/51)and earth-fault
			ii.	LV phase overcurrent and earth fault (51/51N)
			iii.	Buchholz (63)
			iv.	Winding/oil temperature high
			v.	Pressure relief device operation

			vi.	Busbar differential protection (87 BB)
	11KV/3.3 kV Switchgear (incomer & tie feeders)			
			i.	Inverse/definite time overcurrent (51) and earth-fault (51N)
			ii.	Instantaneous short circuit (50)
			iii.	Under voltage (27)
	11 kV and 3.3 kV Motors and breaker controlled 415 volts motors	:		Multifunction Numerical protection comprising -
			i.	Short circuit (50)
			ii.	Differential protection (for motor rated above 1000 kW) (87)
			iii.	Thermal overload (49)
			iv.	Phase over-current instantaneous & definite time lag (50 / 51)
			v.	Instantaneous earth-fault (50 N)
			vi.	Unbalance loading/Single phasing (46)
			vii.	Locked rotor (50 L/R)
			viii.	Under-voltage (27)
	415 volt switchgear		i.	Phase Over current and Earth fault (50 / 51)
	Contactor controlled 415 volts motors below 90 KW		i.	Thermal overload (with built-in or separate SPP feature)
			ii.	Fuses for short circuit protection
	220 V DC System		i.	Earth fault (Alarm only)
			ii.	Under voltage (27)

			iii.	Short circuit protection (by fuse)

6.2.18 **Electrical Control Philosophy**

A centralized control room will be provided at the operating floor of steam turbine-generator building in which controls / control panels for the steam generators, steam turbine generators, GT, GCB and UTs and distributed digital control system (DDCMIS) equipment will be housed. In addition, auxiliary system electrical relay panels and fire alarm control panel will also be provided in this control room.

The control & synchronizing of generator, generator excitation system, GT, UTs and auxiliary transformers, 11/3.3/0.415kV incomers, ties and main outgoing circuit breakers to the auxiliaries will be also achieved from the keyboard of DDCMIS Operator Control Stations in the Main Plant Control room.

6.2.19 **Switchyard control philosophy**

The 400kV switching equipment comprising circuit breakers and associated isolators would be controlled from the main control room. The control, measurement, indication and annunciation functions would be performed by microprocessor based Supervisory Control and Data Acquisition System (SCADA). All the associated RTUs would be located in the switchyard control room and operator interface would be located in the main control room. For increased reliability, a back-up control system with control panel comprising miniature switches for breaker control, minimum number of indicating instruments and facia type window annunciators are proposed. This hard wired backup control panel would be located in common switchyard control room.

The SCADA system consists of PLC and CRT based colour graphic operator interface. Further, the system would be connected to a printer to generate periodical logs, malfunction and sequence of event report in the event of a forced outage. The operator interface would also have features to help operator with operating instructions when a complicated switching operation is to be performed.

Interconnection between SCADA and DCS would be made through soft link in order to acquire the plant parameters in the control room.

All control operations would be performed at operator interface. The entire switching scheme in whole or in part is displayable on the screen with all the associated parameters indicated near the relevant circuits. The annunciations would also be displayed on the CRT. Control of GT bay breaker would be permitted only from the respective control room and control of other switchyard bays would be permitted at all three control rooms through selection scheme.

OPGW optical fibres shall be used for the further power line communication. Fibre optic approach cable shall be armoured fibre optic cable required to connect overhead Fibre optic cable (OPGW) between the final in live splice enclosure on the gantry/ tower forming the termination of Distribution Panel (FODP) installed within the building.

All switchyard protection panels would be of either simplex type or duplex and would be located in switchyard Relay room.

Separate control rooms for the ash / coal handling / EPS / Compressors / DM & WT plants, water intake and other offsite systems will be provided.

However, the output trip of each the relays group shall trip the respective circuit breaker through both trip coils I & II.

6.2.20 Earthing System

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

a) System Earthing: The system neutral earthing at different voltage levels has been described below:

Neutrals of 400 KV and 415 V systems will be solidly earthed. Generator neutrals will be earthed with resistance loaded distribution transformer, 11 KV and 3.3 kV system neutral will be earthed through high resistance limiting the earth-fault current to about 300 amps.

b) Equipment Earthing: The equipment body earthing will be adopted to provide protection to personnel from potentials caused by earth fault currents and lightning discharges. A suitable earth grid will be provided for earthing of equipment and structures maintaining the step and touch potentials within safe limits. An earth mat will be laid in and around the main power station. These mats will be buried at a suitable depth below ground and balance of plant areas and provided with earth electrodes at suitable spacing. The earth mats of main plant & BOP will be interconnected by two or more interconnections. All metallic parts of equipment supposed to be at earth potential will be connected to the earthing mat including building structures, substation towers, plant rail road tracks, perimeter fencing etc. The earthing system will comply with IEEE 80, IEEE 665 and IS: 3043.

6.2.21 Lightning Protection System

Lightning protection system in accordance with IS: 2309 will be installed for protection of tall buildings / structures and equipment against lightning discharge. This will be achieved by providing lightning conductors on tall structures, stacks, power house building, flood light towers etc. and connecting these with ground electrodes.

6.2.22 Emergency Power Supply

To enable the unit to shutdown safely during complete A.C supply failure in the station, certain important plant auxiliaries would be provided with a reliable A.C power supply through a separate source. For this purpose, Two (2) 415 V quick starting diesel generator set with automatic mains failure (AMF) would be provided. The rating of the DG sets would be approximately 1500 kVA to 1750 KVA for 660 MW unit.

The diesel generator would feed emergency 415V switchgear, to which all the essential loads such as the A.C emergency bearing lube oil and seal oil pumps, turning gear motor, battery chargers, emergency lights, elevators, fire alarms and essential instrument power supply feeders would be connected. When the station A.C supply is healthy, the emergency switchgear would be fed from the unit service switch gear. When the station A.C supply fails, the DG set would start automatically and would feed the loads connected to the emergency switchgear. When the normal A.C supply is restored, these essential loads would be manually changed over to the normal power supply.

6.2.23 Cables

Main factors considered for selection of power cable sizes will be as follows:-

- System short circuit current withstand time of 0.16 seconds for circuit breaker controlled feeders

- Derating factors due to higher ambient temperature and grouping of cables.

- Continuous current rating.

- Voltage drop during motor starting(from associated switchgear upto motor terminals) and under continuous operation will be limited to 10% for motor starting and 2.5 % for continuous operation.

Standardization of the cable size to avoid too many sizes.

The following types of cables would be used:

For 11 kV and 3.3 kV system: 11 kV and 3.3 kV unearthed grade respectively, stranded aluminium conductor, cross linked polyethylene (XLPE) insulated, extruded black PVC inner sheathed, galvanised steel wire armoured for three core or aluminium wire armoured for single core and overall FRLS extruded black PVC sheathed cables conforming to IS : 7098.

For medium and low voltage system: Power cables of 1100V grade, stranded aluminium conductor, XLPE insulated, extruded black PVC inner sheathed galvanised steel wire armoured for three cores or aluminium wire armoured for single core and overall FRLS extruded black PVC sheathed cables conforming to IS : 7098.

For control applications: 1100 V grade annealed high conductivity stranded copper conductor, PVC insulated, PVC inner sheathed armoured and FRLS extruded black PVC outer sheathed cables conforming to IS: 1554.

Cables would be laid in fabricated steel ladder type or perforated type cable trays in the station and other auxiliary buildings and upper elevations of the steam generator area. Between buildings, the cables would be routed on pipe/ cable racks. Cables in outdoor switchyard would be laid in galvanised cable trays in built-up trenches of suitable size.

6.2.24 **DC System**

Separate 2 x 100 %, 220 V DC rated batteries with associated float cum boost chargers would be provided to cater emergency loads of main plant, coal handling system, ash handling system, 400 kV GIS, and sea water intake system.

2 x 100 %, 48 V DC rated batteries shall be provided for catering DC loads and SCADA in 400 kV GIS, OPGW System.

The batteries would be of stationary Nickel Cadmium Pocket plate type complete with battery racks, porcelain Insulators, inter-cell and inter-tier connectors.

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

i) **Battery**

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

* Control and monitoring of the entire power plant.

* Alarm and annunciation of plant condition under emergency. The duty of the battery is strenuous particularly during the first one minute after

occurrence of emergency. During this first minute, the battery is required to supply.

* Tripping power for all major circuit breakers simultaneously.
* Starting of jacking oil pump.
* Starting of emergency lube oil pump.
* Starting of barring gear.
* Seal oil pump
* Plant emergency DC illumination system
* Indication, alarm and annunciation

After the lapse of the first minute, the demand on the battery will go down considerably for the next 59 minutes during which the battery will only serve all other loads mentioned above except that for the circuit breakers. The duty cycle of the battery in this one-hour during the emergency condition determines the battery capacity. The storage battery sets at its rated discharge rate having suitable number of cells for 220 volts nominal rating would be required. The ampere-hour capacity of each battery set will also be determined by ageing factor, type of battery etc.

ii) **Battery charger**

Battery chargers of suitable capacity will be provided with trickle charging and boost charging for each of the aforesaid battery sets. The chargers would be of silicon rectifier type with automatic voltage control and load limiting features. Completely automatic and self-regulating type of battery charger

comprises of independent float cum boost chargers. The float charger will be capable of floating the battery and at the same time supply the continuous DC load. The boost charger will be capable of quick charging the battery and have a capacity to restore a fully discharged battery to a state of fully charged condition in 8 hours and at the same time supply the continuous DC load. 25% spare margin over the maximum charging rate should be considered.

iii) **DC Distribution Board**

One main DC distribution board for each of the battery sets will be provided with DC sub-distribution boards as required. The DC distribution board will have two incomer DC switch-fuses and required number of outgoing switch fuse units selected to have a continuous current rating of not less than 125% of the nominal load current.

6.2.25 **Communication System**

For effective communication in the plant, public address system, private automatic branch exchange system (EPABX), radio paging system and Walkie talkie system with the features described below would be provided:

a) **Public Address System**

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

b) **EPABX System**

This system would have adequate number of push button type handset stations, central automatic telephone exchange, etc. The handsets in the control room would be provided with priority service facility to enable them to have immediate access to any handset even if it is already engaged.

c) **Wireless System**

The system shall be capable of being coupled with the EPABX system such that any wireless set can be contacted from any of the EPABX intercom extensions and any wireless set can be used to contact any of the EPABX ï intercom number/pager through the EPABX. It shall also be possible to make a page call on the paging system from the wireless sets.

Necessary number of walkie talkie sets would be provided.

6.2.26 **Illumination System**

Suitable illumination necessary to facilitate normal operation and maintenance activities and to ensure safety of working personnel would be provided. This would be achieved by artificial lighting.

For yard illumination, LED plasma type flood lights would be installed at suitable locations to provide the requisite level of illumination. LED plasma type flood lighting fixed on High mast would be provided for outdoor switchyard. Pole-mounted high pressure sodium vapour fixtures would be used for approach roads.

Generally, fluorescent fixtures would be used for indoor control room illumination. LED medium Bay/well glass fixtures would be used for the

turbine building. For steam generator area and pump houses, LED medium Bay / Well glass fixture would be provided.

The illumination levels at different places would be maintained as per accepted norms. The lighting system would be designed to ensure uniform illumination.

Lighting distribution boards (LDBs) having in built, dry type, 415 V/ 433 V lighting transformers with off circuit tap changer of ï 5% to +5% insteps of 2.5% with MCCB incomer and outgoing MCBs would be provided at various locations. Lighting panels fitted with suitably rated ELCB in incomer and single phase outgoing MCB feeders would be located downstream of these LDBs.

In addition to normal illumination, emergency AC and emergency DC lighting schemes will also be provided in the power station complex. About 20 percent of the total lighting fixtures will be fed from normal cum emergency AC supply and about 10 percent of the fixtures will be fed normally from AC supply; and upon failure of AC, these will be fed from 220V DC through inverters. Remote DC lighting for isolated buildings in areas where 220V DC is not available, will be from self contained battery with charger units, flood lamp fixtures will be energized upon loss of normal AC supply to such isolated areas. The incoming supply to these transformers will be connected by 11kV overhead lines / cables.

6.2.27 Electrical Testing Laboratory Equipment

An electrical lab will be provided for the day-to-day maintenance /testing and calibration of the electrical equipment of the power plant. Suggested list of electrical testing laboratory equipment is given Table-3.

ELECTRICAL TESTING LABORATORY EQUIPMENT

Sr. No.	Equipment	Quantity (Nos.)
1	Portable Digital 5 kV Insulation Tester	2
2	HV Decade Resistance Box	1
3	Portable HV ac/dc Test Set	1
4	Automatic Capacitance and Tan-delta Test Set	1
5	Portable Transformer Oil Breakdown Test Set	1
6	Portable Karl Fischer Test Set	1
7	3-Phase Portable Transformer turns Ratio & Vector Group meter	1
8	Portable Digital DC Resistance Meter	1
9	Portable High Current Digital Micro-ohm Meter	1
10	Portable Primary & Secondary Current Injection Test Kit	1
11	Portable Automatic Earth Tester	1
12	Portable Three-phase Universal Meter/Relay Test Set	1
13	Precision Digital Meter	1
14	Portable Digital Frequency Meter	1
15	Portable Digital Sound Level Meter	1
16	Portable Digital Tachometer	1
17	Cable Fault Locator	1
18	Portable testing kit for Calibration of Digital Energy Meter	1
19	Portable Hand-held SF6 Gas Leakage Detector	1
20	Portable Hand-held Hydrogen Gas Leakage Detector	1

Sr. No.	Equipment	Quantity (Nos.)
21	Portable Vacuum Tester	1
22	Portable Light Intensity Meter	1
23	Portable Circuit-Breaker Motion Analyzer	1
24	Interfacial Tension Meter for Transformer Oil	1
25	Portable Hand-held Thermal-Imaging Camera	1
26	Portable High-voltage/Live-Line Tester	1
27	Portable Hand-held Tong- Tester	3
28	Portable Phase Sequence/ Continuity Indicator	3
29	DC Leakage Analyser	1
30	Standard Tool Kit	2
31	Portable HV Discharge Rod/Earthing Equipment	2
32	Hot Stick	2
33	Portable H_2 purity meter	1
34	Storage type Digital Oscilloscope	1
35	Vibration meter cum-analyser	1
36	Platinum RTD Digital Temperature Indicator	1

6.3 CONTROL & INSTRUMENTATION

6.3.1 Design Philosophy

The Control and Instrumentation will be through state of art microprocessor based Functionally Distributed Digital Control, monitoring and information system (DDCMIS) for SG,TG, Station C&I and its auxiliaries covering the total functional requirements of modulating control, sequence control, interlocks & protection, monitoring, alarm, data logging, fault analysis, performance calculation & optimization, maintenance scheduling & machine monitoring & analysis etc.

PLC based/Relay based control System shall be provided for monitoring, alarm, Control & operations of BOP Packages.

The design of the control system and related equipment will adhere to the principle of ñfail safeò operation at all system levels (i.e.) the loss of signal, loss of power or failure of any component should not cause a hazardous condition; and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.

The DDCMIS will be an integrated control and data acquisition system for providing control and monitoring of power plant equipment from a central control room for boiler, Turbine and its auxiliaries, regenerative cycle, etc. Based on Turbine supplier's proprietary control system, a separate DCS based Control System for DEH / EHGC and BMS/FSSS (in TMR mode) can be accepted. Similarly separate proprietary Emergency Trip Circuit (in TMR mode) for Turbine trip & protection can be accepted, if recommended by Turbine supplier.

The control room operator will be provided with color-graphic displays of the power plant with sufficient details to allow proper control and monitoring of the plant functions including electrical systems like Generator, Switchyard, transformers and motors protection.

Also suitable redundant gateways/soft links (with necessary protocols) and time synchronization including all required software & hardware will be provided for all PLC/microprocessor-based BOP/off site packages for interfacing with DDCMIS.

The DDCMIS system will have facility for sequential start-up of entire main Power plant and accordingly as per process requirement, different group controls / sub-group controls shall get operational commands and in turn individual drive will get start/stop or open/close command, whereas Functional group control hierarchy will be devised for the major plant equipment and their auxiliaries to allow operator to select a lower level of certain system or equipment during trial runs, testing etc. The system will have facility for control, operation, monitoring start/stop etc. from operator workstations and large video screens (LVS). Limited hardwired backup for safe shut down of plant has been envisaged, the LVS should ensure operation of the plant in case of total failure of all operator stations. H/W annunciation system is not required at Central unit control room and LVS shall take care of Annunciation.

The MMI between the operator and main plant will be through Operating Stations and larger video screens.

6.3.2 BTG Control System

Plant BTG control & instrumentation provide a simple effective and fail-safe means for reliable and efficient operation of the plant under dynamic conditions and for attainment of maximum station availability. To achieve this objective, control and monitoring facilities will be designed so that operation of the Boiler,

Turbine, and Generator along with their major auxiliaries would be accomplished from a CCR (Central Control Room). From the CCR, operators would start-up, load, unload, release for remote dispatch, shutdown and monitor the steam generator, turbine and other auxiliaries of the plant. All field instruments like transmitters for flow, pressure level and differential pressure are of smart type.

For systematic and sequential start-up shutdown and safe operation of boiler, Burner Management System (BMS), furnace protection system and turbine protection system etc will be implemented in SIL-3 certified microprocessor based DDCIMS/DCS.

All the control packages of Turbine-Generator, Boiler and their auxiliaries will be preferably of the integral part of DDCMIS and from same family of hardware. In case microprocessor/DCS based TG and SG controls (DCS) will be from separate vendors then the same will be hooked-up to DDCMIS through necessary soft wired interfacing units for monitoring and hardwire interface for protection interlocking, trip and SOE functions.

A System Configuration Diagram is as per **Annexure - 6.10**.

6.3.2.1 **Multi tasking of Controllers**:

The distributed digital control system is required to address the following tasks:

i) Open loop control (binary)

ii) Closed loop control (analog modulating)

iii) Plant monitoring/signal acquisition and processing

The microprocessor-based system will have the capability to perform the above tasks either separately or in a combined form. As multi-loop, multi-function controllers have a number of control functions and will be in completely

redundant mode, security of control functions including those of protection would be maintained even with the loss of the active controller as well as the functions could be taken over by standby controller.

6.3.2.2 Non-redundant Signal Acquisition and Processing Modules for Monitoring Functions

Primary instruments will be Non-redundant for monitoring functions. Dual redundant for non critical and interlock and triple redundant for critical control trip functions will be provided. Keeping this segregation of field instruments, the system philosophy could adopt separate controllers for monitoring tasks or data acquisition tasks. Monitoring task being less critical compared to control tasks; the controllers for monitoring will be -redundant. Alternatively, as the hardwares for monitoring functions are generally similar /identical to those for the control tasks, it is possible to combine the monitoring portions with control tasks. However, in view of the general practice of control engineering, separate non-redundant controllers can be provided for this function.

6.3.3 Controller Task Allocations

The system will have overall control tasks having appropriate redundancy built in for all the system functions both at processor and peripheral level. No failure of any single peripheral or processor will lead to any system function being lost. For the system with multi-loop, multi-function controllers, functional distribution will be adopted and the system will be geographically centralized.

Each group will consist of dedicated microprocessor based controllers including redundancy and dedicated input and output processing cards. The redundant multifunctional controllers will be in a hot back up mode. The back-up controller will take over the function of the failed processor within one loop cycle time or less than 50 msec.

High degree of distribution to ensure high availability. Each CPU will have a minimum working memory (non-volatile) of at least 2 GB and 16 MB RAM.

The processor of the CPU will have a minimum speed of 1 GHz. All memories will be non-volatile. No battery backed-up memories will be allowed. The CPU processing cycle time will be max. 50 ms. For turbine controls, this cycle time will be max. 20 ms. System will be capable of handling 15000 I/Os. Each controller will have sufficient spare capacity of at least 40% to meet modification/extension of the system. Multi loop, Multi-function controllers will incorporate the corresponding interlocks (open loop control tasks of the system). Interlock and modulating controls will be assigned to the controllers in such a way that failure of any controller does not lead to shut down of the entire unit.

For the interlock protection and sequential control tasks, the loop timing from input status change to output contact actuation does not exceed 50 msecs for protective functions.

6.3.4 Redundancy in I/O

The input and output cards of the system are very high in number. It is necessary to identify the level of redundancy and sharing of the signals between the I/O cards so that failure of a card does not have a large impact on the plant.

I/Os will be segregated in a way that the failure of a sub-system will not affect a large area. With this in view, Hot standby 100% redundancy shall be provided for all input/output cards where inputs/outputs are used for CLCS and OLCS. No redundancy at I/O card level is required which are executing purely data acquisition/monitoring functions. However, any I/O card shall not acquire more than 16 inputs or outputs per AI/AO/RTD/TC card except 32 channels for DI/DO card.

Wherever redundant I/O modules/cards are used, both (1:1 redundant) input or output modules shall execute the designated functions parallely. Following restrictions will be imposed with respect to sharing of signals:

- Not more than one critical device like BFP, ID fan etc will be driven from one input / output card.

- Where transmitters/devices will be independent, the corresponding signals will be independently routed through separate input cards associated with each controller, so that even if one input module fails, the signal will be available from the other input module.

6.3.5 Automation

6.3.5.1 Automation System Structure

The automation system will be structured to provide three (3) modes of operation:

a) Automated coordinated master control mode requiring no operator intervention except at the start. In this mode, operator will be informed of various steps being performed. In case any missing criteria occur, this will be informed to the operator.

b) System guided mode in which operator starts / stops the major sequences based on operator guides. The complete sequencing upto command executions for each of the major sequences are built into the system through programs.

c) A manual step-by-step mode in which the operator can directly intervene at the drive level is provided. Operator guides are provided by the system under such mode also. The operator guides presented take into account the mode of start- up and give appropriate messages. The system is also responsible for switching in the auto controls without operator intervention in the auto mode. For shut-down, the system is capable of handling automatically decrease of load of an auxiliary failure and shut

down the equipment completely from load decrease to all auxiliary equipment stop.

6.3.5.2 Automation System Philosophy

The system envisaged will be based on modern network orientation and will be totally flexible in its adaptability to process structures, to the safety and availability requirements of main and auxiliary plants and the communication needs of the user. System will have Server less configuration (i.e DDCMIS system architecture/configuration will be as per Annexure - 6.10.

The control system will have the following functions:

1) Signal Conditioning (I/O System)
2) Control functions
3) Diagnostic feature
4) Man machine interface
5) System communication

6.3.5.2.1 Signal Conditioning

Microprocessor based Opto / Galvanic channel to channel isolation will be provided in order to filter out the process noise and other electrical disturbances of the signal, protect the system against high voltage transients, and convert the analog/binary signal to digital form. The I/O sub system, therefore, will convert the process signal to a form that the controllers will use it to perform computational tasks. All I/O cards shall have status LED indication. All binary Outputs channels will be individually fused. All I/O cards shall have elf diagnostic features also.

6.3.5.2.2 **Control Functions**

All processing and computational tasks will be completed in the controllers using standard & special software modules and procedures. A programme library with built-in macros will be used for constantly recurring functions. The controllers will be built around high performance (32/64 bit) microprocessor and will have a multi tasking operating system.

6.3.5.2.3 **Diagnostic Features**

System will have detailed diagnostic features:

i) Graphical interface for diagnosis and troubleshooting
ii) Online function plans (logic diagnostics)
iii) Field bus diagnostics
iv) System bus diagnostics
v) Controller diagnostics
vi) Redundancy failures
vii) Module faults

6.3.5.2.4 **Man-Machine Interface**

Communication will take place between operator, process and the system. Communication will consist of observations, operations and plant controls, system configurations, diagnostics and data archiving, reports and logs, X-Y plots, bar charts etc. The LED based OWS systems will have the advantage of not only reporting the plant station and variable values but also the process mimics.

6.3.5.2.5 **System Architecture for Main Plant Control System**

Utility operating stations will be connected directly on Proprietary Data Highway at one end and High speed Ethernet TCP/IP based data highway on other end. Other LED based OWSs will be connected directly on Ethernet, TCP/IP bus.
Following Operating work stations & Engineering work stations are envisaged for control & operation of main power plant from Unified Distributed Digital Control, Monitoring and Information System (DDCMIS) (Refer System Configuration Drawing, # 114-01-0100).

6.3.5.2.5.1 **Operating Work stations:-**

i. 6 nos of Operating Stations (one no. of boiler control system like BMS (FSSS), two nos., for Boiler auxiliaries, two nos. for Turbine auxiliaries and one no. for electrical system & BOP) shall be connected directly on Proprietary/ preferably Industrial Data Highway/higher level network of DDCMIS with 2 LJP A4 B/W and 1 LJP A4 Color.

ii. 2 nos. of Operating Stations for Turbine Control System (governing system), like DEHGC, ATRS, ATT, ETS from the respective system shall be connected directly on Proprietary/ preferably Industrial Data Highway/higher level network of DDCMIS with 1 LJP A4 B/W & 1 LJP A4 Color.

iii. 1 no. of Operating Station for TSE for Unit incharge (shift supervisor) with 1 LJP A4 Color.

iv. 1 no. of Operating Station for Unit incharge (shift supervisor) - Printer not required.

v. 1 no. of Operating Station for Station incharge (in the cadre of Executive Engineer) with 1 LJP A4 B/W.

vi. 1 no. of Operating Station at CE's room, 1 no. of Operating Station at Factory manager, and 1 no. of Operating Station at Electrical System incharge room shall be provided, operation/ command shall not be executed from these three consoles to start/stop the equipments. Software and hardware security lock shall be provided not to use these controls for any operations. 1 No. A3 sized Scanner copier cum printer in CE's Chamber/Office and 1 LJP A4 Color with each Operating station shall be provided.

vii. 1 no of Operating Station for performance calculations & optimization for Unit incharge (shift supervisor) shall be provided with 1 LJP A4 B/W.

viii 1 no. of Operating Station for performance calculations & optimization at the Office of Executive Engineer/Efficiency shall be provided with 1 LJP A3 B/W.

ix. 1 no. of Operating Station for water chemistry parameters connected with performance calculations & optimization at the SWAS / Chemical Express lab shall be provided with 1 LJP A4 B/W.

x. 1 no. of Operating Station for Chemical Dosing system with 1 LJP A4 B/W at SWAS Room.

xi. 1 nos. of common Operating Stations at common DDCMIS network in Aux. Boiler control Room with A4 sized B/W LJP.

xii. 1 no. of Operating Work Station for EDMS with 1 LJP A3/A4 B/W at Switchgear Room.

xiii. 1 no. of Operating Work Station for IEMS with 1 LJP A3/A4 B/W at Switchgear Room.

6.3.5.2.5.2 **Engineering Work stations:-**

i. 2 nos. of Engineering Stations for system maintenance Engineer for unit DDC MIS system with 2 LJP A4 Color, 1 No. A3 sized Scanner, copier cum printer, 1 LJP Heavy Duty Industrial grade A3 Color.

ii. 1 no. Engineering Station for system maintenance Engineer for Turbine Control System with 1 LJP Heavy Duty Industrial grade A3 Color.

iii. 1 no. of Engineering Station for Sequential Event Recording with 1 DMP.

iv. 1 no. of Engineering Station with each OPC server for OPC connections with DDC MIS from other systems with 1 LJP A4 B/W each.

v. 2 nos. Engineering Stations for maintaining redundant Historian server with 2 DMP.

vi. 1 no Engineering Station for Turbine Stress Evaluation (if this is not integral of DDCMIS, TSE shall be connected with DDC MIS through OPC) with 1 LJP A4 Color.

vii. 1 no. Engineering Station for performance calculation & optimization with 1 LJP Heavy Duty Industrial grade A3 Color.

viii. 1 no. Engineering Station for each MIS server with 1 LJP A4 B/W each.

ix. Common Redundant OPC server for OPC connections with units DDCMIS from other common systems with Work station & 1 LJP A4 B/W.

x. 1 nos. Engineering Station for system maintenance Engineer for common DDCMIS system with 1 no. LJP A4 Color.

xi. 1 no. OEWS for EDMS as per Vol IV along with A3 Laser Jet printer .

xii. 1 no. OWS for IEMS as per Vol IV along with A3 Laser Jet printer

ñThe local operating stations 8 nos. namely at locations like FOPH, ESP, Zero M Elev. Turbine building, Boiler - A Elevation, CWPH, DM Plant, Ash handling Control room, and SWAS / Chemical Express lab shall be provided with 24ò LED color screen/PC, and a physical node with minimum configuration connected to DDC MIS on redundant connection to show the status/ conditions of various process parameters/equipments in process mimics, trends, logs etc with real time data.

Operation/command shall not be executed from these local operatorsô consoles to start/stop the equipments. Software and Hardware security lock shall be provided for not using these consoles for any operations. Specification of these local stations shall be same as for plant operating stations.

All the locations availing the operating stations namely FOPH, CWPH, Boiler A elevation, Turbine 0 meter, ESP, Ash handling Control room and SWAS / Chemical Express lab, DM Plant shall be air conditioned.

All operating stations connected on redundant data highway shall be interchangeable and operation of the plant shall be possible from Engg.

station after security check. All operator stations shall have full access to the entire plant data base and shall have identical functionalities. The system shall have full data base redundancy. The data base shall be independent and shall reside separate from the operator stations.

The operating / work stations will have 24 inch LED screens with high resolution (1920 x 1080 pixels), minimum 500 GB Hard Disk memory and 4 GB RAM. The response time will not be more than 1 to 2 seconds. All keyboards/key pads will be totally enclosed type.

6.3.5.2.5.3 **Computer Room / Shift In charge Room / Maintenance laboratory Room**

i) **Computer Room**

The computer room will be located adjacent to the unit control room to provide easy access for control room personnel. This room will contain all Distributed Digital Control, Monitoring and Information System (DDCMIS) related equipment necessary for configuring and maintaining the power block management information and balance of plant systems such as Engineering & Diagnostic workstations, WorkStation for Sequence of Event Recording, Workstations for Alarm, MIS and Historian features, Engg Workstation for performance calculation/efficiency calculations & Optimisation, Workstation for TSC, Workstation for TSI (in case TSI is from separate supplier as part of TG integral system), Workstation and A4 sized colored Laser jet printer for HART management system, Workstation and A4 color Laser jet printer for OCAMMMS/Vibration Monitoring system.

ii) **Shift In-charge Room**

One (1) Workstation for Shift Supervisor, which will be for each unit.

iii) **Maintenance Laboratory Room**

One (1) Workstation and A3/A4 sized B/W Digital Laser jet printer cum Copier for LAB instruments calibration and report generation shall be provided in C&I Maintenance Laboratory lab room.

Displays such as Overview of plant, Graphics (Plant Schematics),Line display of data and plant status including electrical parameters, Bar graphs, Trends (Trend point and trend group), Alarms, Open & close loop schemes including instrument face plate, Various logs & reports, Display of messages representing commands and process steps during process upset including help message, Simulations & optimisations, Diagnostic display, Tuning Panel will be provided.

Total Eight (8) nos. Large Video Screens, each with 80/84 inches diagonal (size depending upon availability at the time of supply), graphic controller and other hardware will be provided.

The Large Screen Graphics Wall for each unit in will primarily be used for:

(a) **4 nos. LVS** (size 84/80 inch) for plant operations and monitoring in CCR.

(b) **2 nos. LVS** (size 84/80 inch) interfaced with Turbine Control System (DEHGC) in CCR.

(c) **1 no. LVS** (size 84/80 inch) at station head/Chief Engineer room

(d) **1 no. LVS** (size 84/80 inch) for switchyard operations & monitoring in switchyard control building.

The system will be interfaced on 100 Mbps/1 Gbps LAN (or higher depending upon the latest system / bus speed available). Also there should be a possibility of integrating the RGB, video available in the control room on a later date by

providing some extra input cards. The system should be possible to show the mirror images of eight (8) operator work stations running on windows XP or latest and connected using the Ethernet with the display controller. The system will also interface with video signals to receive & project pictures from SCADA. Remote unit for switching between video signal & MMI signal, selecting the video signal channel will be provided.

The rear projection modules must be based on Single Chip DLP Rear Projection technology having LED light source . The average Life of LED light source will be 60, 000 hours. Each of the rear projection module will be 70ỏ80ò diagonal as minimum with resolution of 1400 x 1050 pixels and offers 16.7 million colours. The dynamic contrast will be equal or better than 1400:1. The whole screen of the large screen graphics wall should behave as a single logical screen and the control of the same should be from a dedicated graphical control unit (Controller) having a keyboard & mouse.

6.3.5.3 Communication System

The communication network of a distributed control system will be tied with the real time network failure of which leads to the catastrophic failure of the entire system. The communication needs will meet the following requirements:

a) Complete redundancy for data highways as well as communication controllers.

b) Deterministic protocols so that each controller can have guaranteed access to the information.

c) High throughput to handle plant wide information base.

6.3.6 Data Highway Cabling Considerations

Data highway cables will have a larger bandwidth. Any disturbance of the highway could have catastrophic consequences for the plant. Special precautions will have to be taken for laying of the cables such that they are free from noise and ground loops/circulating currents. Considering this, special care with respect to electrical isolation of the cable is taken.

The main data highway will have a speed of at least 1000 Mbps. It will consist of medium (physically) redundant fibre optic cables. Station wide LAN for interface between Unit control system and plant auxiliaries.

Interface with other systems:

- There will be possibility to connect Excitation System on Main Data Highway.
- System will support open gateways through MODBUS RTU.
- System will be web-enabled i.e. Users through Internet will be able to access the system for information.
- System will have interface possibility with PA system.

6.3.7 Sequence of Events Recording (SER)

In case DDCMIS system does not have integral SOE functions of 1 millisecond resolution, standalone SER can also be accepted. Incase of standalone SER, all related inputs are hardwired to SER as well as DDCMIS separately. In case of SER built-in as part of DDCMIS system, provision of hardwired inputs for SER is not recommended as there is no distinct advantage in providing a hardwired input to SER in that system because reliability can be taken care of by providing sufficient redundancy at input level. The SER system has high resolution of 1 mili-second with 512 points.

6.3.8 Master Clock System

One (1) number master digital clock with redundant microprocessor controlled system will be provided in control room. Master clock system will be capable of receiving time signals broadcast by National Physical Laboratory and processing it and then transmitting and synchronizing this with all DDCMIS, DCS, PLCs and other microprocessor based systems for subject plant. Slave clocks will also be provided at all major locations and control rooms.

6.3.9 Tube Leak Detection System

Acoustic type tube leak detection system will be provided for Boiler tubes with One (1) Workstation and A4 sized B/W Laser jet printer.

6.3.10 Online Computer Aided Microprocessor based Machinery Maintenance Management System (OCAMMMS)

Microprocessor based standalone online vibration/machinery monitoring and analysis system will be used for condition of monitoring of TG and HT drives/motors. OCAMMMS will take care of predictive maintenance of machine/equipment and will be compatible and of same family of turbine vibration-monitoring system / HT drives vibrations system.

6.3.11 HART Management System

A dedicated and standalone WORK STATIONS based Hart Management system for each of the generating units for centralized configuration, maintenance, diagnostics & record-keeping for all smart type electronic transmitters, smart type analysers and any other HART based instrument/system shall be provided. For easy handling of the various functions at HMS panel itself, and Control & Instrumentation Laboratory, One no laptop PC with HMS software shall also be provided for configuration, maintenance and diagnostic of all smart devices.

6.3.12 Computerised Maintenance & Inventory Management System

CMIM system will consist of different application modules specific to the maintenance tasks normally encountered in Thermal Power Station; system will have capabilities to document maintenance related functions and will streamline the entire maintenance activities. Features like generation of work order, preventive maintenance schedule, inventory control, storing of equipment information, job planning, purchase modules and report generation will be available with the CMIMS system.

6.3.13 Plant Security And Surveillance System

The design of the security& surveillance system shall take into account the potential security risks to the power plant. Plant security and surveillance system shall be an integrated system comprising the following systems/facilities:

(a) Perimeter Intruder Detection System
(b) CCTV Monitoring of Plant and perimeter equipment

6.3.14 Steam Generator, Steam Turbine Generator and Auxiliaries Control

The control system will provide a simple effective fail safe means for reliable and efficient operation of the steam generator with its associated auxiliaries for attainment of maximum availability and maintaining plant parametric values at desired controlled levels.

Binary logic controls will be provided for the sequence, protection and interlock operation of major plant auxiliaries.

Temperatures of all generator bearings, exciter bearings rotor and slot/core temperature of stator and HT motor temperatures will be monitored continuously. Embedded RTDs will be connected to the Control

Instrumentation system to provide continuous data and also trend data as required to depict the temperature profile of the bearings and slots. Limit value monitors will be provided to annunciate temperature 'high' on the basis of group of points with identical setting value. Following major control system shall be provided:-

i. Burner Management System
ii. DEHC (Digital Electro Hydraulic Control) Turbine Governing System
iii. Turbine Stress Control System (TSCS)
iv. HP/LP Bypass System:
v. Automatic On Line Turbine Testing (ATT) System
vi. Automatic Turbine Run-up System (ATRS)
vii. Turbine Supervisory System
viii. Turbine Protection System (TPS)
ix. Secondary Air Damper Control System
x. Auxiliary pressure Reducing And Desuperheating Station (AUX PRDS) Control System
xi. Soot Blower Control System (SBCS)
xii. Coordinated Master control

6.3.15 SG Related Control & Instrumentation System/ Equipments

6.3.15.1 Flame Monitoring System

The purpose of the system is to detect the individual flame and to enhance the boiler/furnace safety, to avoid spurious and unwarranted trips and to increase operational reliability, availability and efficiency of the Steam Generator such that the consumption of fuel oil shall be reduced to optimal minimum.

Fail safe easily mountable Microprocessor based digital flame monitoring system shall be provided, which shall include flame detectors of proven design for the type of fuel, environmental condition and other conditions, of established reliability at all loads of the Steam Generator.

6.3.15.2 Furnace Temperature Probe

Furnace gas temperature probes on each side of furnace shall be provided for monitoring of gas temperature at the furnace outlet. The probes shall be movable type.

6.3.15.3 Acoustic Pyrometers

Acoustic Pyrometers are to be provided to determine the average flue gas temperatures and complete flue gas temperature profile Furnace Exit plane (for FEGT measurements) and at Economiser outlet.

For each temperature measurement plan/section, A WORK STATIONS based system complete with all required software, comprising of minimum eight nos. of acoustic transreceivers, signal processor, interface unit, WORK STATIONS & Colour LaserJet Printer shall be provided.

6.3.15.4 Furnace and Flame Viewing System

The flame cameras shall be suitable for direct online continuous viewing in the central control room of the coal and oil flame and condition of the furnace internals including slogging of the water walls and any other deterioration in the furnace condition.

6.3.15.5 **Mill and Airheater Fire Detection System**

Adequate number of thermocouples type fire detection system for each Mill and Air-heater shall be provided as a composite & complete units with all required signals & accessories with adequate redundancy shall be provided.

For measurement of pulveriser outlet temperature tungsten carbide block thermowells abrasion resistant of tungsten carbide coated thermowells shall be used.

6.3.15.6 **Online IR based device** for temperature measurements at different elevation in order to ascertain the balanced firing inside the furnace and temperature of flame shall be supplied. The 4-20 mA signals from these online IR device shall be hooked upto DDCMIS for historical and monitoring purpose.

6.3.16 **STATION LAN**

6.3.16.1 **General**

A plant wide Local Area Network (LAN) encompassing the different plant buildings shall be provided. The Station LAN shall interconnect the buildings together and shall facilitate the smooth transfer of Data from one building to the other.

6.3.16.2 **Design and Functional Requirement**

A Plant Wide Network shall be provided, so that pre-selected plant graphics & data can be viewed on real time data basis at selected nodes and from remote locations. The LAN shall be redundant with redundant industrial grade Ethernet switches and of the industrial grade with Gigabit type (10 GBPS) and

shall utilize standard IEEE 806.3 protocols such as Ethernet. Complete network shall be provided with External surge protection system and industrial grade fire wall. The Station LAN connection with necessary RJ-45 connectors and other accessories shall be provided at cabins of each occupants in service building, administrative building, fire station building , Time office , Stores, and other buildings.

6.3.17 Management Information System (MIS)

6.3.17.1 MIS-GENERAL

Any integrated management information system (MIS) shall be provided for the plant. System shall be able to provide information related to the following aspects to management personnel and pre-selected plant graphics & data can be viewed on real time data basis at selected nodes and from remote locations

a) Plant operation information.
b) Plant maintenance related information.
c) Environmental information

6.3.17.2 FUNCTIONAL REQUIREMENT

MIS will provide following plant information:

i) Environmental and hazard management.
ii) Equipment maintenance history.
iii) Fault cause analysis.
iv) On-job information report.
v) Plant operation History.
vi) Plant performance details.

vii) Any other plant operation data/details.

6.3.18 **Operator training simulator:**

The Operator Training power plant simulator system shall be provided based on the design of the super critical power plant projects. The Simulator Design shall include equipments, Instrumentation and controls that will enable operator to function in all modes of the specified coal fired power plant operation including normal, abnormal or emergency operating conditions except as specifically noted otherwise.

6.3.19 **Off-Site Packages**

Programmable Logic Controller (PLC) systems will be used for offsite packages such as :

i) Coal handling Plant (CHP),
ii) Ash handling system,
iii) Raw Water Plant
iv) Demineralised water (DMW) Plant, & PT Plant
v) Mill Reject System
vi) Fuel Oil Handling System and other auxiliary systems.

Redundant Gateways for interfacing with DDCMIS will be provided whereas switchyard DAS will be through RTU of DDCMIS. Soot-blower controls will be through DDCMIS.

6.3.20 **Documentation system:**

A complete integrated engineered dedicated Documentation system consisting of editable documentation software, hardware, UPS, furnitures, associated networking, customization, system documentation and user manuals, training, up-gradation and maintenance of software, generation of

required documents and loaded with plant engineering databases and as per specifications stipulated here under shall be supplied each set for 1 X 660 MW Ennore Expansion Project Site & TANGEDCOÕs HQ at Chennai.

6.3.21 **Video Conferencing System:**

Video Conferencing System shall be provided, erected & commissioned in the conference room at TG building (Separate for each unit), service building and Admin Building. Video conferencing system facility with dedicated high speed broadband internet connection shall be provided so as to talk to other thermal power station, load dispatch centre, TANGEDCO Head quarters etc.

Control System For Major BOP/Off – Site Packages Are As Follows:

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
1.	Ash Handling Plant & silo loading/unloading system.	PLC based	Yes	No	SOFTLINK	PLC with Two no. OWS, one no. Operating cum engineering station with one no. A3/A4 size color LJP and Redundant hot standby processor with One (1) no Digital copier cum Laserjet printer A3 size & one no. A3 sized DMP. In addition Backup control desk with coloured Mimic, H.W. Annunciator, P.B. Ammeters, parameters Indicators and indication Lamps, Ammeters shall also be provided.
						PLC based Ash water and ash slurry system with, One no. OWS, one no. Operating cum engineering station and Redundant hot standby processor with one no. A4 size B/W LJP & DMP, redundant soft interface with AHP PLC.
						PLC based HCSD system, One no. OWS, one no. Operating cum engineering station and Redundant hot standby processor with one no. A4 size B/W LJP & DMP, redundant soft interface with AHP PLC.

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
2.	Air Conditioning System & Ventilation System	PLC based	Yes	No	Softlink	PLC with One no. OWS, one no. Operating cum engineering station and with Redundant hot standby processor with one no. A4 size B/W LJP & A3 sized DMP. In addition to OWS operation, Backup control desk with coloured Process Mimics, Hard wired Annunciation system, required Push Button arrangements in Back Panel for complete operation of the systems, Ammeters, Parameter Indicators, LED Based indication Lamps etc., shall also be provided.
3.	Fire Detection & Protection System	PLC based	Yes	No	SOFTLINK	a) PLC based pump controls and solid state Annunciation system. PLC shall be with Redundant hot standby processor & one no. OWS, one no. OEWS with A4 sized B/W LJP & DMP. (b) Microprocessor based Fire Detection and Alarm system shall be provided. Repeater Panel shall be provided. Two (2) nos. work stations shall be provided (one in CCR and other in Fire station) for Fire Detection and Alarm system. Fire Alarm panel shall be provided at different location in plant like each at CCR, Fire station, ESP, AHP, WTP, FO Plant etc.

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
4.	Compressed Air System	PLC & Microprocessor based System	Yes	No	H/W and soft link Interface with DDCMIS for monitoring only.	Microprocessor based System for individual compressor and PLC with one no. OWS & one no. OEWS, One no. B/W LJP, one no. A3 sized DMP & hot redundant processor for loading, Unloading & auto standby start of compressor and control, operation of control valve. Redundant interfacing of PLC with microprocessor based system in addition to HW signals shall be provided.
5.	Mill reject handling system	PLC based	Yes	No	Softlink	PLC with one no. OWS & one no. Operating cum engineering station and with Redundant hot standby processor with one no. A4 size B/W LJP & DMP. Control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall also be provided.
6.	CHP dust separator pumps, Service water pumps and Potable water pumps and misc pumps.	PLC based	Yes	No	SOFTLINK	PLC with one no. Operating cum engineering station, one no. OWS and with Redundant hot standby processor with one no. A4 size LJP B/W & DMP. Control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall also be provided.
7.	RO ï DM water System - sea water pre-	PLC based	Yes	No	SOFTLINK	PLC with Two no. OWS, one no. Operating cum engineering station with one no. A3/A4 size color LJP and Redundant hot standby

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
	treatment system, Ultra filtration system, SWRO system, BWRO system, DM plant with all sub-systems and accessories.					processor with One (1) no Digital copier cum Laserjet printer A3 size B/W & one no. A3 DMP. In addition Backup control desk with coloured Mimic, H.W. Annunciator, P.B. Ammeters, parameters Indicators and indication Lamps, Ammeters shall also be provided.
8.	CW Chlorination System	PLC based	Yes	No	None	PLC with one no. OWS & one no. Operating cum engineering station and with Redundant hot standby processor with one no. A4 size B/W LJP & DMP. Control desk with colored Mimic, H.W. Annunciator, P.B. parameters indicators and indication Lamps shall also be provided.
9.	CW Pumps / ACW and CW make-up system	Main plant DDCMIS based	NO	Yes	H/W	In Cooling Water Pump House ï **Remote I/O unit with redundant micro processor panel of DDCMIS family** is to be employed. Through redundant **fiber optic cable**, the bus is to be connected to DDCMIS of Unit Control Room. Local control panel also shall be provided for annunciation & indicators, Ammeter etc.
10.	DMCW System (SG & TG) &	Main plant DDCMIS	NO	Yes	H/W	DDCMIS Control scope

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
	ACW booster pumps (SG)	based				
11.	TG Cycle (DM) Make-up Pump / Valve control and CST onwards monitoring and Boiler Fill Pump	Main plant DDCMIS based	NO	Yes	H/W	DDCMIS Control scope
12.	Coal handling and crushing system	PLC based	Yes	No	SOFTLINK	a) PLC with Two no. OWS, one no. Operating cum engineering station with one no. A3/A4 size color LJP and Redundant hot standby processor with One (1) no Digital copier cum Laserjet printer A3 size B/W & one no. A3 DMP. In addition Backup control desk with coloured Mimic, H.W. Annunciator, P.B. Ammeters, parameters Indicators and indication Lamps, Ammeters shall also be provided.
						(b) PLC with Redundant hot standby processor based stacker reclaimer machine with One (1) no. 15òLCD based touch screen panel backed up by push button & Annunciation windows. Redundant wireless link & HW link shall be provided between CHP PLC & Stacker reclaimer PLC.

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
						c) PLC with Redundant hot standby processor based track hopper & wagon tippler system with One (1) no. 15ò LCD based touch screen panel backed up by push button. PLC shall be connected to main CHP PLC via redundant link. d) PLC with Redundant hot standby processor based In motion weigh bridge system with One (1) no. OWES & DMP. PLC shall be connected to main CHP PLC via redundant link. e) PLC with Redundant hot standby processor based coal sampling system with One (1) no. 15ò LCD based touch screen panel backed up by push button. PLC shall be connected to main CHP PLC via redundant link.
13.	CW Treatment plant	Relay based	Yes	No	None	Relay based control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall be provided.
14.	Fuel Oil Handling and unloading System	PLC based	Yes	No	Softlink	PLC with Redundant Hot Stand by Processor with one no. OEWS, ONE no. OWS & one no. B/W A4 sized LJP & A3 sized DMP. In addition to OWS operation, Backup control desk with coloured

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
						Process Mimics, Hard wired Annunciation system, required Push .Button arrangements in Back Panel for complete operation of the systems, Ammeters, Parameter Indicators, LED Based indication Lamps etc., shall also be provided.
15.	H2 Gas Plant	PLC based	Yes	No	Softlink	PLC with Redundant Hot Stand by Processor with one no. OEWS, one no. OWS & one no. B/W A4 sized LJP. H.W. Annunciation on Panel.
16.	Effluent Treatment Plant	Relay Based	Yes	No	None	Relay based control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall be provided.
17.	Induced Draft cooling Tower	Relay based	Yes	No	None	Relay based control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall be provided.
18.	BTG (FOPH) Fuel Oil System	DDCMIS based	NO	Yes	H/W	In Fuel Oil Pump House ï Remote I/O unit with redundant micro processor panel of DDCMIS family is to be employed. Through redundant fiber optic cable, the bus is to be connected to DDCMIS of Unit Control Room.
19.	Condensate Polishing Unit	DDCMIS based or PLC based as per	Yes (in case PLC controlled)	Yes (In case DDCMIS controlled)	H/W & Softlink	In case of DDCMIS controlled ï Remote I/O unit with redundant micro processor panel of DDCMIS family is to be employed. Through redundant fiber optic cable, the bus is to be

S.No.	System /Package	Control System	Control From		Interface with DDCMIS	Remarks
			Local Control	UCR/ CCR		
		manufacturers recommendation.				connected to DDCMIS of Unit Control Room. In case of PLC controlled - PLC with Redundant Hot Stand by Processor with one no. OEWS, one no. OWS & one no. B/W A4 sized LJP. In addition to above, local control desk with coloured Mimic, Indicators, Ammeters, H.W. Annunciator, P.B. and indication Lamps shall also be provided.
20.	CONDENSER ON LOAD TUBE CLEANING SYSTEM (COLTCS)	Main plant DDCMIS based	Yes	Yes	H/W	EPC Package DDCMIS Control scope. Local control panel for each side COLTCES shall also be provided.
21.	SEA WATER INTAKE PUMPS & AUX.	PLC based	Yes	No	SOFTLINK	PLC with one no. Operating cum engineering station, One no. OWS and with Redundant hot standby processor with one no. A4 size LJP B/W & DMP. Control desk with coloured Mimic, H.W. Annunciator, P.B. and indication Lamps shall also be provided.

NOTES:

1. For soft-link communication between PLC and DDCMIS, Communication protocol between the Modems shall be RS485 / MODBUS / OPC and the maximum communication time for receipt of signal at DDCMIS end should not exceed 2 seconds. There shall be redundant soft link between DDCMIS and each PLC for to- and fro communication.

6.3.20 **Programmable Logic Controller (PLC)**

PLC system shall be complete with hot standby redundant CPU of word length of 32bits minimum, Input / Output modules, dual serial link interface module for connecting Input / Output Modules, dual Communication Processors, dual Memory modules and redundant Power supply units. Power supply unit shall be redundant for each CPU & I/O rack. PLC system will be interfaced with DDCMIS through redundant serial communication gateway (to be provided at PLC & DDCMIS end) for important process parameters. PLC shall confirm to IEC ï 61131.

The controller will be hundred percent hot standby with bumpless transfer facility with in 50 m sec. The controller shall be 32 bit. Battery back up for RAM duration not less than 360 hours for continuous operations during power failure shall be provided. Each controller will have 40% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops under worst load conditions.

100% redundancy will be provided for all output cards provided with PLC system, used for executing closed loop/sequential interlock and open loop functions for critical applications. No redundancy at I/O card level is required for other control loops and for Data Acquisition/Monitoring functions. Individual input channels shall have galvanic isolation. Output points shall also have optical / galvanic isolation. All I/O cards shall have inbuilt self diagnostic features.

6.3.21 **AC and DC Power Supply for Control and Monitoring System**

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

The total requirement of C&I power supply will be fed from 240V AC industrial graded parallel redundant UPS and valve regulated Ni-Cd batteries with 1.2 V

cell. 240V AC UPS supply will be fed to MMI. 24V DC supply requirement for DDCMIS cards/transmitters etc. will be met through 24VDC parallel redundant charger and battery system:

a) Ability to use the normal power supply available in the plant.

b) High degree of reliability and availability to ensure that under no conditions the supply to the control system of the plant fails.

c) Back up power to be available for the control when the main electric supply in the plant may not be available.

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

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

f) Redundant ACDB with redundant feeders shall be provided for UPS supply in order to ensure no-break power supply of 240V AC and 24VDC.

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

6.3.22 DC Power Supply for Control Portion of the System

The use of parallel redundant 24V DC charger and valve regulated Ni-Cd batteries with 1.2 V cell for providing Uninterruptible Power Supply of 24V DC

for the control portion of the system requirement (voltage requirements) is envisaged. The DC supply from battery/charger will be given to DC distribution board on redundant feeders (2x100%). The scheme provides no break power supply of 24V DC.

The distribution of AC and DC loads for the control and monitoring systems will be done as follows:

- The DC supply will be provided for the auto-control system, interlock, protection and sequencing and annunciation systems.
- Other system loads will be taken on the AC supply through UPS.

For the AC portion of the loads, the use of completely 100% parallel redundant charger cum inverter system will be provided with 50% load sharing. However the battery bank for the system will be 2 x 100% capacity batteries only. The 50% load sharing provided will also ensure that there will be increased margins in the inverters to blow branch fuses. The equipment included for the UPS for such a scheme is given below. UPS will be located in AC room:

Sl. No.	Description	Qty./Unit
1.	100% capacity 12 pulse float-cum-boost chargers	
	100% capacity static inverters	
	100% capacity static switches	
	Manual by-pass switch	
	120 min backup Valve régulâted Ni-Cd batteries	
	Step-down transformer (415V, three phase to 240 V, single phase) and isolation transformers.	As Reqd.
	Voltage Stabilizer (SVS type)	
	AC Power Distribution Boards	

Parallel Redundant 2 x 100%, 24V DC system will also be located in AC room and will consist of following:

Sl. No.	Description	Qty./Unit
1.	100% capacity 12 pulse float-cum-boost chargers	
2.	100% capacity static switches	
3.	60min backup Valve Regulated Ni-Cd batteries of 100% capacity each.	2 set
4.	DC Power Distribution Boards	

For Plant UPS, battery backup time shall be 2 hours and for BOP packages UPS & 24 V DC systems, the back up time shall be for 1 hour. Similarly for BOP packages UPS & 24 V DC system, the 6 pulse float cum boost charger shall be provided.

In order to monitor the batteries, **online battery health monitoring system** shall be employed.

6.3.23 **Control Panel and Operator Interface**

8 Nos. LVS and operating console desks /consoles for group of operating stations in the central control room and also provide operator control consoles in computer room for Engg./Diagnostic Station, SER, alarm operating station, performance calculations/optimization along with their printers and Printer cum scanner cum copier.

Operating stations will be console mounted and placed at an angle for viewing from the front as an operator station. Operating station/KBD will generally be used for control and monitoring; and also large video screens will be used for control and monitoring.

Control panels housing the control cards/equipment will be located in a room adjacent to control room; and have IP-32 degree of protection as per IS-2147 offering dust and vermin protection.

All panels, cabinets and enclosures will be furnished, fully wired with necessary provisions for convenience outlets, internal lighting, grounding, ventilation and vibration isolation pads, integral piping and other accessories as per IS: 5032- 1262.

The sealing of panels/cabinets/enclosures bottom with bottom plate, double compression cable glands and suitable sealing material to prevent entry of dust will be provided. Suitable arrangement for preventing fire propagation through cable entry points like fire seals etc. at cable entry points. Exhaust fans with louvers & filters will be provided in all consoles and panels. All the panels will be equipped with Anti vibration pad of 15 mm size.

6.3.24 Analytical System

All analytical instruments will be of microprocessor based only.

Analytical measurements are of two types:

a) **Flue Gas Analysis**: Flue gas analysis is carried out for percentage oxygen (O2 - zirconium oxide probe type) and Combustibles (CO) (in-situ type).

b) **Steam and Water Analysis**: Continuous analysis is done on steam and water media to establish their purity and suitability for long life of pressure parts. The measurements are carried out at different cycle points of the plant to establish Conductivity, pH, silica, sodium, phosphate, Chloride, Turbidity, and Dissolved oxygen content.

The steam and water analysis system (SWAS) will include all requisite analyzers, sampling system, complete with sampling table, chiller unit and analyzer panels. All data will be available in DDCMIS for information. There shall be two (2) panels, Wet panel for sample conditioning and Dry panel for housing analysers. Dry panel shall be kept in A/C room.

6.3.25 ENVIRONMENT MONITORING SYSTEMS

i. Boiler/Stack emission monitoring system

Flue gas analyzers shall be provided for Boiler/stack continuous emission monitoring system (CEMS) for each unit. Boiler/stack emission monitoring system comprising of carbon mono oxide, Sox /NOx, Stack gas velocity, dust/opacity analyzer & mercury Analyzer. All gas analyzer signals shall be connected to plant DDCMIS.

ii. CONTINOUS AMBIENT AIR QUALITY MONITORING SYSTEM (CAAQMS):

CAAQMS shall be provided to check upon the ambient air quality inside and around the power plant and capable of generating required reports for submission to relevant central & state regulatory agencies. Total four (4) nos such stations shall be provided at the min. one (1) no ósationôshall be located at the UP wind direction path. Balance three (3) no. ósationsôshall be located at different plant locations considering the factors like downwind direction , sensitive receptor, population etc.

CAAQMS shall include monitoring of the following pollutant gases/parameters. However, any other gases/parameters recommended by relevant central & state regulatory agencies during project implementation phase shall also be provided. Method of measurements & standards shall be as per CPCB and state pollution control boards (PCBs) norms.

a) Sulphur dioxide (SO2)
b) Oxides of nitrogen (NOx)
c) Carbon monoxide (CO)
d) Carbon Di-oxide (CO2)

e) Suspended particulate matter (PM10)
f) Suspended particulate matter (PM2.5)-respiratory
g) Ozone (O^3) - at one location only

iii. Meteorological Monitoring System (MMS)

A meteorological monitoring system (MMS) shall be Provided. Meteorological data shall be monitored with The Plant Premises at One (1) Location. The Following Parameters Shall Be Monitored:

a) Wind Direction
b) Wind Speed
c) Ambient Temperature
d) Ambient Pressure
e) Solar Radiation
f) Relative Humidity
g) Rainfall

6.3.26 Field Instrumentation

6.3.26.1 Transmitters

Smart Transmitters will be provided for pressure, temperature, flow and level measurements. Transmitters will be electronic type, two-wire configuration. The output signal will be 4 to 20 mA DC HART compatible and capable of drawings loads up to 600 ohms at 24 V DC. The transmitters will be provided with integral indicator of 5 digit LCD display configured in engg. Units with an accuracy of ± 0.065 % for BOP packages and 0.04% for BTG packages.

6.3.26.2 **Pressure Measurements**

The pressure sensing element/movement material will be SS316 with die cast aluminum/SS316 case. The accuracy will be ± 1%. Local pressure gauges will be 150-mm dial type. The bourdon tube will be SS316 and case material will be die-cast aluminium/SS316. The pointer will be of micrometer type with adjustable zero adjustment in the front. Gauges will be provided with snubbers/ pulsation dampners, siphons, seals as required.

Pressure switches will be provided for pressure measurements. Pressure and differential pressure will be selected based on pressure and temperature operating conditions.

6.3.26.3 **Temperature Measurements**

a) Thermocouples: Thermocouples will be of Duplex K-type with KX Extension cables wire. The elements will be ungrounded type. The sheath OD will be 6mm for thermocouples. The insulation materials will be magnesium oxide. The accuracy for thermocouple will be ± 1.1^{o}C. Thermocouples will have spring-loaded sheathed elements to provided good thermal contact with the well. The gauge size will be 16 SWG.

b) RTD: Duplex type Resistance temperature detector (RTD) will be of 3-wire platinum type. The nominal resistance will be 100 ohm at 0^{o}C. RTDs will be of ungrounded type. The sheath OD will be 6mm. The insulation materials will be magnesium oxide. The response time will be 15 sec. (bare) and 30 sec. with thermo well. The accuracy will be ± 0.35 ^{o} C. RTDs will have spring-loaded sheathed elements provided with good thermal contact with the well. The gauge size will be 18 SWG.

c) Local Temperature Gauges will be liquid filled type with 150mm dial with separable SS316 thermo well. The case material will be die cast

aluminum/SS316. The accuracy & response time will be +/- 1% and max. 15 sec. The process connection size will be M33x2. Extension neck length will be 50 -100 mm above insulation of pipe.

d) Thermo well: Thermo well will be heavy duty tapered, weld in bar stock type as per ANSI B31.1 piping code. Thermo well will be designed for maximum pipeline velocity to prevent well failure. Thermo well material will be SS316.

6.3.26.4 Level Measurements

Accuracy of measurement will be ± 1% of full scale or better. For granular or powdered material level measurement, ultrasonic, RF type detectors/sensors will be used.

For liquid level measurement, float, Capacitance type, Ultrasonic type, Radar/Guided wave radar type, Acoustic 3D type or differential pressure type transmitter will be used depending upon the vessel/tank is closed or open type or the medium for which it is used.

Level gauges will be provided for local indication. All gauge glasses will be provided with graduated suitable scale. Level gauges will be transparent type & back lighted. Float & Board type level gauge shall be provided for overhead tanks.

Level switches will be external cage float side mounted type, Conductivity type, Capacitance type or top mounted displacer type with its body rated depending upon process conditions and vessel or tank design conditions. The body will be provided with individual block vent and drain connections.

6.3.26.5 Flow Elements

For measurement of water flow, orifice plates will be used as primary sensing device. The flow sensors are sized as per BS 1042 or confirming to the latest

codes of ASME and calculation parameters. For airflow measurement, flow-sensing devices will be venturi tubes. For steam flow measurement, flow-sensing devices will be of nozzle type and condensation chambers of identical dimensions will be used and installed as near to the sensor as possible. Sensing Instruments and their mounting accessories for steam line and high-pressure applications will be IBR certified.

For flow measurements of line size upto 500 mm, carrier ring type orifice plates will be used. Beyond this size, disc type orifice plate will be used. The orifice plate will be installed not less than with a straight pipe length of 10 D on the upstream side and 5 D on the downstream side, free from bends, tees, branch pipes, valves etc.

Flow elements with flow transmitter or Flow meter (like Electromagnetic type, Vortex type, Mass flow meter, ultrasonic type etc) shall be provided for flow measurement depending upon of process medium like Steam, Water, Air, Flue Gas, Fuel oil, open channel liquid, solid fuel, ash flow, DM water, Raw water, Instrument and Service air etc.

6.3.26.6 Control Valves

For pneumatically operated control valves, the valve will operate on 0.2 to 1 Kg/cm^2 air signal. Control valves will be sized so that the CV required for normal flow will not be more than 62.5% of the manufacturerôs published CV for 100% valve opening; and the minimum flow will occur at 30% of valve opening and or more to have a good operating range. Valve lift will be limited to 80% of the travel at max. flow load.

Control valves will be complete with I/P converters, position transmitters, Air lock relay, smart Positioners, limit switches, solenoid valves and filter regulators as needed. The valves will be provided with hand wheels for local operation.

Critical service valves like PRDS, HP/LP bypass, Auto recirculation valves, Boiler feed control valves SH/RH spray control valves and SB control valves will be of multi stage & multi path design with sufficient no. of discrete pressure drop stage to eliminate the chance of erosion, cavitations, noise, vibration through out the control range of valve and minimum class V leakage class.

The control valve will have valve position indication in the control room. Position transmitters will be contact less 2-wire type with 4-20 mA DC output. Teflon/asbestos packing will be used upto 200 ^{o}C temperature; and graphite lubricated asbestos will be used for operating temperature higher than 200 ^{o}C. The noise level of the control valves will be less than 85 dB at 1 meter. The control valves will be installed after the flow sensing devices in the direction of flow.

6.3.27 **Cables**

Instrument (pair / core) cables (Annealed tinned copper conductor, 650V Ext grade, 0.5/1.5 sqmm, FRLS type, PVC insulated, armoured) and Extension cables (KX, 1.31sqmm (16 AWG), FRLS type, PVC insulated, armoured) complete with all accessories.

Extension cables will be used to interconnect thermocouples to control and monitoring systems. The type of compensating cable depends on the type of thermocouple being connected to the control and monitoring systems in any one of the following ways:

a) Extension cables from thermocouple head (through JB/Marshalling cubicle or directly as the case may be) will be connected to the control and monitoring system.

b) Thermocouple extension cable will be connected to upto the JB provide cold junction compensator at JB and from thereon shielded instrumentation cable to the control and monitoring system will be used.

c) Connecting the thermocouple extension cable at the JB end to temperature transmitters, which convert the thermocouple signal to a standard current signal for transmission to the control and monitoring system.

6.3.28 Erection Hardware

All required installation hardware including impulse pipes, tubes, valves, manifolds, fittings, etc. required for proper installation and interconnection of instrumentation and control systems will be provided. All materials and installation thereof shall confirm to latest editions of American national Standard Code for pressure piping, ANSI B 31.1, ANSI B 16.1, ASME Boiler and pressure vessel codes, IBR and other applicable ASME, ANSI and local standards.

6.3.29 Maintenance and Calibration Equipment

One (1) set of maintenance and calibration equipments for instrumentation and control systems will be provided for subject unit. This would consist of calibration equipment such as electronic test bench, pneumatic test bench, digital manometers, dead weight tester, manometers, air sets, RCL bridge, digital channel simulator, Multimeters, logic probe, Vibration meter, Pressure calibrators, Temperature calibrators, Temp. Furnace, Temp. Bath, Function Generator, Digital Oscilloscope, etc.

The calibration instruments will have a common PC along with A3/A4 sized B/W Digital Laser jet printer cum Copier for calibration and report generation. All the digital/Electronic calibration instruments will be provided with RS 232C port for PC interface with their own interfacing cables.

6.4 CIVIL AND STRUCTURAL ENGINEERING ASPECTS

6.4.1 SITE TOPOGRAPHY AND GRADE LEVEL

The proposed site area is barren and is well within the boundary wall of ETPS. The proposed plant site is low lying with the average site level as +7.0m above MSL. Some portion of the land needs to be filled, graded and compacted for getting the required plant level in order to consider installation of the proposed power plant. There is no habitation or any permanent structures in the site, hence there will not be any displacement, resettlement an rehabilitation issues. The proposed plant layout does not lie in the CRZ zone.

The detail topographic survey of the proposed power plant area would give clear idea of extent of filling and compacting required for grading the site. No preliminary works such as topography survey and soil testing have been conducted at the proposed site. But adjacent to the proposed site some bore log details are available which will give some indication of the soil profile of the plant site. Environmental Impact Assessment Study has been carried out to establish that the proposed site is suitable for installation of coal based power plant. The EIA report will be submitted for obtaining the clearances from the State Pollution Control Board and MOEF authorities. Since most of the area earmarked for proposed power plant site is in the low lying area, substantial ground filling to an extent of 1.5 m to 2.5 m has been considered. Complete main plant area needs to be filled, compacted, graded and leveled to + 9.50m level in line with present plant elevation. For filling the ground it is proposed to utilize the fly ash generated from the existing Ash dyke and good soil from the excavated earth will be used if the filling material is not sufficient. In case of additional requirement, good soil may have to be brought from nearby Red hills quarry which is about 20 kms from the site. Pile foundation will be required for major equipment and structure foundations. The depth of

piles and the related aspects will be decided appropriately based on detail soil investigations, which are to be carried out.

6.4.2 MAJOR BUILDINGS AND STRUCTURES

Station Building

The station building would be a non-basement structure. For proposed plant, the steam turbine generator and auxiliary equipment would be located in the A-B bay of the building having 34 m span and is accommodated in a length of 10.5 m x 9 bays. The total length of the station building would be 126 m which includes one unloading cum maintenance bay of 10.5 m width towards one end of the station building. The B-C bay having a span of 12 m would be housing the heaters. The control room and electrical building of size 63 m x 21 m is located on the side of the station building to accommodate switch gear, electronic panels and control instrumentation equipment.

For Proposed plant, the turbine ï generator bay would have three floors ï ground floor at 0.00 M level, mezzanine floor at 8.50 M level and operating floor at 17.00 M level. Localised O&M platforms at required levels would be provided. The deaerator would be located at EL. 36.00 M in the B-C bay (heater bay). Road and rail access would be provided to the unloading and maintenance bay for unloading TG components and auxiliary equipment.

For the Proposed Plant, the superstructure would be of structural steel framing with RCC floor slabs. Brick work side cladding up to 3.0 m above operating floor level and metal sheet cladding above this level has been considered. The roof of the TG bay would be permanent metal decking with in-situ concrete and screed on top and supported on steel trusses. Building would have crane girder at a suitable elevation to support the E.O.T cranes. Intermediate floors are supported with internal columns around TG

foundation. All floors of turbine hall (except operating floor and control rooms) would be provided with non-metallic hardener topping. Operating floor would be provided with Glazed vetrified ceramic tiles. Control room floor shall have 3 mm thick PVC anti-skid floor finish.

For proposed plant, The turbine-generator pedestal would be of reinforced concrete frame structure and would be isolated from the building foundations and super-structure. Steam turbine generator would be supported on vibration isolation system. The vibration isolation system would consist of helical spring units and viscous dampers supporting the RCC inertia block, which supports the machine.

6.4.3 Steam-Generator Area and Mill Bay

For the Proposed plant, the mill bay would be of structural steel-framed construction, supporting the steel bunkers. The 12 m wide bay would have floors for the feeders and for the trippers. The mill bay would be located on both sides of the furnace and will be connected by steel framing between the ESP & steam generator in order to isolate dust and vibration that would affect the control room housed in the station building. Concrete paving would be provided in the steam generator and ESP area with necessary drains and trenches. Pipes and cable in this area would, in general, be routed on overhead pipe / cable racks.

6.4.4 Stack

A reinforced concrete stack of 275 M height single flue of 7.0 m exit diameter would be provided for 1 x (660) MW steam generator unit. This would meet the requirement of Indian Emission Regulations OF Ministry of Environment and Forest (MOEF).

6.4.5 Sea Water

Water for condenser cooling system would be drawn from the sea and circulated in the NDCT cooling tower. Three (2W+1S) nos. of Cooling Water Pumps would be installed in the cooling water pump house as shown in the plot plan.

6.4.6 Ash Pond

For proposed power plant 1 x (660) MW, fly ash, (about 80% of the total ash generated) will be disposed off in dry condition and bottom ash (about 20% of the total ash generated) will be disposed into the existing ash pond.

6.4.7 Miscellaneous Buildings

Miscellaneous buildings will be RCC construction with adequate floor area and size.

6.4.8 Hydraulic, Geotechnical and Soil Investigations

A detailed geo-tech investigation needs to be carried out in the proposed power plant site to ascertain the soil profile and decide on the safe bearing capacity to be considered for the foundation design of main columns of major buildings / structures, main equipment.

Construction material such as sand, coarse aggregates good quality bricks and size stone metal required for the construction of the proposed power plan would be procured from nearby sources. Use of environmentally friendly fly ash bricks would be explored for use in the proposed power plant. The construction power would be catered by provision of a temporary power connection from the nearest LT power line.

6.4.9 Foundations

The foundations for the buildings and structures of the proposed power plant, has been considered as Pile foundations.

6.4.10 Roads and Fences / Compound Wall

The roads would initially be of water-bound macadam type with shoulders on either side of carriage width. After major construction activities are completed, these would be surfaced with Concrete. The width of the double lane road would be 7 meter excluding shoulders and single lane would be 4 m. Extra width would be provided on either side, for road side tree plantation, for all internal road in the plant site. It is also considered to provide RCC roads around boilers and transformers. The compound wall would be of stone masonry construction with barbed wire fixed to MS angles on the top.

6.4.11 Rain Water Harvesting (RWH)

RWH structures will be provided to harvest the rain water around the power plant area. The collected rain water shall be utilized for power plant uses to optimize the raw water requirement. The excess rain water may be discharged to the nearest surface water body through dedicated storm water drain. The surface water run-off from the main plant area would be led to a sump for settling and the over flow would be collected in the common water basin for further uses in the power plant to optimize the raw water requirement of the plant.

6.4.12 Design Basis

Dead and live loads would be considered as per relevant IS codes and standard engineering practices. The basic wind speed shall be considered for design of buildings / structures as per IS:875:Part III. The power plant is located in Seismic zone III as per IS:1893 and hence seismic forces would be considered accordingly for the structures and buildings. All designs shall be carried out in SI units and shall be as per relevant IS codes.

6.4.13 Sewage Disposal

Sewage from the plant would be conveyed through closed drains upto Sewage treatment plant as per the Pollution Control Board Norms. The treated water is collected and used for the greenbelt area development.

6.4.14 Landscaping

The various services / utility areas within the plant would be suitably graded to different elevations. Natural features of the plant site would be retained as far as possible to integrate with the buildings to form a harmonious / pleasant environment. Areas in from of various buildings and the entrance of power plant would be landscaped with ground cover, plants, trees based on factors like climate, adaptability, etc. The green belt would consist of native perennial green an fast growing trees. Trees would also be planted around the coal stock pile area and ash disposal area to minimize the dust pollution. Green belt should have suitable trees to act as a shelter-belt during the cyclone periods.

7.0 PLOT PLAN AND GENERAL ARRANGEMENT

7.1 General Site Topography

The general topography of the land proposed for locating the power plant is undulated with mean elevation of 9.5 M above MSL.

7.1.1 Drainage Plan

Area drainage and hydrological studies of project area has been carried out throôAnna University, Chennai ï 25.

Plant Layout

The general plant layout for the proposed power station is as per **Annexure - 7.1.**

The plant layout indicates the location of main plant and equipment with its auxiliary systems. The plant layout has been developed considering the following:-

i. Location within the designated area best suited from the point of view of available land.

ii. Wind direction.

iii. Accessibility through existing road and development of any other facility for transportation of construction material and fuel.

iv. Proximity to water intake system.

v. Accessibility to power evacuation corridor.

The main plant equipment and auxiliaries are selected on the basis of unit system design concept except for common facilities such as switchyard, raw water system, coal unloading and handling facilities, fuel oil system and ash disposal etc.

The layout provides for:

i. Main plant equipment comprising steam generators, steam turbine generators and its auxiliaries, SCR,

ii. Transformer yard, area demarcation for 400 KV switchyard.

iii. Cooling tower, DM Plant and water facilities.

iv. Storage space for coal and secondary fuel in line with GOI guidelines

v. FGD Plant as per Environmental guidelines.

vi. Dry Fly Ash Silos

vii. Coal conveying, unloading & storage area.

viii. Dedicated dead storage of water for fire protection as per TAC requirement (i.e 2 hours for hydrant system & 40 minutes for spray system) in the clarified water storage reservoir.

ix. Green belt all around the plant and Ash Pond.

x. Administrative building.

xi. Adequate space for built-up and open area for construction offices, stores, fabrication yard, open yard for fabrication etc.

xii. The auxiliary and ancillary buildings include:

a) Fire station

b) Workshop

c) Hydrogen generation plant

d) Canteen

e) Compressor House

f) Emergency diesel engine station.

g) Permanent Stores & Storage Sheds

h) Gate Complex and Security building

7.2 General Arrangement

7.2.1 Layout of Steam Generator and Auxiliaries

The main plants and facilities of the project of 1 x 660 MW unit have been accommodated in a plot of approximately 84 acre area. The power block has been suitably located by optimizing the available space.

Adequate area for laydown, storage and pre-assembly / fabrication activities during erection has been provided in the layout.

Main Plant Layout

The Main Plant building arrangement for the proposed 1 unit of 660 MW envisages longitudinal arrangement of T.G. set.

The layout envisages A-B bay of width 36 M and B ï C bay of width 12 M with floors at EL ± 0.0 M, + 8.50 M and operating floor at + 17.0 M level. Apart from T.G. sets, the A - B bay and B ï C bay would house other equipment such as B.F.Ps, CEPs, Lube oil system equipment, vacuum pumps, DM cooling water system equipment etc. H.T. Switchgearsôrooms are proposed to be located in A - B bay between the units and the space at operating floor

above these rooms is proposed to be utilized for laying down of T.G. components during maintenance. 2 Nos. EOT cranes have been envisaged for A-B bay & cater the requirement of material handling during erection & maintenance.

The B - C bay has been kept 12 M wide with floors at suitable levels. The deaerator has been located at 38.0 M level. The B-C bay houses L.P. heaters, H.P. heaters, Air Washer Rooms, chemical dosing equipment, SWAS Room, boiler MCC, Aux. PRDS etc.

One chimney will be of 275 M height.

8.0 ENVIRONMENTAL ASPECTS

8.1 Pollution Control Measures

8.1.1 Air Pollution Control System

Electrostatic precipitators (ESP) would be installed to control the emission of ash particles. The precipitators would be designed to limit the particulate emission to less than 30 mg/Nm^3. One (1) No. Single Flue RCC Stack of 275 meter high will be provided as per existing norms for deciding stack height (**Attachment-8.1(A)**, each of RCC construction. Besides on-line monitoring system as per MoEF guidelines, the chimney would be provided with access for regular monitoring of stack emissions. The exit gas velocity should be more than 22 m/sec. and minimum chimney internal diameter at exit will be 7.0 Meters. For the control of fugitive dust emission within and around the coal handling plant, coal dust extraction and suppression systems would be provided. Dust suppression system would be installed at all requisite points in CHP and coal stackyard.

Advanced combustion technology for lower emission of nitrogen oxide and SCR would be necessary to control NOx emission in the boilers.

Flue Gas Desulphurisation system shall be installed to limit Sox emission to 100 mg/ NM3. . The design and layout of steam generator and its auxiliaries would be such that a wet FGD system can be installed.

Besides, ambient air quality concentration will be maintained as per National Ambient Air Quality Standards (**Attachment - 8.1(B)**).

8.1.2 Water Pollution Control System

Effluent management scheme would be implemented with the objective of optimization of various water systems so as to reduce intake water requirement which would result in lesser waste water discharge. The effluent management scheme would essentially involve collection, treatment and recirculation / disposal of various effluents. Adequate treatment facilities would be provided to all the waste streams emanating from the power plant to control water pollution.

Effluent from the pretreatment plant (clarifier and filteration plants) will comprise sludge and water. Sludge will be separated and compacted in sludge presses and will be disposed of in solid form as landfill. The balance water will again re-cycled in clarifier alongwith raw water available from the reservoir.

Effluents from the demineralizer plant resin regeneration circuit, generally acidic from the cation units and alkaline from the anion units will be neutralized in a neutralizing pit. The neutralized effluent will have less than 100 ppm suspended solids and a pH value of about 7.5 to 8.0. The neutralized effluents will be led into the use CMB.

The cooling tower blowdown will be utilized for ash disposal in slurry form as also for green belt around the plant.

The run-off from the coal handling area will flow through channels around the coal storage area and coal handling buildings into a common basin (settling tank) from where it will be pumped into the station sump.

The oil-water mixture collected in the existing drains, provided around the oil unloading area and the pump house, etc. is led to an oil-water separator. The separated water containing less than prescribed limit of oil and grease and

will be led into the drainage system which will be finally discharged into station sump. The waste oil as separated out will be reutilized, if possible.

The sewage from the various buildings in the power plant as well as the colony will be routed through a sewage treatment Plant. The treated effluents from the sewage treatment plant will be utilized suitably for land application as per the existing standards.

The ash pond will be suitably lined to prevent ingress of ash water in sub soil. In the later years, when ash utilization is progressively increased, lower quantity of raw water will be required and more treated effluent water will be used for CHP dust suppression, BA hopper refractory cooling and watering of green belt. Excess liquid effluent will be discharged in a Central Monitoring Basin, where the treated liquid effluent will be monitored and recycled for use in the ash disposal water system. A suitable water / effluent scheme will be developed for reusing the treated waste water under normal operating condition. The effluent quality of various streams will be maintained as per the existing standards of thermal power effluents (**Attachment - 8.2(A)**). The final effluents, after treatment, will conform to the standards for discharging into / on existing water body / land for irrigation (**Attachment - 8.2(B)**).

Detailed studies were undertaken on drainage pattern in the project area for evolving a drainage decongestion plan, are provided in a separate on-area drainage study report.

8.1.3 Noise Pollution

The major noise generating sources are turbines, generators, compressors, pumps, fans, coal handling plant etc. Acoustic enclosures shall be provided to control the noise level below 90 dB (A). Personal protective equipment shall be provided to the persons working in high noise area.

Ambient noise inside and outside the plant area will conform to the prescribed noise levels for various landuse categories as per National Standards for Ambient Noise (**Attachment - 8.3**). This will be ensured through proper designing of the equipment with adequate acoustics permitting the ambient noise levels without exceeding the specified criteria from the source.

The socio-economic issues are addressed in a separate socio-economic survey report.

8.1.4 Ash Management

MoEF vide gazette notification dated 3rd November 2009 have stipulated about the utilization of ash generated by coal / lignite based thermal power station. The details are as under:

All coal and, or lignite based thermal power station and, or expansion units in operation before the date of this notification are to achieve the target of fly ash utilization as per the table given below:

Sl.No.	Percentage Utilization of Fly Ash	Target Date
1.	At least 50% of fly ash generation	One year from the date of issue of this notification
2.	At least 60% of fly ash generation	Two years from the date of issue of this notification
3.	At least 75% of fly ash generation	Three years from the date of issue of this notification
4.	At least 90% of fly ash generation	Four years from the date of issue of this notification

5.	100% fly ash generation	Five years from the date of issue of this notification

New coal and, or lignite based thermal power station and, or expansion units commissioned after this notification to achieve the target of fly ash utilization as per table given below:

Sl.No.	Fly Ash utilization level	Target date
1.	At least 50% of fly ash generation	One year from the date of commissioning
2.	At least 70% of fly ash generation	Two years from the date of commissioning
3.	90% of fly ash generation	Three years from the date of commissioning
4.	100% of fly ash generation	Four years from the date of commissioning

With a view of proper utilization, fly ash has to be handled separately and fly ash has to be stored in dry form for subsequent utilization. The dry fly ash could be transported in closed trucks for commercial utilization. Alternately, to minimize the cost of transportation, fly ash utilization plants could be located close to the thermal power stations.

Bottom ash after being collected in ash bins for decantation is conveyed in trucks outside the plant site, and is used extensively as a replacement for cinders. The use of bottom ash in area filling has provide satisfactory over the years, by virtue of which it finds ready marketability.

Fly ash, being a high temperature product, has pozzolonic properties and forms a cement like material when mixed with lime and water. These

properties make it suitable for a number of commercial uses; the most promising of these are as follows:

a) **Bulk Utilization**

Fly ash can be utilized in bulk form filling low lying areas, abandoned mines and in forming dykes and bunds. For this purpose, fly ash slurry is prepared specially to render the mass semi-rock once it settles in low lands, thereby making the reclamation of land possible. The slurry thus prepared is termed as ôEmulgateô ôEmulgateôcan also be used to serve irrigation projects by creating bunds to channelize water. Other probable uses can be for making rail & canal embankments, filling for making roads, land scaping etc.

b) **Value Added Utilization**

Modest quantities of fly ash can be used by generating a product which has some commercial value. The products are made by making use of some of the qualities of fly ash. The pozzolanic activity and lime reactivity of fly ash is employed for numerous uses including manufacture of building construction materials, as listed below:

i) Fly ash clay bricks

ii) Fly ash - lime & sand bricks

iii) Cellular bricks / blocks

iv) Light weight aggregate

v) Protland pozzolana cement

vi) Precast concrete blocks

vii) Sewerage pipes etc.

c) High Value Utilization

Products / services of high value can be made by utilizing fly ash. The value of the end product is much more pronounced than the quantity of ash utilized. Probable usage / products are as follows:

i) Treatment of acidic soil for waste land reclamation for Industrial / Horticulture purposes.

ii) Construction of road sub-base and rigid pavements for runways.

iii) Manufacture of coagulants to remove turbidity of water.

iv) Manufacture of insulating bricks.

For the proposed 1 X 660 MW power plant, fly ash will be collected in dry form. This dry fly ash will then be transported to the neighboring ash utilization plants, to be set up by private parties, by truck. Any surplus fly ash not used in the manufacture and bottom ash will be disposed off in slurry form to the ash dyke.

8.2 Post Operational Monitoring Programme

Regular mentoring of pollutants in different environmental disciplines like air, water, etc. will be undertaken during the post operational phase of the plant. The monitoring locations will be finalised in consultation with State Pollution Control Board. However, a minimum of four (4) monitoring locations will be required in all the four directions.

8.3 Institutional Set-up

The post operational monitoring programme will be under the supervision of the Environmental Management Group (EMG) at the project site. The station

will be equipped with all necessary instrumentation / equipment and manpower required for ensuring effective monitoring. The EMG at site will interact with State Pollution Control Board for all environmental issues during operation of the station.

8.4 Statutory Clearances

TANGEDCO to provide/obtain all statutory clearances viz., water, coal, chimney height, defence, CRZ and MoEF etc required for this project.

8.5 Demography & Socio-economic

Construction of any major project invariably leads to socio-economic changes. Large-scale influx of manpower, material and finance tends to change the economic status of the local community. The installation of the power station will activate the people in the area. The impacts would begin to be felt with the start of construction activities. The project will generate many employment opportunities for the local population especially during construction when the floating population would be at its peak. In addition to construction labour, the local population would get business opportunities such as setting up of petty commercial establishments, small contracts for supply of locally available construction material, ancillary infrastructure etc. It is proposed to recruit a majority of the unskilled labour and skilled labour force, depending on the availability, from the local population. Such activity is bound to increase the economic conditions of the people in and around the power station area. Marked improvement can be expected in public life, infrastructure facilities, health, education and employment potential.

8.6 Clean Development Mechanism (CDM)

8.6.1 Overview of Kyoto Protocol

Climate change emerged on the political agenda in the mid-1980s with the increasing scientific evidence of human interference in the global climate system and with going public concern about the environment. Kyoto protocol was signed in 1997 and came into force since 16th February 2005 and protocol commits industrialized countries to reduce their greenhouse gas emissions by 5.2% below 1990 levels in 2008-12.

- Individual, quantified emission targets for each industrialized country
- Six greenhouse gases covered: CO_2, CH_4, N_2O, HFC, PFC & SF_6

The protocol establishes three cooperative mechanisms as given below:

- Clean Development Mechanism (CDM)
- Joint Implementation (JI)
- International Emissions Trading

8.6.2 CLEAN DEVELOPMENT MECHANISM (CDM)

Clean Development Mechanism (CDM) allow emission reduction projects that assist developing countries in achieving sustainable development and the generated Certified Emission Reductions can be used by the industrialized countries or companies.

8.6.3 PROJECTS ELIGIBLE UNDER CLELAN DEVELOPMENT MECHANISM

Renewable Energy	Hydro, Wind, Solar, Biomass, Bagasse, Geothermal, Tidal
Waste Heat Recovery	Cement, Steel/Metal Coke Ovens
Waste Management	Waste Water Management, MSW Management, Fuel pellets, Power Generation, Use as Fuel
Transportation	LPG, NG, Biodiesel, MRTS, Pipeline, Railways Shift
Process Change	Petroleum Refineries, Oil & Gas Refineries, Fertilizer CO_2 Recovery, Nitrous Oxide (N_2 O) Destruction, Refrigerant: HFC Abatement, Aluminum: PFC Control
Energy Efficiency	Efficient Generation (Efficient Machinery, T&D Loss Reduction, Thermal / Fuel, Steam Saving, Thermal Saving, Process Fly ash in Cement)
	Efficient Utilization (Energy efficiency measures for buildings and industries), Efficient Steam Utilization in Process
Industrial Fuel Switch	Fossil Fuel to Natural Gas, LPG Biomass
LULUCF	Plantation / Forestry, Afforestation, Reforestation

The purpose of the project activity is to set up a 1x660 MW Ennore Thermal Power Project, Ennore, Tamil Nadu, India.

The fuel used in the power station will be blended coal (imported + washed coal) for generating electricity with super critical technology which leads to lower greenhouse gas emissions. In the absence of supercritical project activity the same power would have been generated by fossil fuel fired sub-critical plants located in the region. Since the project will use cleaner fuel like washed coal and imported coal the project is eligible for getting carbon credits under clean Development Mechanism of Kyoto Protocol.

8.6.4 Road Map moving ahead

The proposed project needs to be developed under CDM cycle to monetize the carbon credits envisaged from the project. Project will be developed as bilateral CDM project, with CER buyer. CER buyer will take the responsibility to develop and finance the subject project in CDM cycle. CDM Cycle involves following steps and these components will be taken care by CER buyer with no financial implication to TANGEDCO.

8.6.5 CDM project cycle

1 Project Development

- Determine real emissions reduction:
  - ✓ Choose project boundary
  - ✓ Select project baseline
  - ✓ Set crediting period
  - ✓ Calculate emissions reductions
- Develop emissions monitoring and verification protocol
- Prepare investment plan and undertake financial analysis

2. National Approval

- Carry out an Environmental Impact Assessment if required
- Obtain stakeholders comments
- Obtain host country approval

3. Validation and Registration

- Prepare Project Design Document

- Operational Entity evaluates and validates project
- Executive Board registers project

4. **Verification and Certification**

- Operational Entity verifies emissions reduction
- Executive Board certifies project and issues CERs

8.7 Solar Energy Harvesting

The entire plant flat roof buildings are potential area for harvesting solar energy and convert in to useful solar power. This will be based on solar photo voltaic cell panels, which will convert the solar energy to electric energy. All the panels will be wired to a common storage cell, where-from further distribution can be made to different utility. TANGEDCO will approach to such expert agencies that are capable of installing such plant for a proper assessment of the derivable electricity from solar power.

ATTACHMENT – 8.1(A)

THERMAL POWER PLANTS: STACK HEIGHT / LIMITS

Generation Capacity	Stack Height (Meters)
100 MW and above	100 Or H=6.902(QX0.277)0.555 Where Q is emission rate of SO2 in Kg/hr, and H is Stack height in meters Whichever is more
Less than 100 MW	30 Or H=6.902(QX0.277)0.555 Where Q is emission rate of SO2 in Kg/hr, and H is Stack height in meters Whichever is more

Source: *MOEF Notification [33004/99,dated 16th October 2017]*

ATTACHMENT - 8.1(B)

INDIAN NATIONAL AMBIENT AIR QUALITY STANDARDS

S.No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (Notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur dioxide (SO_2) µg/m^3	Annual*	50	20	- Improved West and Gaeke - Ultraviolet fluorescence
		24 hours**	80	80	
2	Nitrogen Dioxide (NO_2)µg/m^3	Annual*	40	30	- Modified Jacob & Hochheiser (Na-Arsenite) - Chemiluscence
		24 hours**	80	80	
3	Particulate Matter (size less than 10 µm) or PM_{10} µg/m^3	Annual*	60	60	- Gravimetric - TOEM
		24 hours**	100	100	- Beta attenuation

4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m^3	Annual* 24 hours**	40 60	40 60	- Gravimetric - TOEM - Beta attenuation
5	Ozone (O_3) µg/m^3	8 hours** 1 hour**	100 180	100 180	- UV photometric - Chemilminescence - Chemical Method
6	Lead (Pb) µg/m^3	Annual* 24 hours**	0.50 1.0	0.50 1.0	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
7	Carbon Monoxide (CO) µg/m^3	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) Spectroscopy
8	Ammonia (NH_3) µg/m^3	Annual* 24 hours**	100 400	100 400	- Chemiluminescence - Indophenol blue method
9	Benzene (C_6H_6) µg/m^3	Annual*	05	05	- Gas chronatmatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo (a) Pyrene (BaP)-particulate phase only, µg/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis

11	Arsenic (As), µg/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), µg/m^3	Annual*	20	20	- ASS /ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note:- Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

Source: *MoEF Noification GSR 826(F) dated 16.11.2009*

ATTACHMENT – 8.2(A)

THERMAL POWER PLANT: STANDARDS FOR LIQUID EFFLUENT

Source	Parameter	Concentration not to be exceed, (mg/l) (except for pH)
Boiler blowdown	Suspended Solids	100
	Oil & Grease	20
	Copper (total)	1.0
	Iron (total)	1.0
Cooling Tower Blowdown	Free available Chlorine	0.5
	Zinc	1.0
	Chromium (Total)	0.2
	Phosphate	5.0
	Other corrosion inhibiting material	Limit to be established on case by case basis.
Ash Pond Effluent	pH	6.5 - 8.5
	Suspended Solid	100
	Oil & Grease	20

Source : *EPA Notification [S.O. 844 (E), dated 19th November1986].*

Attachment – 8.2(B)

INDIAN GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS: EFFLUENTS

S.No.	Parameters	Standards for discharge into/on			
		Inland Surface Water	Public Sewers	Land for Irrigation	Marine Coastal Areas
1.	Colour and odour	*	*	*	*
2.	Suspended solids, mg/l	100	600	200	(a) For process wastewater-100 (b) For cooling water effluent 10% above total suspended matter of influent
3.	Particle size of suspended solids	Shall pass 850 micron IS sieve	ï	ï	(a) Floatable solids, max. 3 mm (b) Settable solids, max. 850 microns
4.	pH value	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
5.	Temperature	Shall not exceed 5^0C above the receiving water temperature	ï	ï	Shall not exceed 7^0C ** above the receiving water temperature

6.	Oil and grease, mg/l	10	20	10	20
7.	Total residual chlorine, mg/l	1.0	-	-	1.0
8.	Ammonical nitrogen, mg/l	50	50	ï	50
9.	Total Kjeldahl nitrogen (as N), mg/l	100	ï	ï	100
10.	Free ammonia (as NH_3),mg/l	5.0	ï	ï	5.0
11.	Biochemical oxygen demand (5 days at 20 ^{0}C), mg/l	30	350	100	100
12.	Chemical oxygen demand, mg/l	250	ï	ï	250
13.	Arsenic (as As), mg/l	0.2	0.2	0.2	0.2
14.	Mercury (as Hg), mg/l	0.01	0.01	ï	0.01
15.	Lead (as Pb), mg/l	0.1	1.0	ï	2.0
16.	Cadmium (as Cd), mg/l	2.0	1.0	ï	2.0

17.	Hexavalent chromium (as Cr^{+6}), mg/l	0.1	2.0	ï	1.0
18.	Total chromium (as Cr),mg/l	2.0	2.0	ï	2.0
19.	Copper (as Cu), mg/l	3.0	3.0	ï	3.0
20.	Zinc (as Zn), mg/l	5.0	15	ï	15
21.	Selenium (as Se), mg/l	0.05	0.05	ï	0.05
22.	Nickel (as Ni), mg/l	3.0	3.0	ï	5.0
23.	Cyanide (as Cn),mg/l	0.2	0.2	0.2	0.2
24.	Fluoride (as F), mg/l	2.0	15	ï	15
25.	Dissolved phosphates (as P), mg/l	5.0	ï	ï	ï
26.	Sulphide (as S), mg/l	2.0	ï	ï	5.0
27.	Phenolic compounds (as C_6H_5OH), mg/l	1.0	5.0	ï	5.0
28.	Radioactive materials (a) Alpha emitters, uc/ml (b) Beta emitters, uc/ml	 10^{-7} 10^{-6}	 10^{-7} 10^{-6}	 10^{-7} 10^{-6}	 10^{-7} 10^{-6}

29.	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
30.	Manganese (as Mn), mg/l	2.0	2.0	ï	2.0
31.	Iron (as Fe), mg/l	3.0	3.0	ï	3.0
32.	Vanadium (as V), mg/l	0.2	0.2	ï	0.2
33.	Nitrate nitrogen, mg/l	10	ï	ï	20

Schedule VI inserted by Rule 2 (d) of the Environment (Protection) Third Amendment Rules,

** 1993 notified vide G.S.R. 801 (E) dated 31.12.1993.

Source : *Pollution Control Acts, Rules and Notifications issued thereunder : Pollution Control Law PCL) / 2 / 1992, published by Member Secretary, Central Pollution Control Board*

ATTACHMENT - 8.3

AMBIENT AIR QUALITY STANDARDS IN RESPECT OF NOISE

Area Code	Category of Area/Zone	Limits in dB(A) L_{eq}.	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note:

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

*dB (A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing

A ñdecibelòis a unit in which noise is measured.

ñAò in dB (A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

Source: *Ministry of Environment and Forests (MoEF) Notification (S.O. 123 (E) dated 14th February 2000), (S.O. 1046 (E) dated 22nd November 2000), (S.O. 1088 (E) dated 11 Oct. 2002), (S.O.1569 (E) dated 19th Sept. 2006) and SO 50 (E) dated11thJanuary 2010 under the Environment (Protection) Act 1986.*

9.0 EXECUTION AND MANAGEMENT

9.1 General

TANGEDCO will arrange to execute the project throôEPC Contractor after completions and carry out operation and maintenance during plant lifetime with their setup.

9.2 Infrastructure Facilities for Construction

9.2.1 Infrastructure Facilities

The proposed 1x660 MW coal based project is a green field plant with no infrastructure already in existence. Adequate mobilization of construction facilities will be organized at various stages for timely and unhindered implementation of the Project. Adequate construction office space and covered storage space is proposed to be utilized for construction activities. These may be retained as site offices, stores, and workshop after the power station is constructed.

In addition to the above, facilities like open storage space, pre-assembly yard for construction period will also be provided. For the construction staff, canteen, medical facilities, safety equipment, rest room, garage, toilets etc. will also be constructed.

9.2.2 Site Access Facilities

i. **Road**

Site is well connected to Chennai City and National Highway No. 5 is about 5 kms from the site. The road will be suitably developed.

No problem is envisaged in accessibility and transportation of heavy equipment to site by road.

9.2.3 Construction Water

The maximum requirement of construction water is estimated to be about 200 Cu.m/hr. The construction water will be sourced out from CM WSSB Authorities taking necessary permission / approval from concerned authorities.

9.2.4 Construction Power

Construction power to the tune of 2.5 to 5 MW is expected to be required during various phases of construction. Since this is an expansion site, a reliable source of construction power will need to be provided.

It is proposed to arrange construction power at 11KV by stepping down from 132 / 33 kV grid supply. For further distribution, smaller rated 11/0.433KV distribution transformers can be arranged.

A number of DG sets each of about 1000~1500 KVA rating may also be required as standby source of construction power and during initial phase of construction before installation of 132 or 33 KV/11kV transformers.

9.2.5 Construction Material

The construction material like Bricks, Stone aggregate, Sand etc will be sourced out from the nearby area whereas Cement, Steel etc will arranged from the bulk suppliers or direct from the manufacturers.

9.2.6 Labour Colony

A temporary labour colony for the construction labour with all relevant facilities and basic amenities will have to be provided by the EPC contractor near to site.

9.3 Construction and Execution

9.3.1 Project Management Organization

The group involved in the implementation of the project will be headed by a Chief Executive Officer (CEO) at the level of CE (Project). He will be the overall in-charge of the project right from the beginning up to the commissioning stage. He will be posted at site and will be responsible for all site activities besides organizing the activities to ensure to complete the job within the time schedule by the contractors.

CEO will be assisted by Executives & Engineers for each discipline of engineering activity.

9.3.2 Quality Assurance

An independent quality assurance group for ensuring the quality during the project engineering, procurement and manufacturing, as well as during material storages will be organized in the Corporate Office. Before the award of any contract the QA Deptt. will discuss with the prospective contractors and finalize mutually acceptable inspection programme and detailed quality plans. The quality plans after discussions and finalization with the contractor form a part of the contract document.

In the post-contract stage, the inspection reports generated by the inspectors will be reviewed to evaluate the quality status with respect the specified levels and to ensure the achievement of the required quality levels.

There will be a close interaction amongst the Engineering wing, Contract Services, Inspection, Expediting and Quality Assurance groups and the project site in arriving at the quality plan and manufacturing and delivery programmes.

To ensure that only technically competent parties are awarded the contract, including those for major civil works, a system of pre-qualification of contractors, based on their technical competence, financial capabilities, past performance is adopted by developer. The enlistment of contractors will be of great help in executing projects in the desired manner.

9.4 Operation and Maintenance

The Operation and Maintenance (O&M) of the power plant will be organized by TANGEDCO as per their set up and norms.

O & M chart is given in **Annexure - 9.1.**

9.4.1 Spare Part Management & Inventory Control System

A full computerized materials management system will be developed for an efficient spare part management which will include stores issues, inventory control, procurement etc. The basic requirement of spare parts inline with norms will be included in the contract. Material management

system will ensure the monitoring of the spare parts consumption during initial phase of operation and forecast the realistic requirements of spares, based on which procurement schedule will be prepared considering the lead time to ensure availability of spares at the right time while maintaining a optimum inventory based on:

a. Proper codification of all spares and consumables.
b. Stores management for storage, preservation, issue and monitoring.
c. Spare parts procurement policy and procedure.
d. Material planning and inventory control.
e. Source development and standardization.

The stores arrangement will include covered and open storage yard with facilities for material handling. Environment controlled rooms will be provided for storage of sensitive spare parts and consumables like electronic cards, chemicals etc.

9.4.2 **Training**

General

The training proposal will consist of the following courses which are based on the Modular System for Training of Owner's operating and maintenance staff.

The sequence and duration of courses will be evident from a separate Training Schedule for each training group. It will show the duration of each training group and will be consistent with the manufacturing and testing schedule in due time.

All courses will be held in the English language of the personnel selected by the Owner at the training facilities on site or in works in different training centers and fabrication and assembly shops as well as testing facilities of the suppliers.

Objectives of the courses

Trainees for operation and maintenance with proven sufficient experience shall start the training directly with the Plant Course.

The Plant Course will be for duration of 6-8 weeks. This will give the trainees an overall conceptual understanding of the layout and operation of the plant systems. Participation in the Plant Course will be mandatory for further training courses and On-the-job training during erection and commissioning of the plant.

The Plant Courses will also be managed at the site training center in ownerûs facilities.

The Maintenance Courses will cover operation / maintenance details for the equipment supplied. The trainees will be divided into groups for each for mechanical, electrical and instrumentation / control engineering. They will be trained in the works with duration of 2-4 weeks for each group.

The Operation Training Course (site-specific training course) will start prior to the start-up of the equipment and systems and will comprise all aspects of plant layout, operation and maintenance. The trainees will be split into groups with erection and commissioning staff. The training will be on plant site and in Ownerûs classrooms equipped with relevant audio-visual aids. This program will be adopted to the significant phases of the

testing and construction activities. To familiarize the trainees with the physical location of the equipment, walks through the plant will be provided.

Training Manager

A Training Manager will ensure that the training topics of the different individual courses will cover al necessary operational and maintenance aspects of the plant. The Training Manager will be at the Site Training Center for the Site Training Period. He will be responsible for the coordinated training of each trainee, and will work together with the responsible Commissioning Manager.

9.5 **Completion Schedule**

a) The first activity to be started at the site, namely the site development work. i.e. leveling, grading etc. will be organized by the successful bidder immediately on the selection of bidder and award of contract.

b) The completion of the units is scheduled as under from zero date.

Original:

1 x 660 MW : 39 months commissioning &
42 months COD (Commercial Operation Date).

The project got stalled due to the financial problem of the EPC Contractor.

Balance works from ñas is where is basis conditionò

36 months from zero date
(33 months to synchronizing and

36 months for COD)

If FGD is also awarded to the same EPC Contractor

(39 months from zero date and

42 months for COD)

Project Schedule is given in **Annexure - 9.2.**

10.0 COST ESTIMATES AND FINANCIAL ANALYSIS

10.1 Cost Estimates

The following assumptions have been made in the preparation of the cost estimates:-

1. The cost of land for 84 acres will be Rs 658.63 crores as per the present rate of land in that area. However, the land for the main plant & equipment staff colony etc. area is in the possession of TANGEDCO and as such the cost has not been included in the cost of generation.

2. The estimate of civil and structural works has been prepared assuming piling to be considered for other areas also if required (e.g. CHP, AHP areas) including TG foundations, Natural Draft Cooling Towers and chimney etc.

3. Freight @ 4% and insurance @ 0.5% for the equipment have been taken.

4. Cost of spares has been taken as 2.5% of the equipment cost i.e. Turbo-Generator, steam generator and balance of plant equipment.

5. Erection, testing and commissioning has been taken as 10% of equipment cost.

6. 3% of Working Capital requirement is capitalized and included as margin money. The margin money has not been considered for the purpose of tariff calculation. This has been limited to 3 % to reduce the project cost.

7. GST has been considered in the cost..

10.2 Financing Structure

It is proposed to finance the project such that Capital structure is built up of:-

Equity Capital	-	20%
Loan Capital	-	80%

The equity capital will be arranged by TANGEDCO / State Contribution.
The debt capital, comprising loan capital and Interest during Construction, will be financed by PFC.

10.3 Interest During Construction

An interest rate of 10.75% has been considered for long-term loans.

Also the payment of interest has been worked out at the end of each quarter of construction period in line with PFC requirements.

10.4 Working Capital

Provision for working capital requirement has been made in line with CERC / TNERC guidelines. These estimates are worked on the basis of

i. 1 month O&M expenses
ii. 2 months receivables
iii. 1 ½ months fuel charges (coal)
iv. 2 months support fuel charges
v. Maintenance & spares 20% of O&M charges.

vi. Maintenance spares @ 1% of historical cost escalated @ 6% p.a of COD.

vii. Interest rate for working capital has been considered as 12.15% per annum.

viii. Discount factor is considered as 13.1%.

10.5 Cost of Generation

Assumptions for working out cost of generation are given below. GOI guideline & TNERC indices, wherever utilized, are marked with asterisk.

➢	Plant Capacity	1x660 MW
➢	Auxiliary Consumption	6 %
➢	Station Heat Rate (K.cal/Kwh)	2066.8 Kcal/Kwh
➢	Depreciation	For Year 1 ï 10 @ 7.00% For Year 11-25 @ 1.33%
➢	O&M	Rs. 18.38 Lakhs/MW/Year
➢	Interest on Loan	10.75 %
➢	Loan period	10 years
➢	Loan repayment	60 equal quarterly installments with 6 months moratorium
➢	GCV of blended coal	
➢	(i) Best Coal (100% imported coal)	5642 kcal/kg
➢	(ii) Design Coal (70% imported & 30% domestic coal)	4789 kcal/kg
➢	(iii) Worst Coal (50% Domestic & 50% Imported)	4221 kcal/kg
➢	Present day Coal Price	
➢	Domestic Coal	Rs 2898 / tonne

➢	Imported Coal	Rs 6293 / tonne		
➢	GCV of Support fuel	10,000 kcal/kg		
➢	Support fuel present day price	` 45,000/tonne on delivered basis @ 4.0% annual escalation.		
➢	PLF	85%		
➢	Return on equity	14%		
➢	Completion Schedule	42 months		
➢	Life of plant	25 years		
➢		Best coal (100% Imported)	Design coal (70% Imported & 30% Domestic)	Worst coal (50% Imported & 50% Domestic)
➢	Cost of Project excluding IDC	5128.72 Crores	5128.72 Crores	5128.72 Crores
➢	Interest During Construction	572.07 Crores	572.07 Crores	572.07 Crores
➢	Cost of Project including IDC and land cost, margin money	6380.81 Crores	6380.81 Crores	6380.81 Crores
➢	Cost/ MW	9.67 Crores	9.67 Crores	9.67 Crores
➢	First year tariff at 85% PLF	5.36/Kwh	5.36/Kwh	5.36/Kwh
➢	Levellised Tariff at 85% PLF	5.32/Kwh	5.32/Kwh	5.32/Kwh

Capital cost and other financial computations are as per following tables:

INPUT

		70% Imported Coal & 30% Indian Coal			
No. Of Unit		1	No.		
Each unit capacity		660	MW		
Total plant Capacity		660	MW		
PLF		85%			
Project Completation Period		39	36	Months	
Anticipated LOI Date		Jul-14	Jan-19		
Project COD		Aug-17	Dec-21		
Exchange Rate-		Mar-13	Jan-19		
	1 US$ =	54.64	70.94	`	
Intrest Rate -					
Pre COD		10.75%			
Post COD		10.75%			
Intrest on WC		12.15%			
Debt		80%			
Equity		20%			
Plant Life		25	Year		
Fuel		Coal			
Blended Fuel price on delivered basis		5275	`/tonne	(Domestic = 2898 Rs/tonne & Imported = 6293 Rs/tonne)	
Esclation on fuel price		1.70%	/ Year		
Blended Coal GCV (70% Imported & 30% Domestic)		4789.4	Kcal/kg	(Domestic = 2800 kcal/kg & Imported = 5642 kcal/kg)	
Station Heat Rate		2066.8	Kcal/kwh		
Aux. Consumption		6%			
Support fuel		HFO / LDO			
Price		47400	`/tonne		
Esclation on fuel price		1%			
GCV		10000	Kcal/kg		
Oil Consumption		0.5	ml/kwh		
Specific Consumption coal		0.456	kg/kWHr		
Sp. Gravity of oil		0.9			
MAT		21.34%			
Corporate Tax		34.61%			
ROE (base rate)		14.00%			
1 - 10 Years		17.80%			
11 - 25 Years		21.41%			
Depreciation(Equipment Cost)					
1 - 10 Years		5.28%			
11-25 Years		2.05%			
Depreciation(Civil Works)					
1 - 24 Years		3.34%			
25 Years		9.84%			
Discounting factor		13.10%			
O&M		18.38	Lac/MW/Year		FY 2018-19
Annual Esc. On O&M		5.72%			
Cost of Lime Stone /Tonne for FGD					
Cost of Ammonia /Cubic meter for SCR					

TANGEDCO

1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT

ESTIMATED PROJECT COST

		Mar-13	Jan-19
Exchange Rate: 1 USD = `		54.64	70.94

* F.C - Foreign component in million US$

** D.C - Domestic Component in ` Crores

Sl. No.	DESCRIPTION	COMPLETED COST							
		EPC Cost		Non-EPC Cost		Total Cost		Grand Total	
		F.C.*	D.C**	F.C.*	D.C.**	F.C.*	D.C.**	` in crores	
1	Design & Engineering		5.00					5.00	
2a	Supply of Equipments including special tools and tackles (Ex works) price	90.82	1584.99					**2229.29**	
b	Charges for Inland transportation, port clearance & handling charges, inland transit insurance, unloading and storage.		21.44					**21.44**	
c	Supply of FGD & SCR including special tools and tackles, Mandatory spares, ETC, freignt, insurance etc.		450.00					**450.00**	
	Type Test Charges	0.38	10.00					**12.70**	
	Total Equipment Cost incl. Freight & Insurance	**91.20**	**2071.43**					**2718.43**	
3	Erection of equipment, testing and commissioning charges		197.10					197.10	
4	Civil Works		1050.84					1050.84	
	Total works Cost		**1247.94**					**1247.94**	
5	Mandatory Spares	23.28	55.98					**221.14**	
6	Workshop and laboratory equipment		6.78					**6.78**	
7	Taxes & duties		720.79					**720.79**	
	Total-EPC Cost	**114.48**	**4102.92**		**22.33**	**114.48**	**4080.59**	**4892.75**	**7.41 Crores/MW**
8	Contingency @ 2.5% of Total works				31.20		31.20	31.20	
9	Establishment Costs @ 1% of Total Project Cost				51.29		51.29	51.29	
10	Consultancy & Engineering @ 0.25% of Total EPC Cost				37.23		37.23	37.23	
11	Quarters (Township, Colony & Amenities)				50.00		50.00	50.00	
12	CSR				5.00		5.00	5.00	
13	Site Development				15.00		15.00	15.00	
14	Start up Fuel				10.00		10.00	10.00	
15	Road to Ash Dyke and Silo				15.00		15.00	15.00	
16	HT Line Shifting				15.00		15.00	15.00	
17	Office Construction/ Modification & provision of facilities				3.50		3.50	3.50	
18	Power Supply facility improvement				1.50		1.50	1.50	
19	Training				1.00		1.00	1.00	
20	Audit & Account @ 0.005% of Total Project Cost				0.26		0.26	0.26	
	Total- Non EPC Cost				**235.97**		**235.97**	**235.97**	
21	**Project cost excluding IDC & Financing costs (EPC + Non EPC)**	**114.48**	**4102.92**		**235.97**	**114.48**	**4316.56**	**5128.72**	**7.77 Crores/MW**
22	Margin Money				16.26		16.26	16.26	
23	Land Cost				658.63		658.63	658.63	
i)	Financing Expenses @ 0.1% of Total Project Cost				5.13		5.13	5.13	
ii)	Interest During Construction				572.07		572.07	572.07	
	Total Project cost including IDC & FC		**4102.92**		**1488.07**		**5590.99**	**6380.81**	**9.67 Crores/MW**

NOTE: Statement of acoounts in the EPC Contract awarded to M/s LITL(If taken into account)

1	**Total Expenditure (including retension)**							**703.21**	**10.73 Crores/MW**
2	**Advance paid to M/s LITL**							**334.80**	
3	**Interest to PFC for the project portion**							**382.45**	
4	**Retention amount in TANGEDCO A/c**						**81.56**		
5	**Advance BGs invoked and credited**						**335.8**		
6	**SDBG invoked and credited +EMD**						**392.15**		
	Total Expenditure (including retension)						**809.51**	**1420.46**	
5	**Net Expenditure (1420.46-809.51)**							**610.95**	**10.02 Crores/MW**
6	**Net Claim filed with the RP / Liquidator**					**1882.03**			
7	**Admitted claim amount by RP/Liquidator**						***708.34**		*** to be realised**

TANGEDCO
1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT

Phasing of Expenditure & IDC Calculation
(All Figures in `)

Project Cost without IDC			5150.11	Crores
Project Completion Period			36	Months
Debt(%)			80%	
Debt (including IDC)			0.00	Crores
Equity(%)			20%	
Equity			0.00	Crores
Project Cost including IDC			0.00	Crores
Rate of interest			10.75%	
No. of Installment/year			4	

IDC 572.07 Crores

Quarterly Installment		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Phased Expenditure(%)		**10**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**10**	**15**	**15**	**15**
Phased Expenditure		515.01	257.51	257.51	257.51	257.51	257.51	257.51	257.51	515.01	772.52	772.52	772.52
Fund Requirement arranged from	Equity	103.00	51.50	51.50	51.50	51.50	51.50	51.50	51.50	103.00	154.50	154.50	154.50
	Debt	412.01	206.00	206.00	206.00	206.00	206.00	206.00	206.00	412.01	618.01	618.01	618.01
Opening Balance	Equity	0.00	104.11	158.40	213.86	270.52	328.39	387.50	447.89	509.57	624.64	794.23	967.47
	Debt	0.00	416.44	633.61	855.45	1082.06	1313.55	1550.01	1791.55	2038.29	2498.55	3176.93	3869.89
Total Equity		103.00	155.61	209.90	265.36	322.02	379.89	439.00	499.39	612.57	779.14	948.73	1121.98
Total Debt		412.01	622.44	839.62	1061.46	1288.07	1519.55	1756.01	1997.56	2450.30	3116.56	3794.94	4487.90
IDC		5.54	13.96	19.80	25.76	31.85	38.07	44.42	50.92	60.32	75.45	93.68	112.31
Arrangement of Interest & Upfront payment from	Equity	1.11	2.79	3.96	5.15	6.37	7.61	8.88	10.18	12.06	15.09	18.74	22.46
	Debt	4.43	11.17	15.84	20.61	25.48	30.46	35.54	40.73	48.25	60.36	74.95	89.85
Closing Balance of	Equity	104.11	158.40	213.86	270.52	328.39	387.50	447.89	509.57	624.64	794.23	967.47	1144.44
	Debt	416.44	633.61	855.45	1082.06	1313.55	1550.01	1791.55	2038.29	2498.55	3176.93	3869.89	4577.75
Debt : Equity Ratio		**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**	**4.00**
Net Requirement of Fund	Equity	104.11	54.29	55.46	56.65	57.87	59.12	60.39	61.68	115.07	169.59	173.24	176.96
	Debt	416.44	217.17	221.84	226.61	231.48	236.46	241.54	246.74	460.26	678.38	692.96	707.86

1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT
Tariff Sheet (70% Imported Coal & 30% Domestic Coal)

Project:	1X660 MW Ennore TPS	
Plant Load Factor (PLF):	85%	
Plant Life :	25	Year

Capacity (MW)	**660**

Project Cost			
`	6364.55	(##)	
Total Eq. ` (Crores)	6364.55		
FINANCING			
DEBT			
` (Crores)	5091.64		
Total Debt ` (Crores)	5091.64		80%
EQUITY			
` (Crores)	1272.91		
Total Equity ` (Crores)	1272.91		20%

Fuel	**Coal**		Esc*.	**Support fuel**	**HFO / LDO**		Esc.
Price	5275	`/tonne	1.70%	Price	47400	`/tonne	1.00%
GCV	4789	Kcal/Kg		GCV	10000	Kcal/Kg	
Transportation Charge (incl. Above)				Transportation charge(incl.above)			
SHR	2067	kCal/kWh		Oil Consumption*	0.50	ml/kwh	
Aux. Cons*	6.00%			Sp.Gr.	0.90		
Dep'tion for 1-10 years	5.28%						
Dep'tion for 11-25 years	2.05%						
	Mar-13	Jan-19					
Exchange Rate	54.64	70.94	`/US$				
ROE	14.00%						
Int. on WC	12.15%						
Dis'ting Factor*	13%						
Int. on Long term loan	10.75%						
O&M Cost	1.90%	5.72%	Annual Esclation				

LEVELLIZED TARIFF AT 85% PLF	**5.32**	**`/KWh**

* As per CERC norms

(##) - Margin money is excluded for the purpose of Tariff Calculations.

1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT
Tariff Sheet (70% Imported Coal & 30% Domestic Coal)

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
US$ Exchange Rate		70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94	70.94
Coal price `/tonne		5275.00	5364.68	5455.87	5548.62	5642.95	5738.88	5836.44	5935.66	6036.57	6139.19	6243.56	6349.70	6457.64	6567.42	6679.07	6792.61	6908.09	7025.52	7144.96	7266.42	7389.95	7515.58	7643.34	7773.28	7905.43
Transportation Cost		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
Coal price at site `/tonne		5275.00	5364.68	5455.87	5548.62	5642.95	5738.88	5836.44	5935.66	6036.57	6139.19	6243.56	6349.70	6457.64	6567.42	6679.07	6792.61	6908.09	7025.52	7144.96	7266.42	7389.95	7515.58	7643.34	7773.28	7905.43
Supp.Fuel price `/tonne		47400.00	47874.00	48352.74	48836.27	49324.63	49817.88	50316.06	50819.22	51327.41	51840.68	52359.09	52882.68	53411.51	53945.62	54485.08	55029.93	55580.23	56136.03	56697.39	57264.36	57837.01	58415.38	58999.53	59589.53	60185.42
Transportation Cost		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
supp.Fuel site price `/tonne		47400.00	47874.00	48352.74	48836.27	49324.63	49817.88	50316.06	50819.22	51327.41	51840.68	52359.09	52882.68	53411.51	53945.62	54485.08	55029.93	55580.23	56136.03	56697.39	57264.36	57837.01	58415.38	58999.53	59589.53	60185.42
Gross Units Generated			Million Units																							
PLF																										
	85%	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	4914.36
Net Units Sent Out			Million Units																							
PLF																										
	85%	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50	4619.50
Coal Charge `/Kwh		2.28	2.32	2.35	2.39	2.44	2.48	2.52	2.56	2.60	2.65	2.69	2.74	2.79	2.83	2.88	2.93	2.98	3.03	3.08	3.14	3.19	3.24	3.30	3.35	3.41
Total Variable Charge `/kwh		2.28	2.32	2.35	2.39	2.44	2.48	2.52	2.56	2.60	2.65	2.69	2.74	2.79	2.83	2.88	2.93	2.98	3.03	3.08	3.14	3.19	3.24	3.30	3.35	3.41
Total Variable Cost			` (Crores)																							
PLF																										
	85%	1118.68	1137.70	1157.04	1176.71	1196.71	1217.06	1237.75	1258.79	1280.19	1301.95	1324.09	1346.60	1369.49	1392.77	1416.45	1440.53	1465.01	1489.92	1515.25	1541.01	1567.21	1593.85	1620.94	1648.50	1676.52
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**
Fixed cost ` (crores)																										
Interest on INR Loan		545.07	515.42	478.93	442.44	405.95	369.46	332.97	298.76	262.27	225.78	189.29	152.80	116.31	79.82	43.33	6.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation (Equipment Cost)		280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88
Depreciation (Civil Works)		35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	103.40
O&M Charges		121.00	127.92	135.24	142.97	151.15	159.80	168.94	178.60	188.82	199.62	211.03	223.11	235.87	249.36	263.62	278.70	294.64	311.50	329.31	348.15	368.06	389.12	411.38	434.91	459.78
Supp.fuel charge		10.48	10.59	10.69	10.80	10.91	11.02	11.13	11.24	11.35	11.46	11.58	11.69	11.81	11.93	12.05	12.17	12.29	12.41	12.54	12.66	12.79	12.92	13.05	13.18	13.31
Return on Equity		226.55	226.55	226.55	226.55	226.55	226.55	226.55	226.55	226.55	226.55	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53	272.53
Tax On Income		73.83	73.86	73.89	73.91	73.94	73.97	74.00	74.03	74.06	74.09	168.95	169.01	169.07	169.14	169.20	169.26	169.33	169.39	169.46	169.53	169.59	169.66	169.73	169.80	206.02
Int. on Working Capital at 85%		65.87	66.23	66.49	66.79	67.11	67.48	67.88	68.37	68.85	69.38	69.32	69.94	70.62	71.34	72.12	72.96	74.48	76.20	77.98	79.84	81.77	83.78	85.87	88.04	92.46
Total Fixed cost at 85%		1358.46	1336.24	1307.46	1279.13	1251.28	1223.94	1197.13	1173.22	1147.57	1122.56	1066.68	1043.06	1020.19	998.10	976.83	956.45	967.25	986.01	1005.80	1026.69	1048.72	1071.98	1096.52	1122.43	1256.39
Fixed Cost per Unit at 85%		2.94	2.89	2.83	2.77	2.71	2.65	2.59	2.54	2.48	2.43	2.31	2.26	2.21	2.16	2.11	2.07	2.09	2.13	2.18	2.22	2.27	2.32	2.37	2.43	2.72

1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT
Tariff Sheet (70% Imported Coal & 30% Domestic Coal)

Payment of Fixed Cost ` (Crores)		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
	85%	1358.46	1336.24	1307.46	1279.13	1251.28	1223.94	1197.13	1173.22	1147.57	1122.56	1066.68	1043.06	1020.19	998.10	976.83	956.45	967.25	986.01	1005.80	1026.69	1048.72	1071.98	1096.52	1122.43	1256.39
	85%	2.94	2.89	2.83	2.77	2.71	2.65	2.59	2.54	2.48	2.43	2.31	2.26	2.21	2.16	2.11	2.07	2.09	2.13	2.18	2.22	2.27	2.32	2.37	2.43	2.72
Levellised Fixed `/kWh																										
	85%	2.94	2.56	2.21	1.91	1.66	1.43	1.24	1.07	0.93	0.80	0.67	0.58	0.50	0.44	0.38	0.33	0.29	0.26	0.24	0.21	0.19	0.17	0.16	0.14	0.14
	85%	**2.61**																								
Payment of Fixed Cost +Variable Charge ` (Crores)																										
	85%	2477.15	2473.94	2464.50	2455.84	2448.00	2441.00	2434.88	2432.01	2427.76	2424.51	2390.77	2389.66	2389.68	2390.87	2393.28	2396.97	2432.26	2475.93	2521.05	2567.69	2615.93	2665.83	2717.47	2770.93	2932.91
`/kwh																										
	85%	5.36	5.36	5.33	5.32	5.30	5.28	5.27	5.26	5.26	5.25	5.18	5.17	5.17	5.18	5.18	5.19	5.27	5.36	5.46	5.56	5.66	5.77	5.88	6.00	6.35
Levellised Total Tariff																										
		5.36	**4.74**	**4.17**	**3.67**	**3.24**	**2.86**	**2.52**	**2.22**	**1.96**	**1.73**	**1.51**	**1.34**	**1.18**	**1.04**	**0.92**	**0.82**	**0.73**	**0.66**	**0.60**	**0.54**	**0.48**	**0.44**	**0.39**	**0.35**	**0.33**
	85%	**5.32**																								

INR Loan		**5091.64 ` (Crores)**														
Interest		10.75%														
Repayment Period		15 YEARS														
Qtr-1																
Outstanding loan	5091.64	4921.92	4582.48	4243.03	3903.59	3564.15	3224.71	2885.26	2545.82	2206.38	1866.93	1527.49	1188.05	848.61	509.16	169.72
Interest	136.84	132.28	123.15	114.03	104.91	95.79	86.66	77.54	68.42	59.30	50.17	41.05	31.93	22.81	13.68	4.56
Repayment		84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86
Qtr-2																
Outstanding loan	5091.64	4837.1	4497.6	4158.17	3818.7	3479.3	3139.8	2800.4	2460.96	2121.52	1782.07	1442.63	1103.19	763.75	424.30	84.86
Interest	136.84	130.0	120.9	111.75	102.6	93.5	84.4	75.26	66.14	57.02	47.89	38.77	29.65	20.53	11.40	2.28
Repayment		84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86
Qtr-3																
Outstanding loan	5091.64	4752.20	4412.75	4073.31	3733.87	3394.43	3054.98	2715.54	2376.10	2036.66	1697.21	1357.77	1018.33	678.89	339.44	
Interest	136.84	127.72	118.59	109.47	100.35	91.23	82.10	75.26	66.14	57.02	47.89	38.77	29.65	20.53	11.40	
Repayment	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	
Qtr-4																
Outstanding loan	5006.78	4667.34	4327.89	3988.45	3649.01	3309.57	2970.12	2630.68	2291.24	1951.80	1612.35	1272.91	933.47	594.02	254.58	
Interest	134.56	125.43	116.31	107.19	98.07	88.94	79.82	70.70	61.58	52.45	43.33	34.21	25.09	15.96	6.84	
Repayment	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	84.86	
Total Interest	545.07	515.42	478.93	442.44	405.95	369.46	332.97	298.76	262.27	225.78	189.29	152.80	116.31	79.82	43.33	6.84

Total Intrest ` (Crores)	545.07	515.42	478.93	442.44	405.95	369.46	332.97	298.76	262.27	225.78	189.29	152.80	116.31	79.82	43.33	6.84

Working Capital																										
Fuel Charges (1 months)	93.22	94.81	96.42	98.06	99.73	101.42	103.15	104.90	106.68	108.50	110.34	112.22	114.12	116.06	118.04	120.04	122.08	124.16	126.27	128.42	130.60	132.82	135.08	137.37	139.71
Support fuel charges (2 Months)	1.75	1.76	1.78	1.80	1.82	1.84	1.85	1.87	1.89	1.91	1.93	1.95	1.97	1.99	2.01	2.03	2.05	2.07	2.09	2.11	2.13	2.15	2.17	2.20	2.22
One month O&M	10.08	10.66	11.27	11.91	12.60	13.32	14.08	14.88	15.73	16.63	17.59	18.59	19.66	20.78	21.97	23.23	24.55	25.96	27.44	29.01	30.67	32.43	34.28	36.24	38.32
Maintenance spares	24.20	25.58	27.05	28.59	30.23	31.96	33.79	35.72	37.76	39.92	42.21	44.62	47.17	49.87	52.72	55.74	58.93	62.30	65.86	69.63	73.61	77.82	82.28	86.98	91.96
Two months Receivables	412.86	412.32	410.75	409.31	408.00	406.83	405.81	405.34	404.63	404.08	398.46	398.28	398.28	398.48	398.88	399.50	405.38	412.65	420.18	427.95	435.99	444.30	452.91	461.82	488.82
Total Working Capital	542.11	545.14	547.27	549.67	552.37	555.37	558.68	562.71	566.70	571.05	570.52	575.66	581.20	587.18	593.62	600.53	612.99	627.14	641.84	657.12	673.01	689.53	706.72	724.62	761.02

1 X 660 MW ENNORE THERMAL POWER STATION EXPANSION PROJECT
Tariff Sheet (70% Imported Coal & 30% Domestic Coal)

FINANCIAL ANALYSIS : Projected Profit & loss account for 25 years at 85% PLF

All figures are in ` (Crores)

	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
1	Income from sale of power	2477.15	2473.94	2464.50	2455.84	2448.00	2441.00	2434.88	2432.01	2427.76	2424.51	2390.77	2389.66	2389.68	2390.87	2393.28	2396.97	2432.26	2475.93	2521.05	2567.69	2615.93	2665.83	2717.47	2770.93	2932.91
2	Add :Other income	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
3	Total Income (1+2)	2477.15	2473.94	2464.50	2455.84	2448.00	2441.00	2434.88	2432.01	2427.76	2424.51	2390.77	2389.66	2389.68	2390.9	2393.28	2396.97	2432.26	2475.93	2521.05	2567.69	2615.93	2665.83	2717.47	2770.93	2932.91
4	Cost of fuel	1118.68	1137.70	1157.04	1176.71	1196.71	1217.06	1237.75	1258.79	1280.19	1301.95	1324.09	1346.60	1369.49	1392.77	1416.45	1440.53	1465.01	1489.92	1515.25	1541.01	1567.21	1593.85	1620.94	1648.50	1676.52
5	Operation & maintenance	121.00	127.92	135.24	142.97	151.15	159.80	168.94	178.60	188.82	199.62	211.03	223.11	235.87	249.36	263.62	278.70	294.64	311.50	329.31	348.15	368.06	389.12	411.38	434.91	459.78
6	Earning before interest, depreciation,tax (EBDIT) (3-4-5)	1237.46	1208.32	1172.22	1136.16	1100.13	1064.15	1028.20	994.62	958.76	922.94	855.65	819.96	784.32	748.74	713.21	677.75	672.60	674.51	676.49	678.54	680.66	682.86	685.15	687.52	796.60
8	Depreciation (Equipment Cost)	280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	280.56	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88	108.88
9	Depreciation (Civil Work))	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	35.10	103.40
10	Earning before interest, tax (EBIT) (6-7)	956.90	927.75	891.66	855.59	819.57	783.58	747.63	714.06	678.19	642.38	746.77	711.08	675.44	639.86	604.33	568.87	563.73	565.63	567.61	569.66	571.78	573.98	576.27	578.65	687.73
12	Interest on working capital	65.87	66.23	66.49	66.79	67.11	67.48	67.88	68.37	68.85	69.38	69.32	69.94	70.62	71.34	72.12	72.96	74.48	76.20	77.98	79.84	81.77	83.78	85.87	88.04	92.46
13	Interest on Long-term loan	545.07	515.42	478.93	442.44	405.95	369.46	332.97	298.76	262.27	225.78	189.29	152.80	116.31	79.82	43.33	6.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Profit before tax (PBT) (8-9-10)	345.96	346.10	346.23	346.37	346.50	346.64	346.78	346.92	347.07	347.21	488.16	488.34	488.51	488.70	488.88	489.06	489.25	489.44	489.63	489.82	490.01	490.21	490.40	490.60	595.26
15	Tax (MAT on PBT for first 10 yrs)	73.83	73.86	73.89	73.91	73.94	73.97	74.00	74.03	74.06	74.09	168.95	169.01	169.07	169.14	169.20	169.26	169.33	169.39	169.46	169.53	169.59	169.66	169.73	169.80	206.02
16	Profit after tax (PAT) (11-12)	272.13	272.24	272.35	272.45	272.56	272.67	272.78	272.89	273.00	273.12	319.21	319.32	319.44	319.56	319.68	319.80	319.92	320.04	320.17	320.29	320.42	320.55	320.68	320.81	389.24

DSCR Calculation

	EBDIT	1237.46	1208.32	1172.22	1136.16	1100.13	1064.15	1028.20	994.62	958.76	922.94	855.65	819.96	784.32	748.74	713.21	677.75	672.60	674.51	676.49	678.54	680.66	682.86	685.15	687.52	796.60
	Interest	545.07	515.42	478.93	442.44	405.95	369.46	332.97	298.76	262.27	225.78	189.29	152.80	116.31	79.82	43.33	6.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Principal Repayment	169.72	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	339.44	169.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	DSCR	1.73	1.41	1.43	1.45	1.48	1.50	1.53	1.56	1.59	1.63	1.62	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
	Average DSCR	**1.53**																								

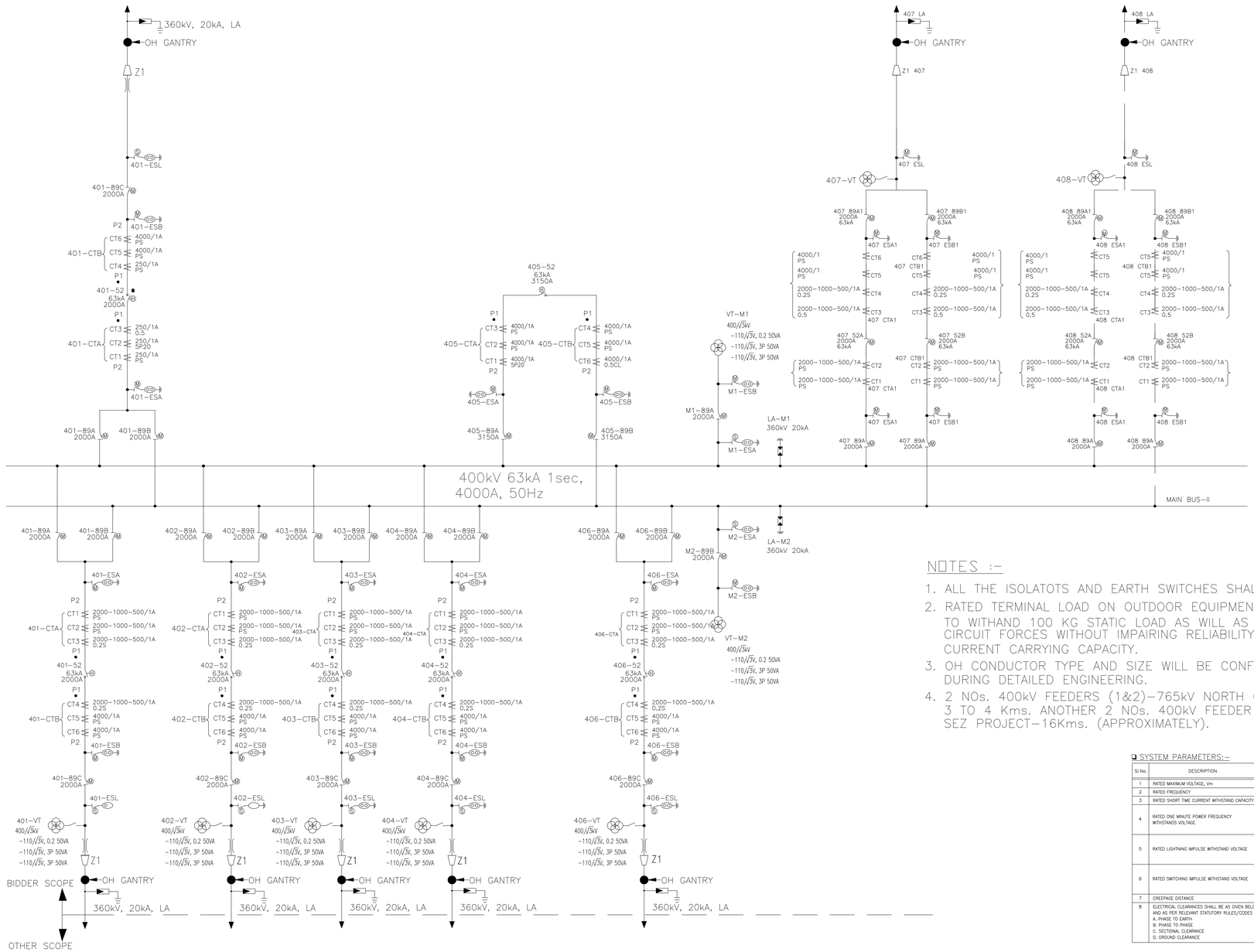
FINANCIAL ANALYSIS : Profitability indicators

IRR Calculation

	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Capital Expenditure	6364.55																								
	EBDIT		1237.46	1208.32	1172.22	1136.16	1100.13	1064.15	1028.20	994.62	958.76	922.94	855.65	819.96	784.32	748.74	713.21	677.75	672.60	674.51	676.49	678.54	680.66	682.86	685.15	687.52
	Net Cash flow	-6364.55	1237.46	1208.32	1172.22	1136.16	1100.13	1064.15	1028.20	994.62	958.76	922.94	855.65	819.96	784.32	748.74	713.21	677.75	672.60	674.51	676.49	678.54	680.66	682.86	685.15	687.52
	IRR	**15.98%**																								

BAY DESIGNATION	401A	401	402	403	404	405	406	407	408
BAY DESCRIPTION	SPARE BAY (EQUIPPED)	BUS REACTOR	2 x 660 MW ENNORE SEZ FEEDER-2	2 x 660 MW ENNORE SEZ FEEDER-1	765kV NORTH CHENNAI POOLING STATION FEEDER-2	BUS COUPLER	765kV NORTH CHENNAI POOLING STATION FEEDER-1	BUS VT/ES	GT	GT FUTURE (UNEQUIPPED)

BAY CIRCUIT



TECHNICAL DATA

NOTE

1. THE DESCRIBED EQUIPMENTS ARE 400kV RATINGS.

CT DATA

DEVICE NO.	CT NO.	CTA			CTB		
	SPEC.	CT1	CT2	CT3	CT4	CT5	CT6
401 BAY	Ratio[A/A]	250/1	250/1	250/1	250/1	4000/1	4000/1
	Vk[V]	>250			>250	>4000	>4000
	Im[mA] at Vk	DDE	DDE	DDE	DDE	DDE	DDE
	Rct[Ohm]	DDE	DDE	DDE	DDE	DDE	DDE
	Accuracy class	PS	5P20	0.5	PS	PS	PS
	APPLICATION	PROTECTION	METERING	METERING	PROTECTION	PROTECTION	PROTECTION

DEVICE NO.	CT NO.	CTA			CTB		
	SPEC.	CT1	CT2	CT3	CT4	CT5	CT6
402 BAY 403 BAY 404 BAY 406 BAY 407A BAY	Ratio[A/A]	2000/1000/500-1A	2000/1000/500-1A	2000/1000/500-1A	2000/1000/500-1A	4000/1	4000/1
	Vk[V]	>2000	>2000			>4000	>4000
	Im[mA] at Vk	DDE	DDE	DDE	DDE	DDE	DDE
	Rct[Ohm]	DDE	DDE	DDE	DDE	DDE	DDE
	Accuracy class	PS	PS	0.25	0.25	PS	PS
	APPLICATION	PROTECTION	PROTECTION	METERING	METERING	PROTECTION	PROTECTION

DEVICE NO.	CT NO.	CTA			CTB		
	SPEC.	CT1	CT2	CT3	CT4	CT5	CT6
405 BAY	Ratio[A/A]	4000/1	4000/1	4000/1	4000/1	4000/1	4000/1
	Vk[V]	DDE	>4000	>4000	>4000	>4000	DDE
	Im[mA] at Vk		DDE	DDE	DDE	DDE	
	Rct[Ohm]		DDE	DDE	DDE	DDE	
	Accuracy class	5P20	PS	PS	PS	PS	0.5
	APPLICATION	METERING	PROTECTION	PROTECTION	PROTECTION	PROTECTION	METERING

DEVICE NO.	CT NO.	CTA			CTB		
	SPEC.	CT1	CT2	CT3	CT4	CT5	CT6
407 BAY 408 BAY	Ratio[A/A]	2000/1000/500-1A	2000/1000/500-1A	2000/1000/500-1A	2000/1000/500-1A	4000/1	4000/1
	Vk[V]	>2000	>2000			>4000	>4000
	Im[mA] at Vk	DDE	DDE	DDE	DDE	DDE	DDE
	Rct[Ohm]	DDE	DDE	DDE	DDE	DDE	DDE
	Accuracy class	PS	PS	0.5	0.25	PS	PS
	APPLICATION	PROTECTION	PROTECTION	METERING	METERING	PROTECTION	PROTECTION

VT DATA

SPECIFICATION	40*-VT, VT-M*		
	3'DRY 1	3'DRY 2	3'DRY 3
PRIMARY VOLTAGE[kV]		400/√3	
SECONDARY VOLTAGE[V]	110/√3	110/√3	110/√3
ACCUPACY	0.2	3P	3P
BURDEN[VA]	50	50	50
APPLICATION	PROTECTION	PROTECTION	METERING

LEGEND

SYMBOL	DEVICE NO.	DESCRIPTION	OPERATION TYPE	QUANTITY
	40*-52	CIRCUIT BREAKER WITHOUT PIR	HYDRAULIC, MANUAL	3# INDIVIDUAL OPERATED, 75A
	401-52	CIRCUIT BREAKER WITH CONTROL SWITCHING DEVICE	HYDRAULIC, MANUAL	3# INDIVIDUAL OPERATED, 11A
	40*-89A, 89B, 89C, 89D, M*-89A	DISCONNECTING SWITCH	MOTOR DRIVEN, MANUAL	3# GROUP OPERATED, 25EA
	40*-ESA, ESB, ESC M*-ESA, M*-ESB	MAINTENANCE EARTHING SWITCH	MOTOR DRIVEN, MANUAL	3# GROUP OPERATED, 18EA
	40*-ESL	HIGH SPEED EARTHING SWITCH	MOTOR SPRING DRIVEN, MANUAL	3# INDIVIDUAL OPERATED, 9EA
	CT1, CT2, CT3, CT4, CT5, CT6	CURRENT TRANSFORMER	RING TYPE	1#, 14AEA
	40*-VT	VOLTAGE TRANSFORMER (1#VT X 3) WITH MANUAL ISOLATING DEVICE	INDUCTIVE TYPE	1#, 2AEA
	LA-M*	LIGHTNING ARRESTER (1# LA X 3)	GAPLESS TYPE	1#, 6EA
	Z1	GAS TO AIR BUSHING WITH BUS DUCT		1#, 21EA

NOTES :-

1. ALL THE ISOLATOTS AND EARTH SWITCHES SHALL BE MOTORIZED.
2. RATED TERMINAL LOAD ON OUTDOOR EQUIPMENT WILL BE ADEQUATE TO WITHAND 100 KG STATIC LOAD AS WILL AS WIND SEISMIC AND SHORT CIRCUIT FORCES WITHOUT IMPAIRING RELIABILITY OR CURRENT CARRYING CAPACITY.
3. OH CONDUCTOR TYPE AND SIZE WILL BE CONFIRMED DURING DETAILED ENGINEERING.
4. 2 NOs. 400kV FEEDERS (1&2)-765kV NORTH CHENNAI POOLING STATION 3 TO 4 Kms. ANOTHER 2 NOs. 400kV FEEDER (3&4)-ENNORE SEZ PROJECT-16Kms. (APPROXIMATELY).

SYSTEM PARAMETERS:-

Sl.No.	DESCRIPTION	VALUE
1	RATED MAXIMUM VOLTAGE, Vm	420kV
2	RATED FREQUENCY	50Hz
3	RATED SHORT TIME CURRENT WITHSTAND CAPACITY	63kA/1sec.
4	RATED ONE MINUTE POWER FREQUENCY WITHSTANDS VOLTAGE	A) 650kV rms PHASE TO EARTH B) 815kV rms ACROSS OPEN SWITCHING DEVICE AND ISOLATING DISTANCE
5	RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE	A) 1425kVp PHASE TO EARTH B) 1425(+240)kVp ACROSS OPEN SWITCHING DEVICE AND ISOLATING DISTANCE
6	RATED SWITCHING IMPULSE WITHSTAND VOLTAGE	A) 1050kVp PHASE TO EARTH AND ACROSS OPEN SWITCHING DEVICE B) 900(+345)kVp ACROSS ISOLATING DISTANCE
7	CREEPAGE DISTANCE	MIN. 31 mm/kV
8	ELECTRICAL CLEARANCES SHALL BE AS GIVEN BELOW AND AS PER RELEVANT STATUTORY RULES/CODES A. PHASE TO EARTH B. PHASE TO PHASE C. SECTIONAL CLEARANCE D. GROUND CLEARANCE	 3500 mm 4000 mm 6500 mm 8000 mm

FOR TENDER PURPOSE ONLY

NOTES

1. DO NOT SCALE, ASK WHEN IN DOUBT.

NOTICE

SR. No.	PARTY
PRINT DISTRIBUTION	

ZONE	MARK	PARTICULARS
	0	PRELIMINARY

6 REVISIONS

DATE	CIVIL	MECH.	ELEC.	C&I	H.O.D.
04.09.18					

APPROVED

SELF - RELIANCE IN ENGINEERING DESEIN

CONSULTANT: DESEIN
CONSULTING ENGINEERS
NEW DELHI - INDIA

CLIENT: TAMILNADU GENERATION & DISTRIBUTION CORPORATION CHENNAI, TAMILNADU

PROJECT: 1X660 MW SUPERCRITICAL ENNORE THERMAL POWER STATION EXPANSION PROJECT

TITLE :- 400kV GIS SINGLE LINE DIAGRAM

APPRD. FOR CONSTRUCTION:

	NAME	SIGN.	DATE
CAD/DRAWN	PARVESH KU		04.09.2018
DESIGNED	RAJESH		04.09.2018
CHECKED	V.N GUPTA		04.09.2018
APPROVED	V.N GUPTA		04.09.2018
SCALE	1:100		
JOB. No.	D-4023		
DWG.No.	112-10-0200		REV. 0

(SHEET SIZE-A2)