CENTRAL ELECTRICITY REGULATORY COMMISSION

DEVELOPING BENCHMARKS OF CAPITAL COST – MODEL FOR BENCHMARKING CAPITAL COST OF THERMAL POWER STATIONS OF UNIT SIZES 500 MW, 600 MW, 660 MW AND 800 MW.

EXPLANATORY MEMORANDUM

1.0 INTRODUCTION

1.1 The Tariff Policy notified by the Central Government on 6th January, 2006 under Section 3 of the Electricity Act, 2003 provided that when allowing the total capital cost of the project, the Appropriate Commission would ensure that these are reasonable and to achieve this objective, requisite benchmarks on capital costs should be evolved by the Regulatory Commissions.

1.2 While framing the Terms and Conditions of Tariff for 2009-14, it was inter-alia, noted as under:

"- In a cost based regulation capital cost of the project is perhaps the most important parameter. The capital cost on the completion of the project is the starting point as the rate base for deciding the return on the investment made by the generators. Different philosophies and practices have been followed "

" - Prior to 1992 and during the period 1992 to 1997 and 1997 to 2001, the capital cost of the project used to be based on gross book value as per the audited accounts. The changes in the capital cost by the way of capitalization and FERV were also being accounted for and tariff was being adjusted retrospectively. This practice has been followed even during the tariff period 2004-09."

"- While admitting the projected capital expenditure as on COD, prudence check of capital cost shall be carried out based on the applicable benchmark norms to be published separately by the Commission from time to time. This is

in line with Tariff Policy. The Commission has already initiated the process for evolving benchmarks for transmission projects……."

1.3 Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2009 applicable for the period 1.4.2009 to 31.3.2014 were notified by the Commission on 19th January, 2009.

Sub-clause (2) of Clause 7 of the above regulations provides that subject to prudence check by the Commission, the capital cost shall form the basis for determination of tariff provided that prudence check of capital cost may be carried out based on the benchmark norms to be published separately by the Commission from time to time:

2.0 INITIATION OF BENCHMARKING PROCESS

2.1 Central Electricity Regulatory Commission (CERC) initiated the process in June, 2008 in this regard.

2.2 The work of Developing Benchmarks of Capital Cost for Thermal Power Stations was awarded to a Consortium of Consultants in September, 2008.

3.0 OBJECTIVES, SCOPE OF WORK AND DELIVERABLES

3.1 Objectives

(i) Developing benchmarks of capital cost for Thermal Power Stations by analyzing all India data for this purpose.

(ii) Recommending appropriate methodology through which a bench mark cost of a completed project would be arrived at for the purpose of prudence check.

(iii) Developing disaggregated benchmarks of capital cost of individual packages. The summation of relevant packages/elements of a project should add to total hard cost of the project. The financing cost, interest during construction, taxes and duties, right of way charges, cost of R&R etc. would be additional and not to be factored in benchmark costs.

(iv) Developing a model for benchmarking which should be self- validating i.e. as data of new projects gets added to the data base, the benchmark should get revised automatically

3.2 Scope of Assignment

- Step-1: The starting point of assignment would be to create a database of capital cost of projects, for which data is reliably available.

- Step-2:Analyzing Project Database so created to define Disaggregated Packages of Hard Cost of a Project to be sufficient for benchmarking

- Step-3: Identifying escalation factors and developing financial/pricing models to assign weightages to various such factors, test accuracy with historical data from project database and developing escalation formula for each disaggregated benchmark with due weightage to various materials

Hard cost of Thermal Power Plant

- To consider illustrated hard cost packages for thermal power plant.
- To give scaling down factors in case station comprises more than one unit.
- To develop benchmarks essentially for power stations comprising unit of 500 MW, 600 MW, 660 MW and 800 MW which could be extension units or green field projects.
- To factor cost of erection, testing and commissioning and other incidental expenses including site preparation and supervision etc. into various disaggregated capital cost heads.

3.3 Deliverables

3.3.1 Stage I Assignment

- Concept Paper on disaggregated bench marks for capital cost for Thermal power stations of unit sizes 500 MW, 600 MW, 660 MW and 800 MW.
- The concept paper should give clear picture of how the benchmarks would be developed and how much data shall be collected and collated and what would be the degree of reliability and accuracy of the benchmarks.
- Develop/revise draft formats for project costs in view of the proposed disaggregated benchmarks in which future capital costs of projects are to be submitted by the project proponents

4.0 THE CONCEPT PAPER

The Concept Paper was submitted by the Consortium on 6th November, 2008. The salient features in regard to the concept and the methodology as contained in the paper are summarized below:

4.1 Concept

4.1.1 The word benchmark comes from the field of surveying. The *Oxford English Dictionary* defines a benchmark as

A surveyors mark, cut in some durable material, as a rock, wall, gate pillar, face of a building, etc. to indicate the starting, closing, ending or any suitable intermediate point in a line of levels for the determination of altitudes over the face of a country.

4.1.2 The term has subsequently been used more generally to indicate something that embodies a performance standard and can be used as a point of comparison in performance appraisals. Benchmarks are often developed using data on the operations of agents that are involved in the activity under study. Statistical methods are useful in both the calculation of benchmarks and the comparison process

4.1.3 Statistical benchmarking has in recent years become an accepted tool in the assessment of utility performance. Benchmarking also plays a role in utility regulation in several jurisdictions around the world.

4.1.4 Benchmarking of the performance of utilities is facilitated by the extensive data that they report to regulators.

4.1.5 Worldwide benchmarking is undertaken by the utilities/regulators for improving operational efficiency and operational cost control.

4.1.6 The accuracy of estimates of costs is a function of details provided in Detailed Project Report (DPR) or Feasibility Report (FR) with regard to specification of plant, equipment and civil construction. These estimates are as per schedule of rates, which generally based on earlier procurement of similar equipment and budgetary prices given by manufacturer. Estimates based on earlier procurements would again depend upon:

- The packaging for the procurement
- Equipment specifications
- The competitiveness in procurement
- Taxes, Tariffs and Trade Policy
- Foreign Market and Currency Fluctuations
- Inflation and Capital Costs.

Thus, within the cost estimates of the project, there is a tendency to build in additional risk factors

4.1.7 Recognized risks in the project configuration relate to such aspects where project designer based his design on certain predictions of assumption which are likely to change due to uncontrollable or force majeure conditions. There are wide ranging factors which create such risks for the developer. These uncertainties vary in degree and size for each specific project. Mitigation of these uncertainties by more thorough investigation, analysis and planning could bring down the risks/capital costs and operating costs of projects. To the extent it is not possible to eliminate these risk factors, pricing mechanism need to be developed to pass the costs to consumers only when suppliers incur liabilities due to one or more of such risks.

4.2 Methodology

4.2.1 Sources and Basis of Database

- Power Stations of the Power Generating Utilities of Central/State Sectors and the IPPs completed and/or under implementation with procurement process having been completed are identified sources for collection of data.

- Indigenous / imported equipments and materials for the projects on the basis of the orders placed and records maintained are considered as sources for data collection.

- Procurement process and maintenance of records of the above utilities are according to the applicable rules, regulations, orders and these are considered sources of reliably available data.

- Generating Stations with unit size of 500 MW, 600 MW, 660 MW and 800 MW are covered under the scope of work and are taken into consideration for data collection.

- Projects which had been completed or were under completion during the financial years 2004-05, 2005-06, 2006-07, 2007-08 and 2008-09 have been considered for data collection and creation of data base. 1st February, 2009 is considered as the date for normalization of costs through price variation process.

4.2.2 Data Collection Process

- Selection of Power Stations from identified list of projects.
- Finalization of Data Collection Formats and Procedure.
- Seeking issue of communication by CERC to the identified power utilities for providing assistance and cooperation in data collection and interaction.
- Forwarding Data Collection Formats and Procedure to the identified utilities for completing the data in advance of the visit of the team.
- Finalization of the order of visits to be undertaken for data collection
- Finalization of program of visit in the order finalized.
- Visit to identified utilities.
- Preliminary discussions with the officials in the power utilities and collection of completed Data Collection Formats.
- Examination of the completed data forms of the utilities, verification and validation based on the records and documents to the extent available.
- Seeking clarifications/explanations and confirmation wherever considered necessary.
- Ascertaining break-up of hard cost of the indigenous and imported equipment and materials procured for the project awarded on EPC contract basis.

4.2.3 Creation of Database

- Project Data Sheet (PDS) for each generation project.
- PDS of each project contains details of the project made out from the data collection sheets which forms basis for database.

4.2.4 Defining Disaggregated Packages

- Preparation of package-wise equipment wise and material procured including the cost of each package
- Preparation of cost of services such as erection, commissioning, testing etc. of each package-wise equipment for each project.

- Factoring of cost of services into the cost of respective package.
- Identifying common packages among the projects and preparation of complete list of such packages including their cost.
- Identifying uncommon packages among the projects and preparation of complete list of such packages including their cost.
- Grouping of uncommon packages into the common packages as practicable on the basis of the best technical consideration and procurement practices in order to minimize the uncommon packages.
- Preparation of list of residual packages including their costs.
- Identification of escalation factors and indices considered in respect of each disaggregated package including the formulae used by the utilities for working out the price adjustment.

4.2.5 Developing Benchmarks

- Database of capital cost of project is analyzed and disaggregated packages are defined following the method mentioned above.
- Disaggregated packages so defined are considered as to sufficiency of information for benchmarking.
- Capital cost of each disaggregated package is worked out and given against each package.
- Accuracy test of identified escalation factors is carried out with historical data from the developed project data base and other available sources.
- Financial/pricing model is developed to assign weightages to various escalation factors through recognized indices and cost escalation formula for each disaggregated package.
- Capital cost of each disaggregated package is linked to each financial/pricing model.
- Price variation adjustment occurring on any given date during the validity period of the capital cost of each disaggregated package is in relation to a reference period say, annually.
- Such price adjustment to the capital cost of each disaggregated package is applied uniformly during that period.
- Price adjustment amount arrived at according to the pricing model/cost escalation formula for each disaggregated package is added to the capital cost of the respective disaggregated package.
- Capital cost and the price adjustment amount added to that cost is the benchmarked capital cost of each disaggregated package up to date designated as normalization date.

- This cost is updated on annual basis using the relevant cost escalation factors and formula.
- Summation of relevant package/element of a project is the total hard cost of the project.

4.2.6 Degree of Reliability and Accuracy of Benchmarking

- Each power utility adopts packages for procurement of equipment based on prevailing conditions and considers the package and procedure most suited for the project..
- Degree of reliability and accuracy of benchmarks rests on data relied upon and stage-wise methodology followed.
- Data relied upon is from the sources of Central, State power utilities and IPPs.
- Data, documents, records and registers available with the above utilities are maintained as per applicable laws, rules, regulations, accounting standards and are subject to audit as per those laws, rules and regulations.
- The benchmarks developed based on such available data are considered to have acceptable reliability and accuracy.

5.0 DATA COLLECTION PROCESS

5.1 CERC Communication

CERC wrote letters to Thermal Power Generating Utilities in the country

5.2 Attachments to CERC Letters

1. Names of the identified projects for data collection
2. Data Collection Procedure
3. Identified source of data
4. Data Collection Formats

5.2.1 Names of Identified Projects

The names of Thermal Power Stations identified for Data Collection, Utility-wise, are shown below:

S.No.	Utility Name		Name (s) of Thermal Power Stations/ Projects	Unit No.	Capacity (MW)
1	NTPC Limited	1	Jhajjar (IGSTPP)	3	500
		2	Rihand Thermal Power Station (Stage I& II)	4	500
		3	Rihand Thermal Power Station (Stage III)	2	500
		4	Vindhyachal Thermal Power Station (Stage II & III)	4	500
		5	Vindhyachal Thermal Power Station (Stage IV)	2	500
		6	Dadri Power Project, Expansion	2	490
		7	Sipat , Bilaspur	2	500
		8	Sipat – I, Bilaspur	3	660
		9	Mauda Super Thermal Power Station	2	500
		10	Ramagundam Thermal Power Stations	2	500
		11	Simadri Thermal Power Station	2	500
		12	Ennore Power Project	2	500
		13	Kahalgaon Thermal Power Station	3	500
		14	Barh Super Thermal Power Station	3	660
		15	Talcher Thermal Power Station	4	500
2	Andhra Pradesh Power Generation Company Limited	1	Vijaywada stage – IV, APGENCO	1	500
		2	Krishnapatnam Thermal Power Station	2	800
		3	Kakatiya Power Plant	1	600
3	BGR Energy Systems Limited	1	Kalisindh Thermal Power Plant, RRVUNL	2	600
		2	Mettur, TNEB	1	600
4	Chhattisgarh State Power Generation Company Limited	1	Korba West Thermal Power Project	1	500
		2	Marwa Thermal Power	2	500

S.No.	Utility Name		Name (s) of Thermal Power Stations/ Projects	Unit No.	Capacity (MW)
			Project		
5	Damodar Valley Corporation	1	Raghunathpura	2	600
6	Essar Power Limited	1	Mahan Thermal Power Plant	2	600
7	Haryana Power Generation Corporation Limited	1	Jhajjar	2	660
		2	Hissar	2	660
8	Jindal Power Limited	1	O.P. Jindal Thermal Power Station, Raigarh	4	600
9	Jindal India Thermal Power Limited	1	Jindal India Thermal Power Limited	2	600
10	Karnataka Power Corporation Limited	1	Bellary	1	500
		2	Bellary Ext	1	500
11	Lanco Infratech Limited	1	Anpara C	2	500
		2	Pathadi Korba	1	600
		3	Nagarjuna Thermal Power Station	2	507.5
12	Maharashtra State Power Generation Company Limited,	1	Khapar Khera Thermal Power Project	1	500
13	Madhya Pradesh Power Generation Company Limited	1	Malwa Thermal Power Project	2	600
14	Mahalakshmi Navabharat Limited	1	Dhenkanal	2	600
15	Neyveli Lignite Corporation Limited	1	Neyveli – III	2	500
16	Nabha Power Limited	1	Talwandi Sabo	2	660
17	Reliance Power Limited	1	Ultra Mega Power Project, Sasan	6	660
		2	Rosa Thermal Power Station	2	600
		3	UMPP, Krishnapatnam (Coastal Andhra Power Limited)	5	800
18	Tata Power Company Limited	1	Mundra UMPP	5	800
		2	Maithan RBC	2	500
19	Uttar Pradesh Rajya Vidyut	1	Anpara D	2	500

S.No.	Utility Name		Name (s) of Thermal Power Stations/ Projects	Unit No.	Capacity (MW)
	Utpadan Nigam Limited	2	Obra Thermal Power Station	2	500
20	Sterlite Industries (India) Limited		Vedanta, Jharsuguda	4	600

5.2.2 Data Collection Procedure

- The projects/units which have been commissioned and the projects/units in respect of which award of contracts for supply of equipment and services for the projects has been completed and/or under construction/completion during the Financial Years (FY) 2004-005, 2005-06, 2006-07, 2007-08 and 2008-09 would be considered for the purpose of data collection, creation of data base and validation of model.

- Data collection would be undertaken under the various heads as contained in the Data Collection Formats designed.

- Data to be given would be based on the completed hard cost of the projects/units where the projects/units have been commissioned and the projects/units in respect of which contracts of supply and services had been awarded and are under construction/completion during the above financial years, the data would be based on the contracts awarded.

- Data to be given on completed projects/units would be sourced from relevant procurement orders, work orders, contract documents etc. or from any other source from the records maintained by the Power Utility which, in the opinion of the Utility, is the reliably available data which could be used for the purpose of the present assignment.

5.2.3 Identified sources of data

S.No.	Source of Data
1	Procurement Orders
2	Work Orders
3	Contract Agreements

4	Others (specify) a. b.

5.2.4 Data Collection Formats

1. Project General Data (PGD)
2. Project Technical Data (PTD)
3. Project Erection, Testing, Commissioning & Incidental Expenses Data (PETCD)
4. Project Commercial Data (PCD)
5. Project Price Basis Data (PPBD)
6. Project Main Variables Data (PMVD)
7. Project Other Variables Data (POVD)

5.3 Data Collection Status

Utilities	Unit Size (MW)				
	500	600	660	800	Total
Central (NTPC/DVC)	13	1	2		**16**
State (HPGCL/APGENCO/KPCL/ MAHAGENCO / CSPGCL/ MPGCL/ UPRVNL)	7	2		1	**10**
IPP (JIPL)	1	1			**2**
Total	**21**	**4**	**2**	**1**	**28**

5.3.1 Most of the data collected pertains to Central and State power utilities. In regard to the private power utilities, though all possible and earnest efforts were made to collect data, the utilities either expressed inability and/or not responded.

5.3.2 The data wherever provided, except in few cases, were not in accordance with the prescribed formats. In some cases, copies of Letters of Intent, Letters of Award, Supply Orders only had been provided. The Consortium had to rework the data provided so as to bring it to the format required for model formulation/validation

5.3.3 The Thermal Power Utilities to whom letters were written but have not supplied the data are shown below

Utility	Remarks
BGR Energy	Inability to provide
ESSAR Power Ltd.	Not responded
HPGCL (Jhajjar Project)	Awarded on tariff based competitive bidding basis. Data not available.
Jindal Power Ltd.	Procurement orders not placed
LANCO Infratech Ltd.	Not responded
Navabharat	Change of configuration below Unit size 500 MW
Neyveli Lignite Corporation Ltd.	Not responded.
Punjab State Electricity Board	Awarded on tariff based competitive bidding basis. Data not available.
Reliance Power Ltd.	Not responded.
Tata Power Company Ltd.	Not responded
Sterlite Industries Ltd	Not responded

5.4 Impediments In Data Collection

(i) Data were provided in the prescribed formats in seven cases by a central power utility. In all other cases, the power utilities did not furnish data in the formats forwarded through CERC letter

(ii) Most of the data received pertained to Central and State power utilities.

(iii) Data made available by the Central power utilities is in the form of data submitted to CERC as part of the application for determination of tariff except in the seven cases mentioned above.

(iv) Data made available by the State power utilities is in the form of Letter of Intent/Letter of Award.

(v) Data received being not as per the formats, the data had to be reworked out to bring it as nearer to the format required for the modeling.

(vi) Consortium Teams pursued with the private utilities for providing the data requested from time to time both during their visits and thereafter but could not succeed.

5.5 Aspects which were also given consideration in connection with developing the benchmarks::

(a) : Operating parameters of plants of different countries

Study was carried out on operating parameters of different country of origin supplied equipment. The table below summarizes the details of operating parameters.

Plant Characteristics

Steam Cycle Parameters	Units	China		Japan		USA		European		Russia	
Pressure	Bar	246	246	246	246	246	246	255	255	255	255
Main steam temperature	°C	540	566	538	566	538	566	542	556	545	565
Reheat temperature	°C	540	566	566	580	566	566	566	580	545	575

Recent supercritical plants in different countries are operating on different steam parameters. These parameters depend on design and related material involved. The cost of material influences the overall cost of equipment.

There is not much difference in the operating parameters of equipment sourced from different countries. However, manufacturing costs, market conditions. Commercial conditions etc. have their impact on costs. With the above considerations, the influencing factors for different countries are considered as under:

Equipment Supplier (Country of Origin)

India	0.0
China	-15 %
Europe	+ 10 %
Russia/ South Korea	+ 5 %
Japan & USA	+ 15

(b) The impact of redundancy system in respect of each sub system:

The impact of redundancy system in respect of each sub system i.e. based on PLF of 85% captured in the Plant load factors and the availability of the equipment. Standard redundancy of the system is described in the technical diary prepared as per CEA's Specification and given below.

(c) : Technical Dairy

(i) Technical data for base case

S.No.	Quantitative Variables (Design Value)	units	BASE CASE		
			2x 500 MW	2 x 660 MW	2x 800 MW
1	Coal Quality - Calorific Value	Kcal/ Kg	3300-4000	3800-4800	4400-5500
2	Ash Content	%	35 -40 %	25 - 35 %	Below 25 %
3	Moisture Content	%	Below 8 %	Below 8 %	Below 8 %
4	Boiler Efficiency	%	86	86	86
5	Suspended Particulate Matter	mg/ Nm3	50-100	50 -100	Below 50
6	Ash Utilization	%	Fly Ash utilization (80%)	Fly Ash utilization (80 %)	Fly Ash utilization (80 %)
7	Turbine Heat Rate	Kcal/ Kwh	1950	1875	1825
8	CW temperature	Dec C	33	33	33
9	Distance of Water Source	Km	5	5	5
10	Water Source		River	River	Sea
12	Type of Fly Ash Disposal and Distance	Kms	Dry Fly Ash at 1 KM	Dry Fly Ash at 1 KM	Dry Fly Ash at 1 KM
13	Type of Bottom Ash Disposal and Distance	Kms	Wet Ash Disposal at 3 Km	Wet Ash Disposal at 3 Km	Wet Ash Disposal at 3 Km
14	Evacuation Voltage Level	KV	400 KV	765 KV	765 KV
15	Foundation Type (Chimney)		Raft	Raft	Pile
16	Condensate Cooling Method		IDCT	NDCT	NDCT
17	Clarifier		Clarifier	Clarifier	Clarifier
18	Mode of Unloading Oil		Train	Train	Train
19	Coal Unloading Mechanism		Track Hopper	Track Hopper	Jetty/ Coal Conveyor
20	Type of Soil		Hard	Hard	Loose
21	Desalination/RO Plant				Desalination Plant
	Qualitative Variables (Main Plant)				

S.No.	Quantitative Variables (Design Value)	units	BASE CASE		
			2x 500 MW	2 x 660 MW	2x 800 MW
22	Completion Schedule		44 Months	52 Months	58 Months
23	Terms of Payment		10% Advance+ 80% on Delivery+ 5% on Completion+ 5% on operational acceptance	10% Advance+ 80% on Delivery+ 5% on Completion+ 5% on operational acceptance	10% Advance+ 80% on Delivery+ 5% on Completion+ 5% on operational acceptance
24	Performance Guarantee Liability		Standard (10% of Contract Value)	Standard (10% of Contract Value)	Standard (10% of Contract Value)
25	Basis of Price (Firm/Escalation-Linked)		Firm Prices	Firm Prices	Firm Prices
26	Equipment Supplier (Country of Origin)		India	India	India
	Optional Packages				
	Cooling Tower		IDCT	NDCT	NDCT
	Desalination Plant/RO Plant				Desalination Plant
	MGR				
	Railway Siding				
	Unloading Equipment at Jetty				
	Rolling Stock/Locomotive				
	FGD Plant				
	Township & Colony				
	Length of Transmission Line till Tie Point				

(ii) Technical data for 2x500MW

Location : Green field

Capacity : 1x500 MW and above

Cooling Water

Source of cooling water : River Water

	Method of cooling	:	IDCT
	Cooling water requirement	:	3800m^3/hr

Fuel

Coal

	Type	:	
	Linked coal mines	:	Domestic Coal Mines
	Gross calorific value	:	3300-4000 Kcal/Kg
	Ash contents	:	
	Volatile matter	:	
	Sulphur content	:	
	HGI	:	

Steam Generator

Type	:	Balanced draft, dry bottom, single drum, controlled circulation / natural circulation RAD, RH, semi-outdoor direct fired
No. of Units	:	1
Make	:	
Capacity	:	1725 t/hr at 540°C and 179 Ata
Steam flow at SH outlet at boiler maximum continuous rating (BMCR)	:	1.02 times the steam flow at turbine VWO condition plus continuous auxiliary steam requirement of unit at TMCR rounded to next integer divisible by 5.
Steam generator control range	:	50% TMCR to 100% BMCR. However the bidder shall specify the feasible mill combinations below 60% TMCR.

Steam pressure at boiler outlet

(i)	SH	:	179 kg/cm^2 (g)
(ii)	RH	:	43.46 kg/cm^2 (g)

Steam temperature at boiler outlet

(i)	SH	:	540 °C
(ii)	RH	:	568 °C

No. of draft fans in service / standby

(i)	Forced	:	2
(ii)	Induced	:	2

No. of air fan service / standby

(i)	Primary	:	2
(ii)	Seal	:	2
(iii)	Scanner	:	2

Airheater

Type	:	Ljungstrom bisector rotary

Nos.		:	2
Fuel Used			
(i)	Primary	:	Coal
(ii)	Secondary	:	HFO
(iii)	Others	:	
Type of fuel firing		:	Tilting, tangential corner fixed
(i)	Coal mill type	:	MPS/MRS
(ii)	No. of coal mill service/standby	:	6+2
(iii)	No. of soot blower	:	
Efficiency		:	86-88%

Turbine

Type	:	Three cylinder, reheat, condensing
Make	:	
Throttle steam pressure	:	170 kg/cm^2 (abs)
Throttle main steam temp.	:	537°C
Reheat steam temp. at turbine inlet	:	565°C
Variations in rated steam temperature and pressure	:	As per IEC 45
Pressure drop in reheat circuit i.e. between HP turbine exhaust and IP turbine inlet	:	10% of HP turbine exhaust pressure (maximum)
Cooling water temp. at inlet to condenser	:	33°C
Condenser design pressure	:	77 mm Hg (abs)
Turbine speed	:	3000 rpm
Frequency variation range around rated frequency of 50 Hz	:	+3% to -5% (47.5 Hz to 51.5Hz)
DM water make up to thermal cycle under TMCR condition	:	3% of throttle steam flow.
Final feed water temperature for heat rate guarantee point and TMCR condition	:	Based on optimization of the turbine cycle.
Type of governing system	:	Through hydraulic speed governor throttle
No. of heaters provided		
(i) HP	:	4
(ii) LP	:	3
HP heaters out of service	:	Turbine shall be capable of continuous operation under all HP heaters out of service condition with maximum output commensurate with boiler heat duty corresponding to 100% BMCR operation with HP heaters in service and the same shall be demonstrated.
HP heaters (one string) out of services	:	Turbine shall be capable of enhanced

			output under HP heaters (one string) out of service with boiler heat duty corresponding to 100% BMCR operating with HP heaters in service.
No of start ups			
Hot start (within 10 hours of unit shut down)		:	4000
Warm start (between 10 hours and 72 hours of unit shut down)		:	1000
Cold start (after 72 hours of unit shut down)		:	150
No. of vacuum pumps			
Service / standby		:	1+1
Turbine efficiency		:	91% (approx.)
Generator			
Make		:	
Type		:	3-phase, horizontal mounted, 2-phase cylindrical rotor type, directly driven by steam turbine running at rated speed conforming to IEC-60034-1, 60034-3 or other equivalent international standards.
Rated capacity			
kW		:	500000
Power factor		:	0.85 Lag
Frequency		:	50Hz
Speed		:	3000 rpm
Short circuit ratio		:	Not less than 0.48 (without negative tolerance)
Efficiency		:	>98%
Insulation of stator and rotor windings		:	Class 155 (F)
Stator			
(i)	Voltage	:	18 to 24 kV
(ii)	Amp.	:	16200
	Rotor		
(i)	Max. voltage	:	600 V
(ii)	Current	:	6300 Amp
(iii)	SC ratio	:	0.48
Excitation system			
Type		:	Brushless
Type of Cooling		:	Hydrogen / DM water

H_2 Pressure : 4 kg/cm^2

Stator cooling water

(i) Primary Pressure : 4.0 kg/cm^2 gauge

(ii) Secondary Pressure : 3.92 (pressure drop 0.08 kg/cm^2)

Transformer

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
Service	Outdoor	Outdoor	Outdoor	Outdoor (Oil filled) / Indoor (Dry type: epoxy cast resin / resin encapsulate air cooled type)
No. of phases	3 nos. single phase, 2 winding, 200 MVA for each 500 MW units	Three (3) phase bank	Three (3) phase bank	Three (3)
Voltage	HV: 420 / √3 kV LV: as per generator terminal voltage	HV: 400 kV LV: 11kV	HV: as per generator terminal voltage LV: 11kV	
Frequency	50Hz	50Hz	50Hz	50Hz
Winding connection	HV: Star (with neutral solidly earthed) LV: Delta	HV: Star (with neutral solidly earthed) LV: Delta (Non-effectively earthed)	HV: Delta LV: Star (Non-effectively earthed)	
Vector Group	YN d11	YN d11 d11 or YN y^0 y^0	Dynl or Dd0	
Type of Cooling	OFAF	OFAF (100% rating) / ONAN (60% rating)	OFAF / ONAN	ONAN for oil filled
Impedance (%)	15 (indicative)		10 (indicative)	As per system requirement
Maximum permissible temp. rise over an ambient of 50°C	In top oil : 50°C In winding: 55°C	In top oil : 50°C In winding: 55°C	In top oil : 50°C In winding: 55°C	

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
Cooling equipments	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan)	
Type of tap Changer	Off circuit tap changer (OCTC)	On Load tap changer (OLTC)	On Load tap changer (OLTC)	Off circuit tap changer with ±5% in steps of 2.5% on HV side
Tapping range	(+)5% to (-)5% in 4 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on OLTC	

Transmission Line	400 kV	765 kV
No. of Feeders		

Technical Description

Particulars	Type	Speed	Critical Speed
ID Fan	Radial Type – Backward curved single thickness plate bladed type or aerofoil type.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
	Axial Type – Stream line, aerofoil shaped section.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
FD Fan	Axial Type – Stream line, aerofoil shaped section.	Max. 1500 rpm	Not less than 125% of fan maximum operating speed.
PA Fan	Axial Type		

Particulars	Type / Numbers	Capacity
APH	Regenerative type- two tri-sector or two bi-sector	
Mills	Ball / Race / Roller / Bowl / MPS 6 operating + 2 standby	70-80 t/hr

Particulars	Type / Numbers	Capacity
Equipment cooling water (ECW) system	Closed circuit type ECW system 3x50%	
CW Pump	Vertical mixed flow semi-open	3500 m^3/hr
BFP	2x50% TDBFP , 1x50% MDBFP	10% margin over VWO condition, 3% makeup, design back pressure and corresponding head.
CEP	3x50%	Combined flow of 2x50% condensate extraction pumps shall be based on 15% margin over highest Condensate flow envisaged during unit operating (excluding HP-LP bypass operation).
Condensate Polishing Unit (CPU)	3x50%	Condensate flow corresponding to maximum TG output at 3% make up, 89 mm Hg (abs) back pressure and all HP heaters out of service.
Boiler Circulating Water Pump	Single Suction -Double Discharge	48000 m^3/minute

Auxiliary Plants

Coal Handling Plant

Capacity	:	2000 t/hr
Number of streams	:	2
Total number of conveyors	:	22 pairs + 1
Size of belt	:	1600 mm

Crusher

Number	:	4
Type	:	Ring Hammer
Capacity	:	1000 MT/Hr

Reclaimer

Capacity	:	2000 t/hr
Number	:	

Mill reject system (if any)

Type	:	Pneumatic conveying system
Belt conveyor	:	

DM Plant

No. of streams	:	4
Capacity of each stream	:	1x135 m^3/hr
DM water storage capacity	:	12000 m^3

Requirement of full load : 2% make up for each boiler

Clarifloculators

(i) No. 2

(ii) Capacity 3600 m^3/hr

Compressor

	No.	Capacity
Plant Air	3	30 Nm^3/hr
Instrument Air	3	30 Nm^3/hr

Ash Handling System

No. of Ash Slurry Series : 2

No. of Pumps/Series : 1+2

Type of evacuation

(i) Fly Ash : Dry

(ii) Bottom Ash : Wet

Fuel Oil

No. of Pumps : 2 and two spindle type screw pump

Hydrogen Generation

Capacity : 12.5 m^3/hr

Availability of bottling

Arrangement : Through compressor

Cooling & Circulating Water System

Cooling Technique : Through cooling tower NDCT / IDCT

(i) Numbers : 2

(ii) Capacity : 35000 m^3/hr for each pump

(iii) Discharge Head : 11 mWc

Cooling water pump

(i) Number : 2

(ii) Capacity : 33000 m^3/hr

(iii) Discharge Head : 20 mWc

Cooling tower fans

Numbers : 1x24

ESP

No. of active field :

Field voltage : 25 kV to 70 kV

Field current : 100 mA to 600 mA

Efficiency		99.98%
Type of rapping		
Collecting electrodes	:	Intermittent type. 10 Nos./hr
Emitting electrodes	:	4 Nos. rapping/hr

(iii) Technical data for 2x660MW

Location	:	Green field
Capacity	:	2x660 MW and above
Cooling Water		
Source of cooling water	:	River/Canal water
Method of cooling	:	Closed cycle
Cooling water requirement	:	4200 m^3/hr
Fuel		
Coal		
Type	:	Domestic Indian coal mines
Linked coal mines	:	
Gross calorific value	:	3800-4800 kCal/kg
Ash contents	:	25-35%
Volatile matter	:	21%
Sulphur content	:	0.23%
HGI	:	48-106
Quantity Requirement		
(i) With design coal	:	
(ii) With actual coal	:	
Stockyard		
(i) Area	:	
(ii) Storage capacity	:	
Oil		
Type	:	
Available storage capacity for the station	:	
Steam Generator		
Type	:	The Steam generators shall be supercritical, water tube, direct pulverized coal fired, balanced draft furnace, single reheat/double reheat, radiant, dry bottom type.
No. of Units	:	2
Make	:	-
Capacity	:	2180 t/hr at 537°C

Steam flow at SH outlet at boiler maximum continuous rating (BMCR)		:	1.02 times the steam flow at turbine VWO condition plus continuous auxiliary steam requirement of unit at TMCR rounded to next integer divisible by 5.
Steam generator control range		:	50% TMCR to 100% BMCR. However the developer shall specify the feasible mill combinations below 60% TMCR.
Steam pressure at boiler outlet			
(iii)	SH	:	247 bar
(iv)	RH	:	42kg/cm^2
Steam temperature at boiler outlet			
(iii)	SH	:	537 ºC
(iv)	RH	:	565 ºC
No. of draft fans in service / standby			
(iii)	Forced	:	2
(iv)	Induced	:	2
No. of air fan service / standby			
(iv)	Primary	:	2
(v)	Seal	:	2
(vi)	Scanner	:	2
Airheater			
Type		:	Ljungstrom bisector rotary
Nos.		:	2
Fuel Used			
(iv)	Primary	:	Coal
(v)	Secondary	:	HFO
(vi)	Others	:	
Type of fuel firing		:	Tilting, tangential corner fixed
(iv)	Coal mill type	:	MPS/MRS
(v)	No. of coal mill service/standby	:	10+2
(vi)	No. of soot blower	:	
Efficiency		:	86-88%

Turbine

Type	:	Three cylinder, reheat, condensing
Make	:	
Throttle steam pressure	:	247 bar
Throttle main steam temp.	:	537ºC
Reheat steam temp. at turbine inlet	:	565ºC
Variations in rated steam temperature and pressure	:	As per IEC 45
Pressure drop in reheat circuit i.e. between HP turbine exhaust and IP turbine inlet	:	10% of HP turbine exhaust pressure (maximum)
Cooling water temp. at inlet to condenser	:	33ºC
Condenser design pressure	:	77 mm Hg (abs)
Turbine speed	:	3000 rpm

Frequency variation range around rated frequency of 50 Hz	:	+3% to -5% (47.5 Hz to 51.5Hz)
DM water make up to thermal cycle under TMCR condition	:	3% of throttle steam flow.
Final feed water temperature for heat rate guarantee point and TMCR condition	:	Based on optimization of the turbine cycle.
Type of governing system	:	Through hydraulic speed governor throttle
No. of heaters provided		
(iii) HP	:	4
(iv) LP	:	3
HP heaters out of service	:	Turbine shall be capable of continuous operation under all HP heaters out of service condition with maximum output commensurate with boiler heat duty corresponding to 100% BMCR operation with HP heaters in service and the same shall be demonstrated.
HP heaters (one string) out of services	:	Turbine shall be capable of enhanced output under HP heaters (one string) out of service with boiler heat duty corresponding to 100% BMCR operating with HP heaters in service.
No of start ups		
Hot start (within 10 hours of unit shut down)	:	4000
Warm start (between 10 hours and 72 hours of unit shut down)	:	1000
Cold start (after 72 hours of unit shut down)	:	150
No. of vacuum pumps		
Service / standby	:	1+1
Turbine efficiency	:	91% (approx.)
Generator		
Make	:	-
Type	:	3x1-phase, horizontal mounted, 2-phase cylindrical rotor type, directly driven by steam turbine running at rated speed conforming to IEC-60034-1, 60034-3 or other equivalent international standards.
Rated capacity		
kW	:	660000
Power factor	:	0.85 Lag
Frequency	:	50Hz
Speed	:	3000 rpm
Short circuit ratio	:	Not less than 0.48 (without negative

			tolerance)
Efficiency		:	>98%
Insulation of stator and rotor windings		:	Class 155 (F)
Stator			
(iii)	Voltage	:	24 to 27 kV
(iv)	Amp.	:	-
	Rotor		
(iv)	Max. voltage	:	600 V
(v)	Current	:	6300 Amp
(vi)	SC ratio	:	0.48
Excitation system			
Type		:	Brushless
Type of Cooling		:	Hydrogen / DM water

Transformer

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
Service	Outdoor	Outdoor	Outdoor	Outdoor (Oil filled) / Indoor (Dry type: epoxy cast resin / resin encapsulate air cooled type)
No. of phases	3 nos. single phase, 2 winding, 275 MVA for each 660 MW units	Three (3) phase bank	Three (3) phase bank	Three (3)
Voltage	HV: 420-765 / √3 kV LV: as per generator terminal voltage	HV: 400 kV LV: 11kV	HV: as per generator terminal voltage LV: 11kV	
Frequency	50Hz	50Hz	50Hz	50Hz
Winding connection	HV: Star (with neutral solidly earthed) LV: Delta	HV: Star (with neutral solidly earthed) LV: Delta (Non-effectively earthed)	HV: Delta LV: Star (Non-effectively earthed)	
Vector Group	YN d11	YN d11 d11 or YN y^0 y^0	Dynl or Dd0	
Type of Cooling	OFAF	OFAF (100% rating) / ONAN (60% rating)	OFAF / ONAN	ONAN for oil filled

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
Impedance (%)	15 (indicative)		10 (indicative)	As per system requirement
Maximum permissible temp. rise over an ambient of 50°C	In top oil : 50°C In winding: 55°C	In top oil : 50°C In winding: 55°C	In top oil : 50°C In winding: 55°C	
Cooling equipments	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan)	
Type of tap Changer	Off circuit tap changer (OCTC)	On Load tap changer (OLTC)	On Load tap changer (OLTC)	Off circuit tap changer with ±5% in steps of 2.5% on HV side
Tapping range	(+)5% to (-)5% in 4 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on OLTC	

Transmission Line	400 kV	765 kV
No. of Feeders		

Technical Description

Particulars	Type	Speed	Critical Speed
ID Fan	Radial Type – Backward curved single thickness plate bladed type or aerofoil type.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
	Axial Type – Stream line, aerofoil shaped section.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
FD Fan	Axial Type – Stream line, aerofoil shaped section.	Max. 1500 rpm	Not less than 125% of fan maximum operating speed.

Particulars	Type	Speed	Critical Speed
PA Fan	Axial Type		

Particulars	Type / Numbers	Capacity
APH	Regenerative type- two tri-sector or two bi-sector	
Mills	Ball / Race / Roller / Bowl / MPS 6 operating + 2 standby	80-90 t/hr
Equipment cooling water (ECW) system	Closed circuit type ECW system 3x50%	
CW Pump	Vertical mixed flow semi-open	2200 m^3/hr each
BFP	2x50% TDBFP , 1x50% MDBFP	10% margin over VWO condition, 3% makeup, design back pressure and corresponding head.
CEP	3x50%	Combined flow of 2x50% condensate extraction pumps shall be based on 15% margin over highest Condensate flow envisaged during unit operating (excluding HP-LP bypass operation).
Condensate Polishing Unit (CPU)	3x50%	Condensate flow corresponding to maximum TG output at 3% make up, 89 mm Hg (abs) back pressure and all HP heaters out of service.
Boiler Circulating Water Pump	Single Suction -Double Discharge	48000 m^3/minute

Auxiliary Plants

Coal Handling Plant

Capacity : 2500 t/hr
Number of streams : 2
Size of belt : 1600 mm

Crusher

Number : 4
Type : Ring Hammer
Capacity : 1250-

Reclaimer

Capacity : 2500-
Number :

Mill reject system (if any)

Type : Pneumatic conveying system

Belt conveyor :

DM Plant

No. of streams : 4
Capacity of each stream : 1x180 m^3/hr
DM water storage capacity : 15000m^3
Requirement of full load : 2% make up for each boiler
Clarifloculators
(iii) No. 2
(iv) Capacity 5000m^3/hr

Compressor

	No.	Capacity
Plant Air	3	30 Nm^3/hr
Instrument Air	3	30 Nm^3/hr

Ash Handling System

No. of Ash Slurry Series : 2
No. of Pumps/Series : 1+2

Type of evacuation

(iii) Fly Ash : Dry
(iv) Bottom Ash : Wet

Fuel Oil

No. of Pumps : 2 and two spindle type screw pump

Hydrogen Generation

Capacity : 10 m^3/hr
Availability of bottling
Arrangement : Through compressor

Cooling & Circulating Water System

Cooling Technique : Through cooling tower NDCT /IDCT
(iv) Numbers : 2
(v) Capacity : 30000 m^3/hr for each pump

Cooling water pump

(iv) Number : 4
(v) Capacity : 30000 m^3/hr

ESP

No. of active field	:	
Field voltage	:	25 kV to 70 kV
Field current	:	100 mA to 600 mA
Efficiency		99.98%

(iv) Technical data for 2x800MW

Location	:	Green field
Capacity	:	2x800 MW and above

Cooling Water

Source of cooling water	:	Sea water
Method of cooling	:	Closed cycle
Cooling water requirement	:	8500 m^3/hr

Fuel

Coal

Type	:	Blended coal
Linked coal mines	:	Domestic/Imported coal mines
Gross calorific value	:	4400-5500 kCal/kg
Ash contents	:	28%
Volatile matter	:	
Sulphur content	:	
HGI	:	

Steam Generator

Type	:	The Steam generators shall be supercritical, water tube, direct pulverized coal fired, balanced draft furnace, single reheat/double reheat, radiant, dry bottom type.
No. of Units	:	2
Make	:	-
Capacity	:	2092 t/hr at 565°C
Steam flow at SH outlet at boiler maximum continuous rating (BMCR)	:	1.02 times the steam flow at turbine VWO condition plus continuous auxiliary steam requirement of unit at TMCR rounded to next integer divisible by 5.
Steam generator control range	:	50% TMCR to 100% BMCR. However the bidder shall specify the feasible mill combinations below 60% TMCR.

Steam pressure at boiler outlet

(v)	SH	:	250-280 bar
(vi)	RH	:	48-
Steam temperature at boiler outlet			
(v)	SH	:	540-600 °C
(vi)	RH	:	565-610 °C
No. of draft fans in service / standby			
(v)	Forced	:	2
(vi)	Induced	:	2
No. of air fan service / standby			
(vii)	Primary	:	2
(viii)	Seal	:	2
(ix)	Scanner	:	2
Airheater			
Type		:	Ljungstrom bisector rotary
Nos.		:	2
Fuel Used			
(vii)	Primary	:	Coal
(viii)	Secondary	:	HFO
(ix)	Others	:	
Type of fuel firing		:	Tilting, tangential corner fixed
(vii)	Coal mill type	:	MPS/MRS
(viii)	No. of coal mill service/standby	:	8+2
(ix)	No. of soot blower	:	
Efficiency		:	86-88%

Turbine		
Type	:	Three cylinder, reheat, condensing
Make	:	
Throttle steam pressure	:	250 bar
Throttle main steam temp.	:	540-600°C
Reheat steam temp. at turbine inlet	:	565-610°C
Variations in rated steam temperature and pressure	:	As per IEC 45
Pressure drop in reheat circuit i.e. between HP turbine exhaust and IP turbine inlet	:	10% of HP turbine exhaust pressure (maximum)
Cooling water temp. at inlet to condenser	:	33°C
Condenser design pressure	:	77 mm Hg (abs)
Turbine speed	:	3000 rpm
Frequency variation range around rated frequency of 50 Hz	:	+3% to -5% (47.5 Hz to 51.5Hz)
DM water make up to thermal cycle under TMCR condition	:	3% of throttle steam flow.
Final feed water temperature for heat rate guarantee point and TMCR condition	:	Based on optimization of the turbine cycle.
Type of governing system	:	Through hydraulic speed governor throttle

No. of heaters provided			
(v)	HP	:	4
(vi)	LP	:	3
HP heaters out of service		:	Turbine shall be capable of continuous operation under all HP heaters out of service condition with maximum output commensurate with boiler heat duty corresponding to 100% BMCR operation with HP heaters in service and the same shall be demonstrated.
HP heaters (one string) out of services		:	Turbine shall be capable of enhanced output under HP heaters (one string) out of service with boiler heat duty corresponding to 100% BMCR operating with HP heaters in service.
No of start ups			
Hot start (within 10 hours of unit shut down)		:	4000
Warm start (between 10 hours and 72 hours of unit shut down)		:	1000
Cold start (after 72 hours of unit shut down)		:	150
No. of vacuum pumps			
Service / standby		:	1+1
Turbine efficiency		:	91% (approx.)
Generator			
Make		:	-
Type		:	3x1-phase, horizontal mounted, 2-phase cylindrical rotor type, directly driven by steam turbine running at rated speed conforming to IEC-60034-1, 60034-3 or other equivalent international standards.
Rated capacity			
kW		:	800000
Power factor		:	0.85 Lag
Frequency		:	50Hz
Speed		:	3000 rpm
Short circuit ratio		:	Not less than 0.48 (without negative tolerance)
Efficiency		:	>98%
Insulation of stator and rotor windings		:	Class 155 (F)
Stator			
(v)	Voltage	:	27 kV
(vi)	Amp.	:	-
	Rotor		
(vii)	Max. voltage	:	600 V

(viii)	Current	:	6300 Amp
(ix)	SC ratio	:	0.48
Excitation system			
Type		:	Brushless
Type of Cooling		:	Hydrogen / DM water
H_2 Pressure		:	6 kg/cm^2
Stator cooling water			
(iii)	Primary Pressure	:	4.0 kg/cm^2 gauge
(iv)	Secondary Pressure	:	3.92 (pressure drop 0.08 kg/cm^2)

Transformer

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
Service	Outdoor	Outdoor	Outdoor	Outdoor (Oil filled) / Indoor (Dry type: epoxy cast resin / resin encapsulate air cooled type)
No. of phases	3 nos. single phase, 2 winding, 315 MVA for each 800 MW units	Three (3) phase bank	Three (3) phase bank	Three (3)
Voltage	HV: 420 / √3 kV LV: as per generator terminal voltage	HV: 400 kV LV: 11kV	HV: as per generator terminal voltage LV: 11kV	
Frequency	50Hz	50Hz	50Hz	50Hz
Winding connection	HV: Star (with neutral solidly earthed) LV: Delta	HV: Star (with neutral solidly earthed) LV: Delta (Non-effectively earthed)	HV: Delta LV: Star (Non-effectively earthed)	
Vector Group	YN d11	YN d11 d11 or YN y^0 y^0	Dynl or Dd0	
Type of Cooling	OFAF	OFAF (100% rating) / ONAN (60% rating)	OFAF / ONAN	ONAN for oil filled
Impedance (%)	15 (indicative)		10 (indicative)	As per system requirement
Maximum	In top oil : 50°C	In top oil : 50°C	In top oil : 50°C	

Particulars	Generator Transformer	Station Transformer	Unit Auxiliary Transformer (UAT)	Auxiliary Service Transformer
permissible temp. rise over an ambient of 50°C	In winding: 55°C	In winding: 55°C	In winding: 55°C	
Cooling equipments	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan and 2x100% oil pumps)	2x50% cooling radiator banks (suitable no of working fans and one no. stand-by fan)	
Type of tap Changer	Off circuit tap changer (OCTC)	On Load tap changer (OLTC)	On Load tap changer (OLTC)	Off circuit tap changer with ±5% in steps of 2.5% on HV side
Tapping range	(+)5% to (-)5% in 4 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on HV side	(+)10% to (-) 10% in 16 equal steps on OLTC	

Transmission Line	400 kV	765 kV
No. of Feeders		

Technical Description

Particulars	Type	Speed	Critical Speed
ID Fan	Radial Type – Backward curved single thickness plate bladed type or aerofoil type.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
	Axial Type – Stream line, aerofoil shaped section.	Max. 600 rpm	Not less than 125% of fan maximum operating speed.
FD Fan	Axial Type – Stream line, aerofoil shaped section.	Max. 1500 rpm	Not less than 125% of fan maximum operating speed.
PA Fan	Axial Type		

Particulars	Type / Numbers	Capacity

Particulars	Type / Numbers	Capacity
APH	Regenerative type- two tri-sector or two bi-sector	
Mills	Ball / Race / Roller / Bowl / MPS 6 operating + 2 standby	70-80 t/hr
Equipment cooling water (ECW) system	Closed circuit type ECW system 3x50%	
CW Pump	Vertical mixed flow semi-open	m^3/hr
BFP	2x50% TDBFP , 1x50% MDBFP	10% margin over VWO condition, 3% makeup, design back pressure and corresponding head.
CEP	3x50%	Combined flow of 2x50% condensate extraction pumps shall be based on 15% margin over highest Condensate flow envisaged during unit operating (excluding HP-LP bypass operation).
Condensate Polishing Unit (CPU)	3x50%	Condensate flow corresponding to maximum TG output at 3% make up, 89 mm Hg (abs) back pressure and all HP heaters out of service.
Boiler Circulating Water Pump	Single Suction -Double Discharge	48000 m^3/minute

Auxiliary Plants

Coal Handling Plant

Capacity	:	1600t/hr
Number of streams	:	2
Total number of conveyors	:	22 pairs + 1
Size of belt	:	5km

Crusher

Number	:	4
Type	:	Ring Hammer
Capacity	:	-

Reclaimer

Capacity	:	-
Number	:	

Mill reject system (if any)

Type	:	Pneumatic conveying system
Belt conveyor	:	

DM Plant

No. of streams	:	
Capacity of each stream	:	– m^3/hr
DM water storage capacity	:	m^3
Requirement of full load	:	2% make up for each boiler
Clarifloculators		
(v) No.		2
(vi) Capacity		/hr

Compressor

	No.	Capacity
Plant Air	3	30 Nm^3/hr
Instrument Air	3	30 Nm^3/hr

Ash Handling System

No. of Ash Slurry Series	:	2
No. of Pumps/Series	:	1+2

Type of evacuation

(v) Fly Ash	:	Dry
(vi) Bottom Ash	:	Wet

Fuel Oil

No. of Pumps	:	2 and two spindle type screw pump

Hydrogen Generation

Capacity	:	6 m^3/hr

Availability of bottling

Arrangement	:	Through compressor

Cooling & Circulating Water System

Cooling Technique	:	Through cooling tower NDCT
(vi) Numbers	:	2
(vii) Capacity	:	m^3/hr for each pump
(viii) Discharge Head	:	11 mWc

Cooling water pump

(vi) Number	:	2
(vii) Capacity	:	77150 m^3/hr

Cooling tower fans

Numbers	:	–

ESP

No. of active field	:	
Field voltage	:	25 kV to 70 kV
Field current	:	100 mA to 600 mA
Efficiency		99.98%

(d) Prices arrived through negotiated procurement in order to assess their competitiveness:

The data analysis showed that of the 10 units covered, in 4 cases, the prices are on Negotiated basis and in 6 cases, the prices are on Tender Process basis. In some cases, prices on negotiated basis are found to be lower than the prices on tender process basis. There does not appear to be any impact on price of plant and equipment on account of the negotiated based prices as against the tender process based prices.

(e) Price Indices used for mechanical equipments have been taken from the Bulletin published by Reserve Bank of India. PV Formulae (Mechanical and Civil Packages) used in the Model are based on the formulae being followed by the Central and State Power Generating Utilities. Price Indices of Electrical Packages are the indices published by IEEMA. PV formulae for Electrical Packages are also as used by IEEMA.

(f) Cascading effect of FGD option with respect capital cost:

The cost of power increased by seven paise according to an approximate calculation based on additional investment and auxiliary power consumption. The additional cost will vary with type and technology followed for FGD. Normally FGD is required only for high sulphur coal. The FGD installed will also lead to reduction in SOx output but lead to high Auxiliary Power Consumption. Normally FGD is required according to Environmental law and as a mandatory requirement. So the increase in cost becomes mandatory. The additional cost is considered for the basic model concept which is 500 MW unit. The cost difference and coal quality is considered for imported coal. So the efficiency impact is already absorbed in the cost by the above factors.

(g) Cascading effect of cooling water temperature w.r.t. to capital cost:

The CW temperature difference leads to difference in efficiency. One degree Celsius higher temperature in the CW leads to reduction in efficiency of 0.35% approximately. For the base case CW temperature considered 33°C, normally prevailing in India. Cost of impact for different CW system has been envisaged in the model. The increase in the cost due to CW variation will be reflected in the efficiency. The maximum achievable cycle efficiency to depend on the CW

temperature at that area. This will lead to influence the total cost of turbine equipment.

6.0 THERMAL MODEL

6.1 Structure

The Terms of Reference (TOR) for assignment initially required establishment of capital cost benchmarks as disaggregated level for 500 MW and 660 MW Units. But the given the number of 600 MW and 800 MW plants likely to come in future, capital cost benchmarking of 600 and 800 MW Units was also included..

A power station consists of a hundreds of small and large equipments. Further, there are some common equipment in the plant, while there are some others which vary with plant location, size etc. (like desalination plant which is required only in case of plants using sea water).

As a starting point, segregation of equipments in power plant as done by CERC in its formats for tariff petition was reviewed. Based on the review, packages were redefined. These packages were further classified into mandatory and optional packages.

6.1.1 Mandatory Packages

The mandatory packages include the equipment which are part of the power station irrespective of location, configuration etc. The mandatory packages and their constituent elements have been listed out below:

S.No.	Mandatory Packages	Constituent Elements
1	Steam Generator Island	Steam Generator Island
		Electrostatic Precipitator
2	Turbine Generator Island	Turbine Generator
		HP/LP Piping
3	Water System	External water supply system
		CW system
		DM water Plant
		Clarification plant
		Chlorination Plant
		Effluent Treatment Plant
		Sewage Treatment Plant
		Fire Fighting System
		Central Monitoring System

S.No.	Mandatory Packages	Constituent Elements
		Dust Suppression System
4	Material Handling System	Fuel Oil Handling & Storage System
		Ash Handling System
		Coal Handling System
5	Mechanical-Miscellaneous Package	Air Compressor System
		AC Ventilation
		Workshop, Laboratory Equipment and Monitoring System & Equipment
6	Switchyard Package	
7	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	Transformers
		Switchgear
		Cable and Cable Facilities
		Grounding & Lighting Packages
8	Emergency DG Set	
9	C&I Package	
10	Chimney	
11	Civil Works	SG Area Civil Work
		TG Area Civil Work
		CW system
		DM water Plant
		Clarification plant
		Chlorination plant
		Fuel Handling & Storage System
		Coal Handling Plant
		Ash Handling System
		Ash disposal area development
		Fire fighting System
		Temp. construction & enabling works
		Road & Drainage
		Off site civil works
		Raw water reservoir
12	Initial Spares	

6.1.2 Optional Packages

Further, there are certain packages which have been identified as optional packages. The optional packages include components which are installed in a plant based on requirements. The list of optional packages has been given below:-

S.No.	Optional Packages
1	Cooling Tower
2	Water Clarification System
3	MGR
4	Railway Siding
5	Unloading Equipment at Jetty
6	Rolling Stock/Locomotive
7	FGD Plant
8	Township & Colony
9	Transmission Line Cost till Tie Point

6.1.3 Benchmarking Process

It was observed that most of the data was for 500 MW units. Further, sufficient data of Greenfield and Extension Unit size 500 MW was also available. Thus, 500 MW unit was used as reference case and benchmarks were created for 1x500, 2x500, 3x500 (all Greenfield) and 1x500, 2x500 MW (all extension). The benchmarks were also created for 4x500 (Greenfield) using suitable trend analysis, though data for the same was not available.

In totality, benchmarks have been created for combinations mentioned below:

500 MW Series

S.No.	Combination
1	1 x 500 MW (Greenfield)
2	2 x 500 MW (Greenfield)
3	3 x 500 MW (Greenfield)
4	4 x 500 MW (Greenfield)
5	1 x 500 MW (Extension)
6	2 x 500 MW (Extension)

600 MW Series

S.No.	Combination
1	1 x 600 MW (Greenfield)
2	2 x 600 MW (Greenfield)
3	3 x 600 MW (Greenfield)
4	4 x 600 MW (Greenfield)
5	1 x 600 MW (Extension)
6	2 x 600 MW (Extension)

660 MW Series

S.No.	Combination
1	1 x 660 MW (Greenfield)
2	2 x 660 MW (Greenfield)
3	3 x 660 MW (Greenfield)
4	4 x 660 MW (Greenfield)
5	1 x 660 MW (Extension)
6	2 x 660 MW (Extension)

800 MW Series

S.No.	Combination
1	1 x 800 MW (Greenfield)
2	2 x 800 MW (Greenfield)
3	3 x 800 MW (Greenfield)
4	4 x 800 MW (Greenfield)
5	1 x 800 MW (Extension)
6	2 x 800 MW (Extension)

The cost details of each package with different years of letter of awards/ date of commercial operation power plants were tabulated. Major constituent elements for each package were identified and after using escalation formulae, cost of packages was arrived for common base year (Mar-10). These costs were converted into per MW and were used for benchmarking. The model has flexibility, so that costs can be computed for desired month and year.

Benchmarks were first established for 500 MW units on the basis of sufficiently available data.. Benchmarking for 600 MW, 660 MW and 800 MW was done thereafter with the help of available data. For combinations for 600 MW, 660 MW and 800 MW units for which data was not available, suitable extrapolation was done with available 500 MW data to obtain benchmarks.

6.2 ESSENTIAL FEATURES

6.2.1 Essential features of model include:

a) Capacity and Unit Size of Plant
b) Mandatory and Optional Packages constituting a power station
c) Prices of major constituent elements for each packages like:-
   - Iron and Steel

- Non-ferrous Metals
- Cement
- Labor

d) Factors influencing the cost of the packages. like:-
- Design Coal Quality
- Boiler Efficiency
- Ash Content etc.

6.2.2 The model is capable of providing capital cost benchmarks for any desired configuration in terms of coal quality, variables in terms of water system, fuel handling system, presence/absence of certain packages like FGD plant, desalination plant etc. These are used as input variables while computing the benchmarks.

6.2.3 The model is self-validating. Latest available indices of constituent elements such as Steel, Non-Ferrous Metals etc from RBI Bulletin can be fed for obtaining updated cost for desired month and year in future.

6.3 MAIN VARIABLES

6.3.1 Entire plant has been divided into a number of mandatory and optional packages. In benchmarking process, factors have been identified which affect the cost of package on the basis of survey conducted by the consortium among leading equipment manufacturers, industry, developers, Power Sector Specialists etc.

6.3.2 Mandatory packages and factors affecting them are tabulated below:

S.No.	Mandatory Packages	Factors
1	Steam Generator Island	Coal Quality -Calorific Value
		Ash Content
		Moisture Content
		Boiler Efficiency
		Suspended Particulate Matter
		Ash Utilisation
		Boiler Configuration
2	Turbine Generator Island	CW temperature
		Turbine Heat Rate
3	Water System	Water Source
		Distance of Water Source

S.No.	Mandatory Packages	Factors
		Clarifier
4	Fuel Oil Handling & Storage System	Mode of Unloading Oil
5	Ash Handling System	Type of Fly Ash Disposal and Distance
		Type of Bottom Ash Disposal and Distance
6	Coal Handling System	Coal Quality
		Coal Unloading Mechanism
7	Mechanical-Miscellaneous Package	None
8	Switchyard Package	Evacuation Voltage Level
9	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	Evacuation Voltage Level
10	Emergency DG Set	None
11	C&I Package	None
12	Chimney	Foundation Type
13	Civil Works	Foundation Type
		Water Table
		Seismic and Wind Zone
14	Initial Spares	None

6.3.3 Optional packages and factors affecting them are tabulated below:

S.No.	Optional Packages	Factors
1	Cooling Tower	Condensate Cooling Method
		CW temperature
2	Desalination Plant	Thermal/RO Plant
3	MGR	None
4	Railway Siding	None
5	Unloading Equipment at Jetty	None
6	Rolling Stock/Locomotive	None
7	FGD Plant	Coal Quality
8	Township & Colony	None
9	Transmission Line Cost till Tie Point	Evacuation Voltage Level

6.3.4 Factors affecting the variables were discussed and analyzed. The impact of variation in value of factors was taken into account and their impact on the capital cost has been computed with the available data. In some cases, where

data was not available, conclusions have been drawn on the basis of discussions with industry experts.

6.3.5 Variables with possible values they can assume for different configuration of plants and their consequent impact on the cost of mandatory and optional packages of a typical 500MW power plant are tabulated below:

S.No.	Factor	Parameters for Variables	Reduction/ Escalation	Value in Percentage
1	Calorific value of coal	3000-4000 kcal/kg	Base cost	100.00%
		3800-4800 kcal/kg	Reduction by 0.5%	99.50%
		4400-5500 kcal/kg	Reduction by 1%	99.00%
		Above 5000 kcal/kg	Reduction by 3%	97.00%
2	Ash content in coal	35-40%	Base cost	100.00%
		25-35%	Reduction by 1%	99.00%
		Below 25%	Reduction by 2%	98.00%
		40-45%	Escalation by 1%	101.00%
3	Moisture content in coal	Less than 8%	Base cost	100.00%
		8%- 15%	Escalation by 1%	101.00%
		More than 15%	Escalation by 2%	102.00%
4	Boiler efficiency	85.00%	Reduction by 2%	98.00%
		86.00%	Base cost	100.00%
		87.00%	Escalation by 1%	101.00%
		88.00%	Escalation by 2%	102.00%
		88.50%	Escalation by 3%	103.00%
		89.00%	Escalation by 4%	104.00%
5	Suspended particulate matter	50-100 ppm	Base cost	100.00%
		25- 50 ppm	Escalation by 1%	101.00%
		Below 20 ppm	Escalation by 2%	102.00%
6	Ash utilisation	Fly Ash Utilisation (80%)	Base Cost	100.00%
		Fly Ash + Bottom Ash Utilisation (100%)	Escalation by 1%	101.00%
7	Boiler configuration	Tower Type	Base cost	100.00%
		Double Pass Type	Escalation by 6%	106.00%
8	Turbine heat rate	1950 kcal/kWh	Base cost	100.00%
		1930 kcal/kWh	Reduction by 0.5%	99.50%
		1895 kcal/kWh	Reduction by 1%	101.00%
		1875 kcal/kWh	Base cost	100.00%
		1850 kcal/kWh	Reduction by 0.5%	99.50%

S.No.	Factor	Parameters for Variables	Reduction/ Escalation	Value in Percentage
		1825 kcal/kWh	Reduction by 1%	101.00%
9	CW temperature (Turbine Generator Island)	33 Degree Celsius	Base cost	100.00%
		30 Degree Celsius	Escalation by 0.5%	100.50%
		27 Degree Celsius	Escalation by 1%	101.00%
10	CW temperature (Cooling Tower)	33 Degree Celsius	Base cost	100.00%
		30 Degree Celsius	Escalation by 3%	103.00%
		27 Degree Celsius	Escalation by 6%	106.00%
11	Distance of water source (river)	2 km	Reduction by 25%	75.00%
		5 km	Base cost	100.00%
		10 km	Escalation by 50%	150.00%
		20 km	Escalation by 150%	250.00%
		30 km	Escalation by 250%	350.00%
12	Raw water system	River water	Base cost	100.00%
		Onshore coastal	Escalation by 50%	150.00%
		Offshore coastal	Escalation by 100%	200.00%
13	Clarification plant	Without clarifier	Reduction by 30%	70.00%
		With clarifier	Base cost	100.00%
14	Evacuation voltage level	400 kV	Base cost	100.00%
		765 kV	Escalation by 100%	200.00%
15	Mode of unloading fuel oil	Train	Base cost	100.00%
		Truck	Reduction by 80%	20.00%
16	Foundation type	Raft type	Base cost	100.00%
		Pile type	Escalation by 1%	101.00%
17	Type of soil	Hard soil	Base cost	100.00%
		Loose soil	Reduction by 15%	85.00%
18	Seismic and wind zone	Low	Base cost	100.00%
		High	Escalation by 10%	110.00%
19	Type of fly ash disposal	Dry fly ash disposal at 1 km	Base cost	100.00%
		Dry fly ash disposal at 2 km	Escalation by 23%	120.00%
		Dry fly ash disposal at 3 km	Escalation by 44%	140.00%
		HCSS at 2 km	Escalation by 72%	170.00%
		HCSS at 3 km	Escalation by 83%	180.00%
		HCSS at 5 km	Escalation by 90%	190.00%
		Fly wet ash disposal at 2 km	Escalation by 44%	145.00%

S.No.	Factor	Parameters for Variables	Reduction/ Escalation	Value in Percentage
		Fly wet ash disposal at 3 km	Escalation by 62%	160.00%
		Fly wet ash disposal at 10 km	Escalation by 74%	175.00%
20	Type of wet ash disposal	Wet bottom ash disposal at 3 km	Base cost	100.00%
		Wet bottom ash disposal at 5 km	Escalation by 50%	150.00%
		Wet bottom ash disposal at 10 km	Escalation by 150%	250.00%
		Dry bottom ash disposal	Escalation by 75%	175.00%
21	Coal unloading mechanism	Track hopper	Base cost	100.00%
		Wagon tippler	Reduction by 30%	70.00%
		Conveyor (3 km)	Reduction by 20%	80.00%
		Conveyor (5 km)	No reduction	100.00%
		Conveyor (8 km)	Escalation by 20%	120.00%
22	Water level (civil works)	Less than 3 meters	Base cost	100.00%
		More than 3 meters	Escalation by 5%	105.00%
23	Condensate cooling method	Once through (sea water)	Escalation by 80%	180.00%
		Natural draught	Base cost	100.00%
		Induced draught	Reduction by 20%	80.00%
24	Desalination / RO plant (sea water)	Reverse osmosis (RO) plant	Base cost	100.00%
		Desalination plant (RO type)	Escalation by 35%	135.00%
		Desalination plant (thermal)	Escalation by 35%	175.00%
25	Transmission line	400 kV		0.70 Crore
		765 kV		1.0 Crore

6.4 PROJECT OTHER VARIABLES

6.4.1 it was suggested that a suitable rating scale for objectively determining the values of 'other variables' such as Demand Supply scenario, credit worthiness of developers, performance guarantee liability, Basis of Price etc." should be incorporated. It was also suggested that efforts should be made to examine the prices arrived at through negotiated procurement in order to assess their competitiveness and reasonable mark up to work out a factor which could be applied to the benchmarked capital cost.

6.4.2 The Data Collection Formats which were forwarded to the identified power utilities through CERC letter dated 24 April, 2009 provided the following other variables,

1	Delivery Schedule	
2	Terms of Payment	
3	Performance Guarantee Liability	
4	Basis of Price (Firm/Escalation-Linked)	
5	Equipment Supplier	Domestic
		European/ Japanese / Korean / Chinese / USA

6.4.3 Data was requested from 20 thermal power utilities covering 44 units of various sizes. Seven Central/State power utilities provided copies of Letters of Intent (LOI)/Letter of Award (LOA)/Purchase Order containing the terms and conditions and the prices covering 10 units. These include Andhra Pradesh Generation Company Ltd.(APGENCO) (3), Chhattisgarh State Power Generation Company Ltd. (CSPGCL) (2), Damodar Valley Corporation (DVC) (1), Haryana Power Generation Corporation Ltd. (HPGCL) (1), Maharashtra State Power Generation Company Ltd. (MAHGENCO) (1), Madhya Pradesh Power Generation Company Ltd. (MPPGCL) (1), Uttar Pradesh Rajya Vidyut Utpadan Ltd. (UPRVUNL) (1).

6.4.4 Terms and conditions and the prices of the Main Plant and Equipment as contained in the LOI/LOA/Purchase Order provided by the Utilities were considered. The standard Terms & Conditions of the International Financial Institutions such as World Bank (IBRD), Asian Development Bank (ADB), Kfw and National Financial Institutions such as Power Finance Corporation (PFC) were also considered in this regard.

6.4.5 The data has been analyzed. Briefly stated, the item-wise position is as follows:

Item 1 – Completion Schedule

Number of Units	Completion Schedule from Zero Date (Date of Advance Payment/LOA/NOA)	Main Plant and Equipment Price (In Rs.Crores)	Year of Award
1x500	1. 36 months for synchronization	953.24	2005
	39 months for trial operation		

Number of Units	Completion Schedule from Zero Date (Date of Advance Payment/LOA/NOA)	Main Plant and Equipment Price (In Rs.Crores)	Year of Award
	2. 42 months	942.00	2008
	3. 38 months for synchronization	1247.47	2007
	41 months for trial operation		
2x500	1. 45 months for Unit 1	1942.00	2008
	47 months for Unit 2		
	2. 39 months for Unit 1	3390.00	2008
	42 months for Unit 2		
1x600	1. 40 months for synchronization	1325.00	2008
	42 months for trial operation		
2x600	1. 35 months for Unit 1	2970.95	2007
	38 months for Unit 2		
	2. 35 months for Unit 1	2344.41	2007
	38 months for Unit 2		
	3. 39 months for Unit 1	2333.03	2008
	43 months for Unit 2		
660 MW	Information not available		
2x800	Unit – 1 – 47 months Unit – 2 – 53 months	3334.27	2008

Unit Size 500 MW/600 MW:

- CERC norms provide for 44 months for green field and 42 months for extension projects.
- Average completion period works out to 41.33 months.
- Average main plant and equipment price works out to Rs. 1938.67 or Rs. 2.26/ crores per MW,
- Among three 1x500 MW and two 2x500 MW projects, while the completion period is either identical or slightly higher, the prices in one case each is higher by 32.42% and 74.56%. The reasons for such higher prices could be attributed to prevailing demand-supply conditions.
- In the case of 1x600 MW, there being only one project, no comparison could be made but the price otherwise seems to be reasonable.
- Among three 2x600 MW projects, while the completion period, is identical or slightly higher, the price in one case is higher by 27.30%. The reasons for such higher prices could be attributed to prevailing demand-supply conditions.

- Data analysis indicates no substantial impact on the capital cost of main plant on account of marginal variation in completion schedule in relation to the standard or average period.

Unit Size 660 MW/800 MW

- CERC norm provides for 52 months for green field and 50 months extension.
- There is no information available for unit size 660 MW.
- There is only one 2x800 MW project, , the completion schedule of which is 53 months based on information available from one utility. The price appears to be reasonable both in terms Rs.2.08 crores per MW and the completion schedule.

Findings:

- Due to availability of limited data, it is found to be difficult to make a realistic assessment of the variation in the price of the main plant and equipment in relation to completion schedule. However, Analysis of available data shows higher price in a few cases in relation to completion schedule.
- It is considered prudent to provide for an adjustment factor to be applied in the case of plant and equipment of a project claiming a higher range of prices on account of a shorter/longer completion schedule than the standard completion schedule.
- Completion Schedule Adjustment Factor (CSAF) of 5% of the benchmarked. Capital cost for the completion schedule shorter or longer by 3-6 months than the standard norm is considered reasonable.

Item 2: Terms of Payment

No. of Units covered	Terms of Payment	Main Plant & Equipment Price (In Rs. Crores)	Year of Award
Unit Size 500/600 MW			
2	- 10% initial advance - 70% pro-rata basis on equipment dispatch - 15% pro-rata basis on equipment receipt. - 3% on synchronization - 2% on trial operation	1. 953.24 (1x500) 2. 1325.00 (1x600)	2005 2008
2	- 10% initial advance	1. 942.00 (1x500) 2. 1942.00 (2x500)	2008 2008

No. of Units covered	Terms of Payment	Main Plant & Equipment Price (In Rs. Crores)	Year of Award
	– 85% on pro-rata basis		
	– 2.5% on completion of facilities		
	– 2.5% on completion of PG Tests.		
2	– 10% initial advance	1. 2970.95 (2x600) 2. 2333.03 (2x600)	2007 2008
	– 60% pro-rata basis on dispatch		
	– 20% pro-rata basis on receipt		
	– 5% on completion of facilities		
	– 5% on completion of PG tests.		
1	– 10% initial advance	2344.41 (2x600)	2008
	– 80% on delivery of equipment		
	– 10% on issue of final taking over certificate.		
1	– 10% of contract price as initial advance	1247.47.00 (1x500)	2007
	– 85% on production of invoice and satisfactory completion of works.		
	– 5% on completion of PG tests.		
1	– 15% initial advance	3390.00 (2x500)	2008
	– 83% on monthly progress basis		
	– 2% on completion of initial operation		
Unit Size 660/800 MW			
	There is no data available for 660 Unit size.		
1	– 15% initial advance	3334.27 (2x800)	2008
	– Next Stages payments not given.		

Terms of Payment of International and National FIs are as follows:

IBRD (World Bank)	ADB	KfW	PFC
10% initial advance	90% on shipment		
80% upon delivery to carrier.	10% on completion of installation.	In accordance with usual international practice dependent upon delivery of supplies and performance of services. Advance payment not to exceed 20%.	Generally to be in accordance with standard commercial practice. Advance payment to be limited to be

			limited to 10%
5% upon issue of completion certificate			
5% upon issue of operational acceptance certificate.			

Findings

- Terms of payment generally conform to terms of payment of the World Bank guidelines except in 3 cases where second stage payment is broken into two or more stages.
- The price is found to be higher where second stage payment is further broken into two or more stages, resulting in time-shift in release of payments, as compared to the standard slab rate payment.
- There is marginal impact of terms of payment on the price of the plant equipment supply where there is variation from the standard slab rate percent.
- Terms of Payment Adjustment Factor (TPAF) of 10% to be applied in cases where there is no provision for advance or where second stage payments are further staggered into two or more stages is considered reasonable.

Item 3: Performance Guarantee Liability

Units Covered	Contract Performance Security (&)	Facilities Performance Guarantees	Main Plant Equipment Price (Rs. in Crores)	Year of Award
1x500	10	15	953.24	2005
	10	10	942.00	2008
	10	NA	1247.47	2007
2x500	10	10	1942.00	2008
	15	15	3390.00	2008
1x600	10	15	1325.00	2008
2x600	10	10	2970.95	2007
	10	25	2344.41	2007
	15	NA	2333.03	2008
1x800	10	NA	3334.27	2008

The performance guarantee liability includes:

Performance Security towards the faithful performance of the contract and Performance Guarantee of the Facilities/Equipment supplied. In the former case, the

liability is normally limited to 10% of the contract price. In the latter case, the failure to attain guaranteed performance of the facilities/equipment, during performance tests, attract liquidated damages of various percentages/amounts normally limited to 10% of the contract price. Maximum limit of both these liabilities is in conformity with limit specified by international and National Financial Institutions.

The data analysis shows that in most of the cases the maximum limit of performance liability in respect of the performance of the facilities/equipment supplied conforms to 10% of the contact price while in three cases, the same is 15% of the contract price. In the case of performance liability for faithful performance of the contract, in 2 out of 10 cases, the maximum limit specified is 15%. In one case, the maximum limit of 25% specified is on cumulative basis and the same has not been considered.

Findings

- It is seen that where the percentage performance liability limit is higher than the standard limit of 10%, there seems to be impact on the price of the plant and equipment. It is considered necessary to provide for an adjustment factor for such cases.
- Performance Guarantee Adjustment Factor (PGAF) of 5% is considered reasonable. The factor proposed is based on the average of the minimum and maximum price variations.

Item 4 : Basis of Price (Firm/Escalation-Linked)

Basis of Price is divided into two following parts:

a. Firm/Escalation-Linked Price
b. Negotiated Price

a. Firm/Escalation-Linked Price

Units Covered	Price Basis	Price (Rs. in Crores)	Year of Award
1x500	Firm	953.24	2005
	Escalation-Linked	942.00	2008
	Escalation -Linked	1247.47	2007
2X500	Escalation-Linked	1942.00	2008
	Firm	3390.00	2008
1x600	Escalation Linked	1325.00	2008
2X600	Escalation-Linked	2970.00	2007
	Firm	2344.41	2007

	Firm	2333.03	2008
2X800	Firm	3334.27	2008

Findings

- The data analysis shows that of the 10 units covered, in 5 cases, the prices are on Firm Price basis and in 5 cases, the prices are on Escalation-Linked basis
- As seen in few cases, there seems to be impact on price in case of firm price basis. It is considered necessary to provide for an adjustment factor for such cases.
- Firm Price Adjustment Factor (FPAF) of 10% is considered reasonable. The factor proposed is based on the average of the minimum and maximum price variations.
- .

b. Negotiated Price

Units Covered	Mode of Procurement	Price (Rs. in Crores)	Year of Award
1x500	Negotiated	953.24	2005
	Negotiated	942.00	2008
	Tender Process	1247.47	2007
2X500	Negotiated	1942.00	2008
	Tender Process	3390.00	2008
1x600	Negotiated	1325.00	2008
2X600	Tender Process	2970.00	2007
	Tender Process	2344.41	2007
	Tender Process	2333.03	2008
2X800	Tender Process	3334.27	2008

Findings:

- The data analysis shows that of the 10 units covered, in 4 cases, the prices are on negotiated basis and in 6 cases, the prices are on tender process basis
- In some cases, prices on negotiated basis are found to be lower than the prices on tender process basis.
- There does not appear to be any impact on price of plant and equipment on account of the negotiation based prices as against the tender process based prices, as analyzed on the basis of the available data.
- There being no impact on the price of plant and equipment, no reasonable mark up to work out a factor which could be applied for benchmarked capital cost could be made.

Item 5: Equipment Supplier

Domestic
European/ Japanese / Korean / Chinese / USA

- Assessment has been made on the basis of the cost of the Main Plant Equipment (BTG) based on available information of the approximated cost of the Main Plant (BTG) and own experience assuming the Base Cost as the Domestic Equipment Cost.

It was suggested that 'Adjustment factors proposed in the case of Country of Origin should be linked to specific parameters of the performance of the equipment to justify the factor. A study was carried out on operating parameters of different country origin supplied equipment. Details of operating parameters are summarized below:

Steam Cycle Parameters	Units	China		Japan		USA		European		Russia	
Pressure	Bar	246	246	246	246	246	246	255	255	255	255
Main Steam Temperature	°C	540	566	538	566	538	566	542	556	545	565
Reheat Temperature	°C	540	566	566	580	566	566	566	580	545	575

Recent supercritical plants in different countries are operating on different steam parameters. These parameters depend on design and related material involved. There is not much difference in the operating parameters of equipment supplied by manufactures of different countries. Prices offered by suppliers differ on account of difference in cost of manufacture, technical and commercial conditions of supply, performance guarantees etc. Based on this, the following adjustment factors are considered reasonable:

India	0.0
China	-15 %
Europe	+10%
Russia/ South Korea	+ 5%
Japan & USA	+15

6.4.6 Adjustment Factors of Benchmarked Capital Cost

S.No.	Other Project Variable	Adjustment Code	Adjustment Factor (%)

S.No.	Other Project Variable	Adjustment Code	Adjustment Factor (%)
1	Completion Schedule	CSAF	5
2	Terms of Payment	TPAF	10
3	Performance Guarantee Liability	PGAF	5
4	Basis of Price (Firm/Escalation-Linked)	FPAF	10
5	Equipment Supplier (Country of Origin)		
	India	COO (IND)	0.0
	China	COO (CH)	-15 %
	Europe	COO (EU)	+10%
	Russia/ South Korea	COO (RUS/SK)	+ 5%
	Japan & USA	COO (JAP/US)	+15

In cases where an applicant attributes increase in the capital cost of a project, higher than benchmarked capital cost, to more than one project other variables, the MAXIMUM Adjustment Factor applicable among the attributed project other variables shall only be applied.

7.0 DATA INPUTS

7.1 For the purpose of model, data obtained from following stations has been considered.

S.No.	Name of the Plant	Unit Size	Number of Units
1	Bellary - I	500	1
2	Bhopallapally	500	1
3	Kaparkheda	500	1
4	Korba- Stage-III	500	1
5	Ramagundum Stage-III	500	1
6	Vindhyachal Stage-II	500	1
7	Bellary - II	500	1
8	Anpara-D	500	1
9	Sipat STPS, Stage-II	500	2
10	Valur STPS Ph-I	500	2
11	Mauda	500	2
12	Marwa	500	2
13	DVC Koderma	500	2
14	Udipi, Lanco	507	2

S.No.	Name of the Plant	Unit Size	Number of Units
15	Simadhri-I	500	2
16	Simadhri STPS Stage-II	500	2
17	Vindhyanchal Stage-IV	500	2
18	Vindhyachal Stage-III	500	2
19	Rihand Stage-II	500	2
20	Talcher STPS Stage-II	500	2
21	Jhajjar	500	3
22	Malwa- MPPGCL	600	2
23	Raghunathpura	600	2
24	Kakatiya	600	1
25	TNEB , North Chennai	600	1
26	Jindal, Orissa	600	4
27	Sipat Stage -I	660	3
28	Barh STPS	660	3
29	Krishnapattnam	800	2

Data in the required format was furnished for only seven (7) stations. The details of the same are given below:

S.No.	Name of the Plant	Unit Size	Number of Units
1	Simadhri STPS Stage-II	500	2
2	Vindhyanchal Stage-IV	500	2
3	Talcher STPS Stage-II	500	2
4	Jhajjar	500	3
5	Sipat STPS, Stage-II	500	2
6	Valur STPS Ph-I	500	2
7	Mauda	500	2

7.2 The package-wise cost details were not available for other stations; Therefore, a prudent analysis was done and data furnished was segregated suitably (using percentage breakup of cost available for above mentioned stations in order to derive the costs for different packages. The same percentage breakup has been used for 600 MW, 660 MW and 800 MW units as well as for BoP packages.

7.3 Thermal Model has been validated with the data of stations covered in the data base to zero in the causes of large variations in package wise cost so as to rectify the model to achieve the necessary level of 97-98% with variation in overall cost within the assured limits of +/-5% as desired by CERC. CERC also

intimated in the first week of January, 2010 that a number of projects of capacity of 500 MW and above have since been ordered by the State utilities and IPPs and that the data collection from these stations would help to validate the model.

The projects which had been ordered by the State utilities and IPPs were ascertained and, on the request made by the Consortium, CERC issued letters to the State utilities/IPPs in the second of week of January, 2010 for furnishing the information in the given format/s for validation of the model. These projects and the utilities are as indicated below:

S.No.	Utility Name	Power Station Location	Capacity (MW)	Extension/ Greenfield.
1	MAHAGENCO	Koradi TPS, Maharashtra	3x660	Extension
		Chandrapur TPS, Maharashtra	2x500 (Unit 9 & 10)	Extension
		Bhusawal TPS, Maharashtra.	2x500	Extension
2	M/s Avanth Power & Infrastructure Ltd.	Bhandear TPS, Raigarh, Chhattisgarh.	1x600	Greenfield
3	M/s Monnet Power Company Ltd.	Angul TPS, Orissa	2x600	Greenfield
4	NTPC Limited.	Vellore TPS, Ennore, Tamil Nadu	500	Extension
5	M/s Jindal Steel & Power Limited	Raigarh TPS, Chhattisgarh	4x600	Extension
6	M/s Jaiprakash Associates Ltd.	Prayagraj TPS, UP.	3x660	Greenfield
		Nigire TPS, M.P.	2x660	Greenfield.

In response, data has been received from MAHAGENCO covering three projects which included Chandrapur TPS, Bhusawal TPS and Kaperkheda TPS (All Extensions). The other utilities have not responded.

8.0 ASSUMPTIONS

8.1 Key assumptions made in the model include:

- Most of the data furnished by utilities was not in the required format. Of the twenty one (21) plant data available for 500 MW Units, only seven (7) were found to be in the desired format. The package wise cost details were available only for these plants. The segregated data of these seven (7) plants was divided into percentages and same percentages were used to obtain package wise costs for rest of the plants.
- Variables impacting cost of package have been derived from a number of brainstorming sessions with the experts. The same was also shared with industry experts and based on their feedback; suitable additions were incorporated after careful scrutiny and due diligence.
- Escalation of costs has been done by using price variation formulae as used in industry.
- Suitable extrapolation and analysis has been done for benchmarking of cost for unit size 600 MW, 660 MW and 800 MW on account of limited data availability in respect thereof.

9.0 VALIDATION

9.1 Plants included in Base Case:

9.1.1 For the purpose of the model, the total plant data has been segregated into various packages on the basis of the methodology submitted by the Consortium and considered by CERC. From the packages thus segregated, package cost data of the plants having similarity has been used for benchmarking. The data found to be uncommon in the course of segregation has not been considered. In the data provided for validation, though the base cost data is available but the various variable factors influencing the cost such as distance of water source and coal mine, type of unloading, quality of coal as have been stated in this memorandum was not available.

9.1.2 The validation results of capital costs of plants included in base case without the impact of various influencing variable factors due to non-availability of relevant data in respect thereof, as mentioned above, have been worked out and is shown in paragraph 10.1.

9.2 Plants with Package-wise Available Data

(1) Package wise cost data was available only in respect of Kahalgaon STPP Stage-II. However, as process for validation was being carried out, it was noticed that costs submitted in petition were not solely for 2x500 MW. There were some costs which corresponded to 2x500 MW units while some

costs were for 3x500 MW. Validation was carried out assuming that all the costs are for 3x500 MW. The results of validation are shown in paragraph 10.2.

(2) The Thermal Model has also been validated with the data received from MAHAGENCO covering three power stations as stated above. The results of the validation are shown in paragraph 10.2.

(3) The Thermal Model has also been validated with the data received from Private IPP. The results of the validation are shown in paragraph 10.2.

10.0 RESULTS

10.1 Validation Results of the plants included in Base Case:

Plant Name	Capacity	No. of Units	Actual Cost	Benchmark Cost	%
			Jan-09	Jan-09	
Bellary - I	500	1	4.84	4.84	0.0%
Bhopallapally	500	1	2.66	2.41	9.7%
Kaparkheda	500	1	2.66	2.75	-3.1%
Korba- Stage-III	500	1	2.08	2.16	-3.6%
Ramagundum Stage-III	500	1	4.39	4.39	0.0%
Vindhyachal Stage-II	500	1	5.92	5.94	-0.4%
Bellary - II	500	1	4.30	4.27	0.5%
Sipat STPS, Stage-II	500	2	3.69	3.67	0.7%
Valur STPS Ph-I	500	2	4.80	4.73	1.6%
Mauda	500	2	3.96	4.08	-3.1%
Marwa	500	2	2.28	2.30	-0.7%
DVC Koderma	500	2	4.07	4.04	0.9%
Udipi, Lanco	507	2	4.03	4.54	-12.5%
Simadhri-I	500	2	3.68	4.13	-12.1%
Anpara-D	500	2	3.86	3.41	11.7%
Simadhri STPS Stage-II	500	2	4.41	4.26	3.5%
Vindhyanchal Stage-IV	500	2	4.23	4.16	1.6%
Vindhyachal Stage-III	500	2	3.05	3.08	-1.0%
Rihand Stage-II	500	2	2.69	2.72	-1.4%
Talcher STPS Stage-II	500	2	2.92	2.46	15.9%

Plant Name	Capacity	No. of Units	Actual Cost	Benchmark Cost	%
			Jan-09	Jan-09	
Jhajjar	500	3	3.57	3.57	0.0%
Malwa- MPPGCL	600	2	1.10	1.27	-15.5%
Raghunathpura	600	2	4.13	3.96	4.1%
Kakatiya	600	1	1.93	1.93	0.0%
TNEB , North Chennnai	600	1	3.89	3.88	0.3%
Jindal, Orissa	600	4	1.85	1.70	7.9%
Sipat Stage -I	660	3	4.08	4.08	-0.1%
Barh STPS	660	3	4.13	4.13	0.1%
Krishnapattnam	800	2	4.34	4.34	0.0%
					6.4%

The percentage variation among the various plants given therein has not been consistent mainly for the reasons that the validation does not account for the impact of the various influencing variable factors due to lack of data in respect thereof.

10.2 Validation Results of Plants with Package-wise Data:

(1) Kahalgaon Stage-II

Mandatory Packages

S.No.	Package Name	Date of Award	Value of Award (INR Crore)	Cost Per (INR Crore / MW)	Value as per Model (INR Crore / MW)	Difference
1	Steam Generator Island	Nov-03 and Mar-04	2624.24	1.75	0.80	0.95
2	Turbine Generator Island	Jan' 04	869.04	0.58	0.46	0.11
3	Water System	Mar' 04, July 04, Nov' 04	147.72	0.10	0.19	(0.09)
4	Fuel Oil Handling & Storage System		Not Provided			-
5	Ash Handling System	Mar' 04	78.02	0.05	0.10	(0.04)
6	Coal Handling System	Jun' 04	170.88	0.11	0.207	(0.09)
7	Mechanical-Miscellaneous Package	Dec'04,Oct'04 and July'04	38.71	0.03	0.02	0.01
8	Switchyard Package	Aug' 04	23.15	0.02	0.081	(0.07)
9	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	Mar '04, April'04 and Aug' 04	114.62	0.08	0.22	(0.14)
10	Emergency DG Set		Not Provided			-
11	C&I Package	Sept' 04	40.27	0.03	0.037	(0.01)
12	Chimney	April' 04	18.44	0.01	0.033	(0.02)
13	Civil Works	Aug' 03, Sept' 03, Feb' 04	149.09	0.10	0.71	(0.61)
14	Initial Spares		Not Provided			
15	Cooling Tower	Jun' 04	51.28	0.03	0.13	(0.09)
	TOTAL		**4325.46**	**2.88**	**2.98**	(0.10)

Optional Packages

S.No.	Package Name	Date of Award	Value of Award (INR Crore)	Cost Per INR Crore/MW	Value as per Model (INR Crore)	Difference
1	Water Clarification System			-		-
2	MGR			-		-
3	Railway Siding	Oct' 05	51.8	0.03	0.11	(0.08)
4	Unloading Equipment at Jetty			-		-
5	Rolling Stock/Locomotive	Oct' 04	39.77	0.03	0.04	(0.01)
6	FGD Plant			-		-
7	Township & Colony			-		-
8	Transmission Line Cost till Tie Point (If applicable)			-		-
	TOTAL		**4468.31**	**0.06**	**0.15**	
	Grand Total		**8,793.77**	**2.94**	**3.13**	**0.19**

Note:- Comparison has been made with values obtained for 3 x 500 MW (Greenfield) from model

(2) MAHAGENCO Projects:

		Chandrapur	Bhusawal
Total Hard Cost (Excluding Taxes)	INR Crores	3640.4	3688.242
Total Hard Cost / MW		3.640	3.69
As per Benchmarking costs		3.87	3.56
Difference		(0.23)	0.13
Difference (%)		-6.31%	3.48%

(3) Private IPP Projects:

Total Hard Cost (Excluding Taxes) in INR Crore	7225.06
Total Hard Cost / MW	3.01
As per Benchmarking Cost/ MW	3.17
Difference	0.16
Difference (%)	-5.34%

11.0 PRICE VARIATION MODELS – Essential Features

11.1. The price variation for the following packages of Thermal Power Station is considered:

Mandatory Packages

- Steam generator Island
- Turbine generator Island
- Water system
- Fuel Oil Handling & Storage System
- Ash Handling System
- Coal Handling System
- Mechanical-Miscellaneous Package
- Switchyard Package
- Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages
- Emergency DG Set
- Chimney
- Civil Works
- Cooling Tower

Optional Packages

- Water Clarification System
- MGR
- Railway Siding
- Unloading Equipment at Jetty
- Rolling Stock/Locomotive
- FGD Plant
- Township & Colony
- Transmission Line Cost till Tie Point

11.2 Indices

11.2.1 There are some basic materials that impact the prices of packages. However, unlike IEEMA which publishes PV formulae for electrical industry, there is no such body which conducts similar exercise for mechanical and civil packages. In the absence of the standard PV formulae for mechanical and civil packages,

discussions were held with various stakeholders including developers, equipment manufacturers to arrive at basic materials and their weightage which drive the cost of packages. The standard practice for price variation followed by industry was also reviewed. It was concluded that the cost of mechanical equipments is primarily driven by prices of materials like steel, cement, labor, non-ferrous metal and alloys. Escalation formulae were accordingly developed and are listed below.

11.2.2 The prices indices used for mechanical equipments were taken from Bulletin published by Reserve Bank of India (RBI).

11.2.3 For electrical packages indices published by IEEMA and formulae adopted by IEEMA have been used.

11.2.4 Raw materials impacting the cost of mechanical equipment are as follows:

S.No.	Basic Raw materials	Notations
1	Base Metal and Alloys	A1/Ao
2	Non-Ferrous Metals	B1/Bo
3	Steel	C1/Co
4	Cement	D1/Do
5	Labour	E1/Eo

11.2.5 Price Indices of raw materials considered for electrical packages are as follows::

S.No.	Basic Raw materials	
1	Copper	F1/Fo
2	Electrical Lamination Steel	G1/Go
3	Constructing Steel	H1/Ho
4	Insulating Material	I1/Io
5	Oil	J1/Jo
6	Labour	K1/Ko

11.2.6 Price Variation Formulae (Mechanical & Civil Packages)

Package	Formulae
Steam Generator	$P1 = P_0 * (0.15 + (0.40 * (A1/Ao)) + (0.27* (C1/Co)) + (0.13* (E1/Eo))$

Package	Formulae
Island	
Turbine Generator	P1 = Po * (0.15 + (0.18 * (B1/Bo)) + (0.53* (C1/Co)+ (0.14*(E1/Eo)
Water System	P1 = Po * (0.15 + (0.14 * (B1/Bo)) + (0.28* (D1/Do)) + (0.28 *(C1/Co)) + (0.14 *(E1/Eo))
Fuel Oil Handling & Storage system	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Ash Handling System	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Coal Handling System	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Mechanical- Miscellaneous Package	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Switchyard Package	P1 = Po * (0.15 +(0.25* (F1/Fo)) + (0.28*(G1/Go)) + (0.07*(H1/Ho)) + (0.03*(I1/Io) + (0.07* (J1/Jo)) +(0.15* (K1/Ko)
Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	P1 = Po * (0.15 +(0.25* (F1/Fo)) + (0.28*(G1/Go)) + (0.07*(H1/Ho)) + (0.03*(I1/Io) + (0.07* (J1/Jo)) +(0.15* (K1/Ko)
Emergency DG Set	P1 = Po * (0.15 +(0.25* (F1/Fo)) + (0.28*(G1/Go)) + (0.07*(H1/Ho)) + (0.03*(I1/Io) + (0.07* (J1/Jo)) +(0.15* (K1/Ko)
Chimney	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Civil Works	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Cooling Tower	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Desalination Plant	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
MGR/ Railway Siding/ Unloading Equipment at Jetty	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Rolling Stock/Locomotive	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
FGD Plant	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Township & Colony	P1 = Po* (0.15 + (0.35 *(C1/Co)) + 0.35*(D1/Do) + 0.15* (E1/Eo))
Transmission Line Cost till Tie Point	P1 = Po * (0.15 +(0.25* (F1/Fo)) + (0.28*(G1/Go)) + (0.07*(H1/Ho)) + (0.03*(I1/Io) + (0.07* (J1/Jo)) +(0.15* (K1/Ko)

11.3 Validation

PV formulae used in the model are based on the formulae being followed by the Central and State Power Generating utilities.

12.0 ACCURACY AND CONFIDENCE LEVELS OF MODEL

12.1 The models that have been developed based on the data available, as also, reworked data indicate that the accuracy level works out to a maximum of ± 5.

12.2 Confidence level of up to 98% can be expected from the results of these models.

13.0 DEVELOPING/REVISION OF DRAFT FORMATS OF PROJECT COSTS1

13.1 The existing Forms contained in Appendix I of the CERC (Terms and Conditions of Tariff) Regulations, 2009 have been reviewed and revised. The revised forms will be incorporated at the time of notification of benchmark cost.

14.0 BENCHMARK NORMS OF CAPITAL COST OF THERMAL POWER STATIONS TO BE SPECIFIED IN TERMS OF SUB-CLAUSE 2 OF CLAUSE 7 OF CERC (TERMS AND CONDITIONS OF TARIFF) REGULATIONS, 2009.

A. The Governing Conditions:

1. The benchmark norms of capital cost of Thermal Power Stations specified below are intended for prudence check of capital cost of thermal power projects as per the requirements of Sub-clause 2 of Clause 7 of Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2009.
2. The actual hard cost of the project shall be compared with the benchmark cost . In case of a large variation between the two, the Commission may undertake detailed examination to ascertain the reason and justification for the variation, after accounting for the variables as provided in the model wherever considered applicable.
3. Benchmark norms of capital cost represent the hard cost of the project and do not include the cost of land, financing cost, interest during construction, taxes and duties, right of way charges, cost of R&R etc. and the same would be additional.
4. The cost of erection, testing and commissioning and other incidental expenses including preparation, site supervision etc. are factored into the benchmark norms of capital cost.

5. The date for normalization of costs through price variation process has been taken as the end of February, 2009. The escalation formula shall be applied on benchmark norms from the reference date of normalization for the purpose of updating the benchmark norms on annual basis for the next five years i.e. for 2009-14, the period during which the regulations referred to above shall remain in force.
6. The model for benchmarking norms developed is a self-validating model i.e. as data of new projects gets added to the data base, the benchmark norm would get revised automatically.
7. Tariff Filing Forms (Thermal) – Part I Form 2 shall be furnished as per the specimen form annexed herewith. This includes Section 1 – Plant Characterstics, Section IIA – Variable Factors with impact on Capital Cost Components for Coal/Lignite based projects, Section IIB – Variable Factors with impact on Capital Cost Components for Gas/Liquid Fuel based projects and Section IIC – Format for Model Validation.

B. BASIS OF BENCHMARK NORMS OF CAPITAL COST OF THERMAL POWER STATIONS:

CERC

Capital Cost Benchmarking

Thermal Power Plants

Variable	Parameters for Variables	Reduction/Escalation	Reduction/Escalation	Reduction/Escalation	Reduction/Escalation
		500 MW	600 MW	660 MW	800 MW

Calorific Value of Coal	3000-4000 Kcal/Kg	Base Cost	Base Cost		
	3800-4800 Kcal/Kg			Base Cost	Base Case
Ash Content in Coal	Below 25%				Base Cost
	35-40%	Base Cost	Base Cost	Base Cost	
Moisture Content in Coal					
	8%- 15%	Base Cost	Base Cost	Base Cost	Base Cost
Boiler Efficiency					
	86.00%	Base Cost	Base Cost	Base Cost	Base Cost
Suspended Particulate Matter	50-100 ppm	Base Cost	Base Cost	Base Cost	
	25- 50 ppm				Base Cost
Ash Utilisation	Fly Ash Utilisation (80%)	Base Cost	Base Cost	Base Cost	Base Cost
Boiler Configuration	Tower Type	Base Cost	Base Cost	Base Cost	Base Cost
Turbine Heat Rate	1950 Kcal/Kwh	Base Cost	Base Cost		
	1875 Kcal/Kwh			Base Cost	
	1825 Kcal/Kwh				Base Cost
CW Temprature (Turbine Generator Island)	33 Degree Celsius	Base Cost	Base Cost	Base Cost	Base Cost
CW Temprature (Cooling Tower)	33 Degree Celsius	Base Cost	Base Cost	Base Cost	Base Cost
Distance of Water Source (River)					
	5 km	Base Cost	Base Cost	Base Cost	Base Cost
Raw Water	River Water	Base Cost	Base Cost	Base Cost	

System					
	Onshore Coastal				Base Cost
Clarification Plant					
	With Clarifier	Base Cost	Base Cost	Base Cost	Base Cost
Evacuation Voltage Level	400 kV	Base Cost	Base Cost		
	765 kV			Base Cost	Base Cost
Mode of Unloading Fuel Oil	Train	Base Cost	Base Cost	Base Cost	Base Cost
	Truck				
Foundation Type	Raft Type	Base Cost	Base Cost	Base Cost	Base Cost
	Pile Type				
Type of Soil	Hard Soil	Base Cost	Base Cost	Base Cost	
	Loose Soil				Base Case
Seismic and Wind Zone	Low	Base Cost	Base Cost	Base Cost	Base Cost
	High				
Type of Fly Ash Disposal	Dry Fly Ash Disposal at 1 km	Base Cost	Base Cost	Base Cost	Base Cost
Type of Wet Ash Disposal	Wet Bottom Ash Disposal at 3 km	Base Cost	Base Cost	Base Cost	Base Cost
Coal Unloading Mechanism	Track Hoppper	Base Cost	Base Cost	Base Cost	Base Cost
Water Level (Civil Works)	Less than 3 meters	Base Cost	Base Cost	Base Cost	Base Cost
Condensate Cooling Method	Once Through (Sea Water)				
	Natural Draft	Base Cost	Base Cost	Base Cost	Base Cost
	Induced Draft				

Desalination / RO Plant (Sea Water)	Reverse Osmosis (RO) Plant	Base Cost	Base Cost		
	Desalination Plant (RO Type)			Base Cost	Base Cost
	Desalination Plant (Thermal)				
Transmission Line	400 kV	Base Cost	Base Cost		
	765 kV			Base Cost	Base Cost
Completion Schedule	44 Months	Base Cost	Base Cost	52 Months	58 Months
	47 Months			58 Months	64 Months
Terms of Payment	10% Advance+ 80% on Delivery+ 5% on Completion+ 5% on operational acceptance	Base Cost	Base Cost	Base Cost	Base Cost
Performance Guarantee Liability	Standard (10% of Contract Value)	Base Cost	Base Cost	Base Cost	Base Cost
Basis of Price (Firm/Escalation-Linked)	Firm Prices	Base Cost	Base Cost	Base Cost	Base Cost
Equipment Supplier (Country of Origin)	India	Base Cost	Base Cost	Base Cost	Base Cost

C. BENCHMARK NORMS OF CAPITAL COST OF THERMAL POWER STATIONS TO BE SPECIFIED UNDER SUB–CLAUSE 2 OF CLAUSE 7 OF CERC (TERMS AND CONDITIONS OF TARIFF) REGULATIONS, 2009

SEE ANNEXURE – II

ANNEXURE

PART – I – TARIFF FILING FORMS (THERMAL)

PART–I

FORM–2

PLANT CHARACTERISTICS AND VARIABLE FACTORS

SECTION I – PLANT CHARACTERSTICS:

Name of the Company	_____						
Name of the Power Station	_____						
Basic characteristics of the plant[1]	_____						
Special Features of the Plant							
Site Specific Features[2]	_____						
Special Technological Features[3]	_____						
Environmental Regulation related features[4]	_____						
Any other special features	_____						
Fuel Details[5]	**Primary Fuel**			**Secondary Fuel**		**Alternate Fuels**	
Details	**Module number or Unit number**						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	& so on
Installed Capacity (IC)							
Date of Commercial Operation (COD)							
Type of cooling system[6]							
Type of Boiler Feed Pump[7]							

[1] Describe the basic characteristics of the plant e.g. in the case of a coal based plant whether it is a conventional steam generator or circulating fludized bed combustion generator or sub-critical once through steam generator etc.

[2] Any site specific feature such as Merry-Go-Round, Vicinity to sea, Intake /makeup water systems etc. scrubbers etc. Specify all such features.

[3] Any Special Technological feature like Advanced class FA technology in Gas Turbines, etc.

[4] Environmental regulation related features like FGD, ESP etc.

[5] Coal or natural gas or naptha or lignite etc.

[6] Closed circuit cooling, once through cooling, sea cooling etc.

[7] Motor driven, Steam turbine driven etc.

PETITIONER

PART-I

FORM-2

SECTION IIA – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR COAL/LIGNITE BASED PROJECTS.		
S.N.	**Break Down**	**Variable Factors**
(1)	**(2)**	(3)
1.0	**Cost of Land & Site Development**	
1.1	Land	
1.2	Rehabilitation & Resettlement (R&R)	
1.3	Preliminary Investigation & Site development	
	Total Land & Site Development	
2.0	**Plant & Equipment**	
	BTG	
2.1	Steam Generator Island	a. Coal Quality i. LHV ii. HHV iii. Amount of Sulphur iv. Moisture content b. Boiler Efficiency c. Ash utilization d. Single pass / double pass type

SECTION IIA – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR COAL/LIGNITE BASED PROJECTS.		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
		e. Sub critical / super critical
2.1.1	ESP	SPM (design)
2.2	Turbine Generator Island	a. Turbine Heat Rate b. CW temperature
2.2.1	HP/LP Piping	
	BOP Mechanical	
2.3	Water System	
2.3.1	External water supply system	a. Water Source – River / onshore costal/ offshore costal b. Water source distance
2.3.2	CW system	Type of cooling – cooling tower once through (c)
2.3.3	DM water Plant	
2.3.4	Clarification plant	Clarifier required
2.3.5	Chlorination Plant	
2.3.6	Effluent Treatment Plant	
2.3.7	Sewage Treatment Plant	
2.3.8	Fire Fighting System	
2.3.9	Central Monitoring System	
2.3.10	Dust Suppression System	
2.3.11	Desalination Plant	a. Thermal type b. RO type
2.4	Material Handling System	
2.4.1	Fuel Oil Handling & Storage System	Mode of unloading track / train
2.4.2	Ash Handling System	c. Type of Disposal d. Distance to Ash Disposal Area
2.4.3	Coal Handling System	a. Coal Quality b. Coal unloading mechanism
2.5	Mechanical–Miscellaneous Package	

SECTION IIA – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR COAL/LIGNITE BASED PROJECTS.		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
2.5.1	Air Compressor System	
2.5.2	AC Ventilation	
2.5.3	Workshop, Laboratory Equipment and Monitoring System & Equipment	
2.6	Optional Packages – Mechanical	
2.6.1	MGR/ Railway Siding / Unloading Equipment at Jetty	a. Plant Location b. Green Field/Extension c. Coal Mine Distance
2.6.2	Rolling Stock/Locomotive	a. Plant Location b. Green Field/Extension c. Coal Mine Distance
2.6.3	FGD Plant	a. Coal Quality i. LHV ii. HHV iii. Amount of Sulphur b. Technology
	BOP Electrical	
2.7	Switchyard Package	a. Evacuation voltage b. No of bays
2.8	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	a. Voltage Level
2.9	Emergency DG Set	
2.10	Transmission Line Cost till Tie Point (If applicable)	a. Voltage Level b. Tie Point Distance for Evacuation
2.11	C & I Package	
	Civil Works	
2.12	Main Plant, Administration Building,	a. Type of foundation –Pile /Raft

SECTION IIA – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR COAL/LIGNITE BASED PROJECTS.		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
	Foundations, Water System, Material Handling System and Miscellaneous System	b. Type of soil c. Water table
2.13	Site Development, Temporary Construction & Enabling Works, Road & Drainage and Area Development for Ash Disposal	
2.14	Cooling Tower	a. NDCT / IDCT
2.15	Chimney	
2.16	Optional Packages – Civil	
2.16.1	MGR/ Marshalling Yard / Jetty	a. Green Field/Extension
2.16.2	Township & Colony	a. Green Field/Extension
2.16.3	FGD Plant	a. Coal Quality i. LHV ii. HHV iii. Amount of Sulphur
2.16.4	Desalination Plant	a. Water source and Quality
	Initial Spares (Included in above Packages)	
	Total Plant & Equipment including Civil Works but excluding taxes & Duties	
2.18	**Taxes and Duties**	
2.18.1	Custom Duty	
2.18.2	Other Taxes & Duties	
	Total Taxes & Duties	
	Total Plant & Equipment including Taxes & Duties	
3.0	**Construction & Pre- Commissioning Expenses**	

SECTION IIA – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR COAL/LIGNITE BASED PROJECTS.		
S.N.	**Break Down**	**Variable Factors**
(1)	**(2)**	**(3)**
3.1	Erection Testing and commissioning	
3.2	Site supervision	
3.3	Operator's Training	
3.4	Construction Insurance	
3.5	Tools & Plant	
3.6	Start up fuel	
	Total Construction & Pre- Commissioning Expenses	
4.0	**Overheads**	
4.1	Establishment	
4.2	Design & Engineering	
4.3	Audit & Accounts	
4.4	Contingency	
	Total Overheads	
5.0	**Capital cost excluding IDC & FC**	
6.0	**IDC, FC, FERV & Hedging Cost**	
6.1	Interest During Construction (IDC)	
6.2	Financing Charges (FC)	
6.3	Foreign Exchange Rate Variation (FERV)	
6.4	Hedging Cost	
	Total of IDC, FC, FERV & Hedging Cost	
9.0	**Capital cost including IDC, FC, FERV & Hedging Cost**	

1. In case of time & Cost overrun, a detailed note giving reasons of such time and cost overrun should be submitted clearly bringing out the agency responsible and whether such time & cost overrun was beyond the control of the generating company.

PETITIONER

PART-I

FORM-2

SECTION II B – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR GAS/LIQUID FUEL BASED PROJECTS		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
1.0	Cost of Land & Site Development	
1.1	Land	
1.2	Rehabilitation & Resettlement (R&R)	
1.3	Preliminary Investigation & Site development	
	Total Land & Site Development	
2.0	Plant & Equipment	
	GTG	
2.1	Generator Turbine HRSG Island	a. Gas Quality i. LHV ii. HHV iii. Amount of Sulphur iv. Moisture content b. HSRSG Efficiency c. GT Efficiency
2.2	Turbine Generator Island	a. Turbine Heat Rate b. CW temperature
2.2.1	HP/LP Piping	
	BOP Mechanical	
2.3	Water System	
2.3.1	External water supply system	a. Water Source – River / onshore costal/ offshore costal b. Water source distance
2.3.2	CW system	Type of cooling – cooling tower once through (c)
2.3.3	DM water Plant	

SECTION II B – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR GAS/LIQUID FUEL BASED PROJECTS		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
2.3.4	Clarification plant	Clarifier required
2.3.5	Chlorination Plant	
2.3.6	Effluent Treatment Plant	
2.3.7	Sewage Treatment Plant	
2.3.8	Fire Fighting System	
2.3.9	Central Monitoring System	
2.3.10	Desalination Plant	a. Thermal type b. RO type
2.4	Material Handling System	a. Gas Quality
2.4.1	Gas Unloading System	
2.4.2	Fuel Oil Handling & Storage System	
2.5	Mechanical-Miscellaneous Package	
2.5.1	Air Compressor System	
2.5.2	AC Ventilation	
2.5.3	Workshop, Laboratory Equipment and Monitoring System & Equipment	
	BOP Electrical	
2.6	Switchyard Package	a. Evacuation voltage b. No of bays
2.7	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	a. Voltage Level
2.8	Emergency DG Set	a. Green Field/Extension b. Redundancy & Capacity
2.9	Transmission Line Cost till Tie Point (If applicable)	a. Voltage Level b. Tie Point Distance for Evacuation
2.10	C & I Package	

SECTION II B – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR GAS/LIQUID FUEL BASED PROJECTS		
S.N.	Break Down	Variable Factors
(1)	(2)	(3)
	Civil Works	
2.11	Main Plant, Administration Building, Foundations, Water System, Material Handling System and Miscellaneous System	a. Type of foundation –Pile /Raft b. Type of soil c. Water table
2.12	Site Development, Temporary Construction & Enabling Works, Road & Drainage	
2.13	Cooling Tower	a. NDCT / IDCT
2.14	Chimney	
2.15	Optional Packages – Civil	
2.17.2	Township & Colony	a. Green Field/Extension
2.17.4	Desalination Plant	a. Water Source and Quality
	Initial Spares (Included in above Packages)	
	Total Plant & Equipment including Civil Works but excluding taxes & Duties	
2.18	Taxes and Duties	
2.18.1	Custom Duty	
2.18.2	Other Taxes & Duties	
	Total Taxes & Duties	
	Total Plant & Equipment including Taxes & Duties	
3.0	Construction & Pre- Commissioning Expenses	
3.1	Erection Testing and commissioning	
3.2	Site supervision	
3.3	Operator's Training	
3.4	Construction Insurance	
3.5	Tools & Plant	

SECTION II B – VARIABLE FACTORS WITH IMPACT ON CAPITAL COST COMPONENTS FOR GAS/LIQUID FUEL BASED PROJECTS		
S.N.	**Break Down**	**Variable Factors**
(1)	**(2)**	**(3)**
3.6	Start up fuel	
	Total Construction & Pre- Commissioning Expenses	
4.0	**Overheads**	
4.1	Establishment	
4.2	Design & Engineering	
4.3	Audit & Accounts	
4.4	Contingency	
	Total Overheads	
5.0	**Capital cost excluding IDC & FC**	
6.0	**IDC, FC, FERV & Hedging Cost**	
6.1	Interest During Construction (IDC)	
6.2	Financing Charges (FC)	
6.3	Foreign Exchange Rate Variation (FERV)	
6.4	Hedging Cost	
	Total of IDC, FC, FERV & Hedging Cost	
9.0	**Capital cost including IDC, FC, FERV & Hedging Cost**	

1. In case of time & Cost overrun, a detailed note giving reasons of such time and cost overrun should be submitted clearly bringing out the agency responsible and whether such time & cost overrun was beyond the control of the generating company.

PETITIONER

PART-I
FORM-2

FORMAT FOR MODEL VALIDATION
(THERMAL MODEL)

SECTION IIC

Choose Month and Year of Escalation	
Choose Plant Configuration	

S.N	Particulars	Units	(INR Crores / MW)
	Location		
	Unit No.		
	Capacity	MW	
	MANDATORY PACKAGES		
1	Steam Generator	INR Crores	
2	Turbine Generator Island	INR Crores	
3	Water System	INR Crores	
4	Fuel Oil Handling & Storage system	INR Crores	
5	Ash Handling System	INR Crores	
6	Coal Handling System	INR Crores	
7	Mechanical-Miscellaneous Package	INR Crores	
8	Switchyard Package	INR Crores	
9	Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	INR Crores	
10	Emergency DG Set	INR Crores	

S.N	Particulars	Units	(INR Crores / MW)
11	C & I Package	INR Crores	
12	Chimney	INR Crores	
13	Civil Works	INR Crores	
14	Initial Spares	INR Crores	
	Optional Packages (Includes Equipment Cost and Associated Civil Works)		
1	Cooling Tower	INR Crores	
2	Desalination Plant	INR Crores	
3	MGR	INR Crores	
4	Railway Siding	INR Crores	
5	Coal Unloading Equipment and Jetty	INR Crores	
	- Coal Jetty	INR Crores	
6	Rolling Stock/Locomotive	INR Crores	
	- Rolling Stock/Locomotive	INR Crores	
7	FGD Plant	INR Crores	
8	Township & Colony	INR Crores	
	- Township & Colony	INR Crores	
9	Transmission Line Cost till Tie Point	INR Crores	
	Total Hard Cost	INR Crores	

S.No.	Quantitative Variables	Values
1	Coal Quality -Calorific Value	
2	Ash Content	
3	Moisture Content	
4	Boiler Efficiency	
5	Suspended Particulate Matter	
6	Ash Utlilisation	
7	Turbine Heat Rate	

8	CW temperature	
9	Distance of Water Source	
10	Water Source	
11	Water Table	
12	Type of Fly Ash Disposal and Distance	
13	Type of Bottom Ash Disposal and Distance	
14	Evacuation Voltage Level	
15	Foundation Type (Chimney)	
16	Condensate Cooling Method	
17	Clarifier	
18	Mode of Unloading Oil	
19	Coal Unloading Mechanism	
20	Type of Soil	
21	Desalination/RO Plant	

Qualitative Variables	Values
Completion Schedule	
Terms of Payment	
Performance Guarantee Liability	
Basis of Price (Firm/Escalation-Linked)	
Equipment Supplier (Country of Origin)	

Choose Optional Packages	Yes/No
Cooling Tower	
Desalination Plant/RO Plant	
MGR	
Railway Siding	
Unloading Equipment at Jetty	

Choose Optional Packages	Yes/No
Rolling Stock/Locomotive	
FGD Plant	
Township & Colony	
Length of Transmission Line till Tie Point	

Variable	Parameters for Variables
Calorific Value	3000-4000 Kcal/Kg
	3800-4800 Kcal/Kg
	4400-5500 Kcal/Kg
	Above 5000 Kcal/Kg
Ash Content	Below 25%
	25-35%
	35-40%
	40-45%
Moisture	Less than 8%
	8%- 15%
	More than 15%
Boiler Efficiency	0.85
	0.86
	0.87
	0.88
	0.885
	0.89

Variable	Parameters for Variables
Suspended Particulate Matter	50-100 ppm
	25- 50 ppm
	Below 20 ppm
Ash Utilisation	Fly Ash Utilisation (80%)
	Fly Ash + Bottom Ash Utilisation (100%)
Turbine Heat Rate	1950 Kcal/Kwh
	1930 Kcal/Kwh
	1900 Kcal/Kwh
	1880 Kcal/Kwh
CW Temperature	33 Degree Celsius
	30 Degree Celsius
	27 Degree Celsius
Boiler Configuration	Single Tower Boiler
	Double Pass Boiler
Technology (Boiler)	Sub-Critical
	Super-Critical
Boiler Feed Pump	100% x 2 TDFP + 30% MDFP
	100% x 2 TDFP + 50% MDFP
	50% x 3 MDFP
Distance of Water Source (River)	2 km
	5 km

Variable	Parameters for Variables
	10 km
	20 km
	30 km
Raw Water System (Coastal)	River Water
	Onshore Coastal
	Offshore Coastal
Clarification Plant	Without Clarifier
	With Clarifier
Evacuation Voltage Level	400 kV
	765 kV
Mode of Unloading Fuel Oil	Train
	Truck
Foundation Type	Raft Type
	Pile Type
Type of Soil	Hard Soil
	Loose Soil
Type of Fly Ash Disposal	Dry Fly Ash Disposal at 1 km
	Dry Fly Ash Disposal at 2 km
	Dry Fly Ash Disposal at 3 km
	HCSS at 2 km
	HCSS at 3 km

Variable	Parameters for Variables
	HCSS at 5 km
	Fly Wet Ash Disposal at 2 km
	Fly Wet Ash Disposal at 3 km
	Fly Wet Ash Disposal at 10 km
Type of Wet Ash Disposal	Wet Bottom Ash Disposal at 3 km
	Wet Bottom Ash Disposal at 5 km
	Wet Bottom Ash Disposal at 10 km
Coal Unloading Mechanism	Track Hopper
	Wagon Tippler
	Conveyor (3 km)
	Conveyor (5 km)
	Conveyor (8 km)
Water Level (Civil Works)	Less than 3 meters
	More than 3 meters
Technology (Cooling Tower)	Once Through (Sea Water)
	Natural Draught
	Induced Draught
Desalination / RO Plant (Sea Water)	Desalination Plant
	Reverse Osmosis (RO) Plant
Transmission Line	400 kV
	765 kV

Variable	Parameters for Variables
Completion Schedule	44 Months
	47 Months
Terms of Payment	10% Advance+ 80% on Delivery+ 5% on Completion+ 5% on operational acceptance
	Others
Performance Guarantee Liability	Standard (10% of Contract Value)
	Others
Basis of Price (Firm/Escalation-Linked)	Firm Prices
	Adjustable Prices
Equipment Supplier (Country of Origin)	India
	China
	European
	Russian
	South Korea/Japan
	Others (USA etc.)

C. BENCHMARK NORMS OF CAPITAL COST OF THERMAL POWER STATIONS TO BE SPECIFIED UNDER SUB-CLAUSE 2 OF CLAUSE 7 OF CERC (TERMS AND CONDITIONS OF TARIFF) REGULATIONS, 2009

ANNEXURE-II BENCHMARK COST (INR Crore/MW)																								
Name of package																								
UNIT SIZE	500 MW	500 MW	500 MW	500 MW	500 MW	500 MW	600 MW	600 MW	600 MW	600 MW	600 MW	600 MW	660 MW	660 MW	660 MW	660 MW	660 MW	660 MW	800 MW	800 MW	800 MW	800 MW	800 MW	800 MW
NO OF UNITS	1	2	3	4	1	2	1	2	3	4	1	2	1	2	3	4	1	2	1	2	3	4	1	2
TYPE	G. field	G. field	G. field	G. field	Ext	Ext	G. field	G. field	G. field	G. field	Ext	Ext	G. field	G. field	G. field	G. field	Ext	Ext	G. field	G. field	G. field	G. field	Ext	Ext
Mandatory Packages																								
Steam Generator	1.255	1.230	1.108	1.046	1.17	1.144	1.175	1.152	1.038	0.980	1.095	1.072	1.170	1.147	1.034	0.976	1.091	1.067	1.365	1.338	1.206	1.138	1.273	1.245
Turbine Generator Island	0.773	0.738	0.626	0.622	0.763	0.704	0.810	0.773	0.655	0.652	0.783	0.740	0.742	0.708	0.600	0.597	0.716	0.677	0.932	0.889	0.754	0.750	0.900	0.851
Water System	0.228	0.215	0.208	0.205	0.227	0.208	0.169	0.167	0.162	0.160	0.178	0.156	0.154	0.153	0.147	0.147	0.171	0.141	0.129	0.131	0.127	0.126	0.149	0.118
Fuel Oil Handling & Storage system	0.06	0.05	0.04	0.04	0.05	0.05	0.06	0.05	0.04	0.04	0.05	0.05	0.09	0.08	0.06	0.06	0.08	0.08	0.07	0.06	0.05	0.05	0.06	0.06
Ash Handling System	0.15	0.13	0.12	0.11	0.15	0.11	0.17	0.14	0.14	0.12	0.17	0.12	0.22	0.19	0.18	0.17	0.23	0.17	0.19	0.16	0.15	0.14	0.19	0.14
Coal Handling System	0.214	0.213	0.207	0.205	0.213	0.200	0.363	0.361	0.351	0.348	0.361	0.339	0.33	0.33	0.32	0.32	0.33	0.31	0.28	0.27	0.27	0.26	0.27	0.26
MechanicalMiscellaneous Package	0.031	0.0297	0.023	0.020	0.023	0.016	0.020	0.019	0.015	0.01	0.014	0.010	0.037	0.037	0.027	0.02	0.032	0.023	0.024	0.023	0.018	0.015	0.016	0.012
Switchyard Package	0.099	0.098	0.099	0.100	0.087	0.073	0.075	0.075	0.076	0.08	0.066	0.056	0.097	0.096	0.097	0.10	0.085	0.071	0.062	0.061	0.062	0.062	0.054	0.045
Transformers, Switchgear, Cables, Cable Facilities, Grounding & Lighting Packages	0.29	0.29	0.28	0.27	0.22	0.22	0.20	0.20	0.20	0.19	0.15	0.15	0.27	0.27	0.26	0.25	0.21	0.21	0.17	0.18	0.17	0.16	0.13	0.13
Emergency DG Set	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
C & I Package	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05
Chimney	0.05	0.05	0.04	0.04	0.06	0.05	0.05	0.04	0.04	0.03	0.05	0.04	0.07	0.06	0.06	0.05	0.08	0.07	0.05	0.04	0.04	0.04	0.05	0.05
Civil Works	0.91	0.90	0.89	0.85	0.85	0.74	0.58	0.58	0.62	0.55	0.53	0.50	0.49	0.48	0.80	0.70	0.77	0.67	0.63	0.63	0.64	0.59	0.58	0.53
Initial Spares	0.12	0.12	0.12	0.12	0.11	0.08	0.11	0.11	0.11	0.11	0.10	0.08	0.14	0.14	0.14	0.14	0.13	0.10	0.18	0.19	0.18	0.19	0.17	0.13

Cooling Tower	0.18	0.17	0.16	0.16	0.18	0.16	0.14	0.13	0.12	0.12	0.14	0.13	0.20	0.18	0.18	0.17	0.20	0.18	0.12	0.11	0.11	0.11	0.12	0.11
Total-Mandatory	4.398	4.263	3.960	3.831	4.139	3.801	3.947	3.834	3.598	3.433	3.729	3.484	4.073	3.927	3.958	3.765	4.162	3.805	4.246	4.118	3.820	3.674	4.019	3.714
Optional Packages (Includes Equipment Cost and Associated Civil Works)																								
Desalination Plant	0.13	0.12	0.11	0.10	0.13	0.12	0.12	0.11	0.10	0.13	0.12	0.12	0.09	0.09	0.08	0.07	0.09	0.09	0.09	0.09	0.08	0.07	0.09	0.09
MGR	0.05	0.05	0.04	0.04	0.06	0.05	0.02	0.02	0.01	0.01	0.02	0.02	0.03	0.03	0.02	0.02	0.04	0.03	0.03	0.03	0.02	0.02	0.04	0.03
Railway Siding	0.15	0.14	0.12	0.10	0.10	0.12	0.15	0.14	0.12	0.10	0.10	0.12	0.15	0.14	0.12	0.10	0.10	0.12	0.15	0.14	0.12	0.10	0.10	0.12
Coal Unloading Equipment and Jetty	0.15	0.15	0.20	0.20	0.15	0.15	0.15	0.15	0.20	0.20	0.15	0.15	0.15	0.15	0.20	0.20	0.15	0.15	0.15	0.15	0.20	0.20	0.15	0.15
Rolling Stock/Locomotive	0.05	0.04	0.04	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.02	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.03
FGD Plant	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Township & Colony	0.14	0.09	0.08	0.06	0.08	0.05	0.10	0.06	0.06	0.04	0.06	0.03	0.15	0.09	0.09	0.06	0.09	0.05	0.15	0.09	0.09	0.06	0.09	0.05
Transmission Line Cost till Tie Point	-	-	-	-	-	-																		
Total-Optional	0.855	0.770	0.773	0.720	0.754	0.702	0.756	0.682	0.697	0.691	0.661	0.645	0.801	0.716	0.727	0.676	0.693	0.648	0.801	0.716	0.727	0.676	0.693	0.648