CENTRAL ELECTRICITY REGULATORY COMMISSION

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DEVELOPING BENCHMARKS OF CAPITAL COST – MODEL FOR BENCHMARKING CAPITAL COST OF SUBSTATION ASSOCIATED WITH 400/765 Kv TRANSMISSION SYSTEM

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 Bench Marks of Capital Cost for Transmission System Elements (including Sub-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 Substations associated with 400/765 Kv Transmission system 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 for Substation

- Developing benchmarks for 400 KV and 800 KV sub-stations

- Developing -
  - Suitable disaggregated benchmarks in terms of number of switch gear bays, ICTS, reactors etc for arriving at total hard cost of sub-station
  - Suitably spreading cost of sub-station like grounding, civil works, control and instrumentation, air conditioning, firefighting, carrier communication, DC batteries etc in disaggregated benchmarks

- Factoring 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

Stage I Assignment

- Concept Paper on disaggregated bench marks for capital cost for 400 kV and 800 kV substations.
- 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 in 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 efficiency and 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

- Substations of the Transmission 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.

- 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 January, 2009 is considered as the date for normalization of costs through price variation process.

4.2.2 Data Collection Process

- Selection of Substations from identified list of projects.
- Finalization of Data Collection Formats and Procedure.

- Issue of communication by CERC to the identified utilities for providing assistance and cooperation in data collection and interaction.
- Visit to identified utilities.
- Preliminary discussions with the officials in the 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 Sub-Station 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 wise procured including the cost of each sub-station 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 weight ages 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.

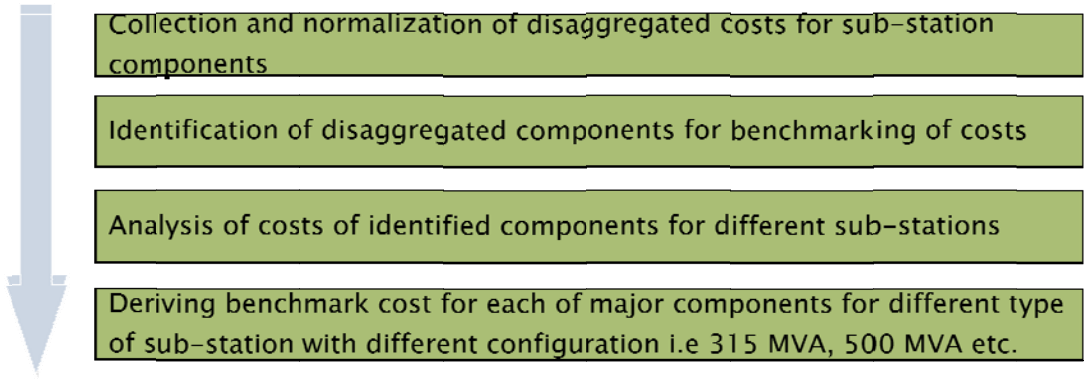
4.2.6 Degree of Reliability and Accuracy of Benchmarking

- Each 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 Main Features considered for Model Creation:

- Activities involved in establishing a substation
- Typical Substation 400/220 kV – Configuration
- Typical Substation 765/400 kV – Configuration
- Typical Substation – Single Line Diagram
- EHV Substation – categorization of works
- Variable costs in Substation
- BOQ for Typical 400/220 kV Substation
- ICTs and Shunt Reactors
- Abstract cost of 2 x 500 MVA 400/220 kV Substation
- Abstract cost of 2x315 MVA,400/220 kV Substation
- Comparison of costs
- Data Collection
- Framework of Concept Model
- Validation of Unit Prices

The process for development of model is shown in schematic below.



. Developing the bench mark cost of 400/220 & 765/400 kV sub-stations using the disaggregated costs of various components.

The typical sub-station considered

- 400 /220 kV sub-station.
- 765 / 440 / 220 kV sub-station.
- GIS
- Series Compensation

Configuration of a Sub station depends on:

- The number of Terminal Bays:

- Line bays.
- Transformer bays

- Number & Capacity of ICTs.
- Number , Capacity & Type of Reactors

- The BOQ for no. of configurations of Sub-stations developed.

- The disaggregated component costs computed for successive periods to arrive at benchmark costs for specified years.

EHV Sub-Station –Categorization of works:

- General common works.
- I.C.Ts.
- Reactors – Shunt / Bus.
- 400 kV – Line & I.C.T Bays.
- 220 kV – Line & I.C.T Bays.

The BOQ & cost for no. of configurations in respect of 400/220 KV Sub-Stations is developed.

A sub-station cost – to be evaluated – compared with the Model

- To produce the matching Alternative.
- To compare the BOQ and costs.

If the Sub Station to be evaluated differs from any of the models, the following method to be adopted:

- The model which is nearest in configuration is to be chosen.
- BOQ & cost of Terminal bay/ s will be suitably added or deleted.

The BOQ & cost of following various Terminal bays are computed to enable to match the sub-station to be evaluated

- 400KV Line Bay with Shunt Reactor
- 400KV Line Terminal Bay.
- 220 kV line bay
- 1X 315MVA, with 400/220KV ICT with bay
- Additional Shunt Reactor to 400 kV Line bay.
- 400 kV Bus Reactor bay.

The cost of various configurations of sub-stations has been computed using relevant price indices & P.V. formulae.

Framework of Concept Model

Input	Process	Output
• Cost data of sub-station at disaggregated level • Escalation formulae for accounting escalation in prices of raw material and labour	• Normalizing the cost of identified components to base year using escalation formulae • Analysis of cost of sub-station with different configuration at disaggregated level	• Development of benchmark cost for a sub-station

6 DATA COLLECTION PROCESS

6.1 CERC Communication

CERC wrote to Transmission Utilities in the country.

6.2 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

6.2.1 Names of Identified Projects

The names of Substation projects identified for Data Collection, Utility-wise, are shown below:

S.No.	Name of sub-station	Source	Base Date of P.I. in the work Award	S.No.	Name of sub-station	Source	Base Date of P.I. in the work Award
1	Arasur	PGCIL	*Aug-05	13	Ludhiyana	PGCIL	*Oct-04
2	Rurkee	PGCIL	*April-06	14	Fathebad	PGCIL	*Oct-04
3	Pugalur	PGCIL	*Aug-05	15	Gwaliar	PGCIL	*Oct-04
4	Damooh	PGCIL	*jan-06	16	Patna	PGCIL	*Aug-04
5	Karaikudi	PGCIL	*Aug-05	17	Narendra	PGCIL	*Sep-03
6	Warangal	PGCIL	*Aug-05	18	Melakottaiyur	PGCIL	*May-05
7	Kankroli	PGCIL	*May-05	19	Jaisalmer	Rajasthan	*Oct-07

8	Kaithal	PGCIL	*june-02	20	Malkaram	A.P	*Mar-08
9	Thirunalveli	PGCIL	*May-05	21	Koradi	Maharastra	*Jan-09
10	Subhash gram	PGCIL	*Sep-03	22	Kaparkheda	Maharastra	*Oct-07
11	Raigarh	PGCIL	*March-04	23	Chakhan	Maharastra	*Oct-07
12	Amrithsar	PGCIL	*Sep-03	24	Bhilai -NSPCL	Bhilai steel plant	*Aug-07

6.2.2 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) 2002-03, 2003-04, 2004-005, 2005-06, 2006-07, 2007-08 and 2008-09 were considered for the purpose of data collection, creation of data base and validation of model.

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

- Data collected 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 based on the contracts awarded.

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

6.2.3 Identified sources of data

S.No.	Source of Data
1	Procurement Orders / Purchase orders
2	Detailed work awards
3	Contract Agreements

6.2.4 Data Collection Formats

Transmission Elements General Data (TEGD)

Element-wise break-up of project cost for Transmission System (EBTS)

Variable Factors with impact on Capital Cost.

6.3 Data Collection Status

Utilities	765/ 400 kV	400 / 220 kV	GIS	Series Compensation	Total
Central (PGCIL)	5	18	2	5	**30**
State (RRVPNL / MSETCL / APTCL)		5			**5**
Public Sector - Bhilai - NSPCL		1			**1**
Total	**5**	**24**	**2**	**5**	

7 SUBSTATION MODEL

7.1 Structure

7.1.1 Sub-Station Models Composition

a) 400 / 220 kV sub-stations.
b) 765/400/220 kV sub-stations.
c) 400/220 kV GIS.
d) Series compensation for 400 kV transmission lines.

7.1.2 Major Components of Sub-stations

a) Common general works
b) ICTs
c) Reactors
d) Earth mat & earthing materials
e) Bay equipments of various voltage classes
f) Protection equipments & Automation
g) Erection charges
h) Civil engineering works.
i) GIS modules.
j) Series capacitor banks
k) Protective Spark Gap - forced triggered
l) Damping Circuit
m) Metal Oxide Varistor,
n) Insulated platforms

7.1.3 Sub-station Alternates & Bay combinations

a) 400/220kV Sub-Stations

20 Alternates/Configurations and 6 Bay Components were conceptualized based on the configurations of existing Sub Stations, for which contracts are issued and are under execution as per the following Table :

S.N.	Description	Number of Line Bays		Number of ICT Bays		Number of ICTs -Capacity in MVA		Number of Reactors	
		400 kV	220 kV	400 kV	220 kV	315	500	Shunt	Bus
1	ALT-1	4	6	2	2	2	0	0	0
2	ALT-2	4	6	2	2	2	0	2	0
3	ALT-3	4	6	2	2	2	0	4	0
4	ALT-4	4	4	2	2	2	0	2	0
5	ALT-5	2	4	2	2	2	0	2	0
6	ALT-6	2	4	1	1	1	0	2	0
7	ALT-7	6	6	2	2	2	0	2	0
8	ALT-8	4	11	1	1	0	1	3	0
9	ALT-9	11	12	2	2	0	2	5	0
10	ALT-10	6	6	2	2	2	0	2	2
11	ALT-11	2	4	2	2	2	0	1	0
12	ALT-12	2	4	2	2	2	0	0	1
13	ALT-13	2	4	1	1	1	0	1	1
14	ALT-14	6	6	2	2	0	2	2	2
15	ALT-15	4	6	3	3	3	0	2	1
16	ALT-16	2	4	2	2	2	0	0	0
17	ALT-17	2	4	2	2	2	0	2	1
18	ALT-18	12	5	2	2	2	0	4	2
19	ALT-19	7	0	0	0	0	0	2	1
20	ALT-20	4	0	0	0	0	0	2	1

Note: ALTs 19 & 20 pertain to 400KV Switching Stations.

b) 765/400/220kV Sub-Stations:

Three Alternates/Configurations and 11 Bay Components were conceptualized base on the configurations of existing Sub Stations, for which contracts are issued and which are under execution as per Table below:

S.N.	Particulars	ALT-765 - 1	ALT-765 - 2	ALT-765 - 3
1	765KV Lines	2	2	4
2	765/400KV Transformer: 3X500 MVAR	3	2	2
3	765KV Shunt Reactor: 3X80	2	1	2

S.N.	Particulars	ALT-765 - 1	ALT-765 - 2	ALT-765 - 3
	MVAR			
4	765KV Bus Reactor: 3X80 MVAR	1	1	1
5	No. of diameter	3	2.5	3.5
6	400KV Lines	4	2	8
7	400/220KV Transformer : 315 MVA	2	0	2
8	400KV Shunt Reactor : 80 MVAR	2	1	1
9	400KV Bus Reactor : 125 MVAR	0	0	2
10	400KV Bus Reactor : 80 MVAR	0	1	0
11	No. of diameter	5	3	7
12	220KV Lines	4	0	4
13	220KV TBC	1	0	1
14	220KV BC	1	0	1
15	No. of diameter	8	0	8

c) Series Compensation for 400kV lines:

Two alternates for S/C & D/C lines Alternates/Configurations were conceptualized base on the configurations of existing Sub Stations, for which contracts are issued and which are under execution.

7.1.4 Bill of Quantities

a) Single Line Diagrams and Switch yard Layouts are drawn for all the alternates /Configurations.

b) Bill of quantities (BOQ) are finalized in standard format. BOQ fell into 4 major groups.

i. **Group - 1 : Common General Works** :
This constituted such of the Civil Engineering Works and Electrical Works, Earth mat, Automation, Power & control cables, cable ducts, Illumination, A.C & D.C auxiliary supplies, PLCC equipments, Fire fighting etc, which are generally required for the Sub Station irrespective of number of Bays, ICTs and Reactors.

ii. **Group - 2 : ICTs**:
This constituted Power Transformers 765/400KV, 400/220kV class depending upon type of Sub Station and voltage transformation required with foundation and erection

iii. **Group - 3 : Reactors**:

This constituted 765KV & 400KV Shunt or Bus Reactor as per requirement of Alternate/Configuration with Foundation and erection.

iv. **Group – 4 : Equipments**:
This constituted Equipments, Control & Protection panels, Steel Structures, Bus bar materials, etc for 765KV, 400KV AND 220KV Switchyards as the case may be.

7.1.5 Computation of Average Price

a) Prices from a large number of LOAs / Purchase order contracts are tabulated for each of the equipment and material.
b) Taxes & Duties were segregated from ex-works prices based on the rate of Taxes & duties prevalent on the day of purchase order and basic unit price of individual material / component is computed.
c) Prices which confirms to various dates of purchase orders are computed to a common date i.e., January 2009 adopting the standard price variation formulae.
d) Average rate of all the equipment and material is computed from a large number of updated prices.

7.1.6 Computation of Hard Cost

a) Using the Average rates, the hard cost of all the Sub Station Alternates/Configurations and Bay components were computed for January 2009.
b) The hard costs as computed above are without Taxes & Duties.
c) The hard cost of Substation and Bay Components were also computed to the various required dates using the price variation formulae and respective price indices.
d) The disintegrated hard cost of each group and the hard cost of total Sub Station are computed, for the various Alternates and with or without Bay components and the Models are developed based on the above data.
e) Models have a provision to compute the hard cost of sub-stations & bay combinations to any Price indices i.e. any date.

7.2 Essential Features

a) The main feature of the model is that it compares the sub-station (to be validated) in complete form to the model.

b) If the sub-station does not match with any of the alternate of sub-station model, due to variation of line bays, ICTs, & Reactors etc, the exact matching can be done by suitably adding / deleting the required bay combinations.

7.3 Main Variables

a) The main variables in the sub-stations are:
   i. Number of ICTs,
   ii. Number of Reactors.
   iii. Number of terminal bays

7.4 Data Inputs

a) Type of switching schemes.
b) Number of line bays
c) Number of ICTs
d) Number & Type of Reactors
e) Date of PO/LOA
f) Base date for price variation
g) Price indices

7.5 Assumptions

The assumptions are made in respect of following, which are based on the size & sub-station configurations

7.6 Validation

a) Sub-station Automation:

i. Lump sum price is provided in most of the contracts, but in some other contracts, the price was based on number of CBs. In some of the contracts one more element of A/C Kiosks was provided. Prices of A/C Kiosks for 400KV & 220KV systems were equal in some cases and it was different in some other cases.

ii. After a thorough study of various configurations of Automation, Average basic price (Price in respect of basic S/S having 2 nos. of 400KV lines, 4 nos. of 220KV lines and 2 nos. of ICTs 2 was assessed.

iii. A factor of 0.076 (7.6%) for the addition of every 400 kV Circuit breaker and 0.068 (6.8%) for the addition of every 220 kV Circuit breaker.

iv. After calculating values for all the 20 ALTs & 6 bay combinations a common % is indicated for each Alternate based on basic cost, in case of 400/220 kV Sub Stations.

v. A similar exercise has been done for 765/400/220 kV sub-stations also.

b) PLCC

i. Prices for 400KV & 220KV Line Traps were available, but prices for other Materials like protection coupler, telephones etc., couldn't be reckoned for 400KV & 220KV Systems separately. Hence Basic price was determined. For addition of a 400KV line or 220kV line a percentage equivalent to 21% and 14.73% respectively was added. Values for all the 20 Alternates & 6 Bay components was computed and a general % is indicated for each of the Alternate & 6 bay combinations of 400/220 kV sub-stations.

ii. A similar exercise has been done for 765/400/220 kV sub-stations also.

c) Main Earthmat conductor(40mm MS Rods)

Quantity of Earthmat conductor is a highly variable since the same is based on Resistivity of the soil. Added to this in most of the contracts, only the lumpsum price is indicated and not the quantity and the unit price. In a handful of contracts quantity is mentioned with unit rate. From the data available Basic quantity is found out and the area of 400KV and 220KV area is determined as per our standard lay outs prepared for this exercise. From the basic price the quantity is computed based on the area of the particular Alternate, and factored.

d) Structural steel and Tubular steel

In most of the cases total lumpsum price is available and not the total tonnage and weights of individual structures. Hence in one or two contracts where total tonnage is available, weights of individual structures like Towers, Beams, equipment support structures, lightning/lighting masts are computed and these weights are adopted in all the Alternates.

e) Fire fighting & Fire protection

i. On thorough evaluation, it was surmised that the price of Fire fighting & Fire protection (FF) consists of a fixed cost

component and variable components based on number of power Transformers and number of Reactors.

ii. Considering number of S/S, a formula was derived.
Cost of Fire fighting & Fire protection:
= Rs Lakhs (55.00 +10.0 * Number of Trs + 5.0*Number of reactors).

iii. A multiplying factor is adopted after determining the price for each ALT, using the above formula.

f) Power & Control Cables

Considering the Quantity for a basic S/S, which consists of two 400KV Lines, four 220KV lines & two 400/220KV ICTs. quantity of Power & Control Cables for other ALTs is factored on the basis of number of 400 kV bays and 220kV bays, separately for 400KV switchyard and 220KV switchyard. A Similar exercise been done for 765/400/220 kV sub-stations.

g) Bus Bar Materials

Considering the Quantity for a basic Sub-station, which consists of two 400KV Lines, Four 220KV Lines & Two 400/220KV ICTs, quantity of Bus Bar Materials for other S/S is calculated on the basis of number of 400kV bays and 220kV bays. Similar procedure for 765/400/220 kV sub-stations.

h) Illumination

There will not be significant change in the quantity and hence the price for different configuration in respect of illumination, due to following reasons.

i. Indoor illumination will remain constant, since the same depends upon control building and FFPH building, which remains same for any configuration.

ii. Switchyard illumination will depend on the number of Lighting cum Lightning masts and the area. Change in the area of various Alternates and hence the change in quantity & change in the price is not considerable, this is also reckoned as constant

iii. Hence the price of illumination is not factored. But average price is considered from a wide range of S/S.

7.7 Validation Results

The results of the validations are furnished in following table:

Validation of 400/220KV Sub Station Costs

Validation of 400/220KV Sub Station Costs								
S.N.	Sub-Stations	Date of index in P.O	Alternate Number in the Model	Cost As per P.O	Cost as per Model	Difference in Rs Lakhs	% variation	STDEV
1	Amrithsar	*September -03	16- 1*400kV Bay-1*ICTbay-2*220 kV bays	2316.66	2295.68	-20.97	-0.91	4.48
2	Arasur	*August -05	16	4424.03	4777.08	353.05	7.39	
3	Damoh	*January - 06	17	6248.37	6478.83	230.46	3.56	
4	Fathehbad	*October -04	17 - 1*Shunt reactor bay	5230.93	4980.93	-250.00	-5.02	
5	Gwaliar	*October -04	12 - 1* 400 kV line Bay	4545.73	4646.51	100.78	2.17	
6	kaithal	*June-02	16	4107.95	4115.23	7.28	0.18	
7	Karaikudi	*April-06	12	6078.62	6200.61	121.99	1.97	
8	Ludhiyana	*October -04	11	5186.15	4934.39	-251.76	-5.10	
9	Melakottaiyur	*May -05	11	5421.41	5219.38	-202.03	-3.87	
10	Narendra	*September -03	16	3612.2	3888.42	276.22	7.10	
11	Pugalur	*August -05	16	4676.65	4777.08	100.43	2.10	
12	Raigarh	*March - 04	11	4829.96	4851.21	21.25	0.44	
13	Roorkee	*April-06	16	5029.39	5405.84	376.45	6.96	
14	Subhashgram	*September -03	16	3557.54	3888.42	330.88	8.51	
15	Thirunalveli	*May -05	18	10830.04	11497.76	667.72	5.81	
16	Warrangal	*August -05	16	4574.92	4777.08	202.16	4.23	
17	Mallkaram - AP	*March-08	16- 2*220 kV line Bays	5049.43	5453.55	404.12	7.41	
18	Jaisalmer - Rajasthan State	*October -07	5	6793.61	6621.28	-172.33	-2.60	

Validation of 765/400/220 kV Sub-stations

S.N.	Sub-Station	Date of index in P.O	Alternate Combination	Computed for Jan-09 in Rs lakhs		Difference in Rs Lakhs	% Difference	STDEV
				As per P.O	As per Model			
1	SEONI	*Septr -04	1	42089.91	42459.86	369.95	0.87	3.16
2	Fathehpur	* NOV -08	3 +2 * Shunt Reactor bays	43247.49	44414.13	1166.64	2.63	
3	Lucknow	*Aug -08	2 - 1*765 kV line Bay	28952.07	27968.27	-983.8	-3.52	

Validation of Series Compensation

S.N.	Name of the sub-station	Cost In Rs Lakhs			% Difference	STDEV
		Actual	As per Model	Difference		
1	Ballabgarh	3068.46	3162.37	93.91	2.97	0.80
2	Raipur	3104.28	3162.37	58.09	1.84	

8. PRICE VARIATION MODELS

8.1 Essential Features

a) ICTs
b) L.T. Transformers
c) Reactors
d) Circuit Breakers
e) Current Transformers
f) Capacitive voltage transformers.
g) Isolators
h) Surge Arrestors
i) Bus Bars materials including Bus bar conductors, insulators & hard ware
j) Steel structures
k) Earth mat
l) Power & control cables.
m) All civil engineering works viz. buildings, foundations, land development, roads and cable ducts etc.
n) Erection charges.

8.2 Indices

8.2.1 The price indices of various materials are as published in the Monthly IEEMA Journals. The price indices of following raw material are used for sub-stations:

S.N.	Basic Raw materials
1	Copper
2	Electrical Lamination Steel
3	Contraction Steel
4	Insulating Material
5	Aluminum
6	Epoxy Resin
7	Index INSLR
8	Zinc
9	Cobalt
10	Ball clay
11	Bismath
12	Fuels/power
13	Published Price Index of Structural Steel
14	Published Price Index of Electrolytic Zinc
15	PVC Compound
16	Metal (Lead)
17	IOC _HSD basic ceiling selling price ex -refinery issued by IOC Norgen region New Delhi.
18	All india average consumer price index for industrial worker(base 1982=100)as published by a labour bureau, Government of india and circulated by emo.
19	Index No. of whole sell price in india for iron and steel as published by reserve bank of india bulletin
20	Index No. of whole sell price in india for non metallic mineral products(Structural clay product) as published by RBI.
21	Cement
22	Diesel

8.3 Price Variation Formulae

S.N.	Description	Formulae
Supply of Equipments & Materials		
1	Power Transformer , Shunt Reactor Bus Reactor & NGR	0.15 + 0.25 * Copper + 0.28 * Elecl. Lamination - CRGO + 0.07 * Constr Steel + 0.03 * Insulation Materials + 0.07 * Oil + 0.15 * Labour.
2	Circuit Breaker	0.15 + 0.15 * Constr. Steel + 0.23 * Copper + 0.11 * Aluminum + 0.16 * Epoxy Resin + 0.20 * Labour.
3	Isolators	0.15 + 0.15 * Constr. Steel + 0.23 * Copper + 0.11 * Aluminum + 0.16 * Epoxy Resin + 0.20 * Labour
4	Current Transformer & CVT	0.15 + 0.15 * Constr. Steel + 0.23 * Copper + 0.11 * Aluminum + 0.16 * Epoxy Resin + 0.20 * Labour

S.N.	Description	Formulae
5	Surge Arrestor	0.15 + 0.20 * Zinc + 0.15 * Cobalt + 0.20 * Aluminum + 0.10 * Fuel / Power + 0.20 * Labour.
6	Structural Steel	0.15 + 0.58 * Structural Steel + 0.16 * Electrolytic Zinc + 0.11 * Labour.
7	Main EarthMat – 40 mm M.S Rods	0.15 + 0.74 * Structural Steel + 0.11 * Labour.
8	Bus Bar Materials	0.15 + 0.60 * Aluminum + 0.15 * Insulator Index + 0.10 * Labour.
9	Power & Control Cables	0.85 + 0.15 * PVC Compound
10	LT Transformer	0.15 + 0.28 * Copper + 0.25 * Elecl. Lamination – CRGO + 0.07 * Constr. Steel + 0.03 * Insulation Materials + 0.07 * Oil + 0.15 * Labour.
	Erection	
1	Erection of Equipments, Busbar, EarthMat etc. ,	0.2 + 0.8 * Labour
	Civil Works	
1	Soil Investigation	0.2 + 0.8 * Labour
2	Initial Civil Engineering Works like Leveling, Retaining walls, Approach Road, Peripheral Fencing etc	0.2 + 0.8 * Labour
3	Ant weed treatment & Site Surfacing	0.2 + 0.8 * Labour
4	Road work	0.2 + 0.8 * Labour
5	Switch yard fencing	0.2 + 0.8 * Labour
6	DG room & Fire fighting Room (FFPH)	0.20 * 0.20 * Diesel + 0.10 * Labour + 0.30 * Cement + 0.20 * Structural Clay
7	Control room with cable vaults	0.20 * 0.20 * Diesel + 0.10 * Labour + 0.30 * Cement + 0.20 * Structural Clay
8	Cable ducts	0.20 * 0.20 * Diesel + 0.10 * Labour + 0.30 * Cement + 0.20 * Structural Clay
9	Providing water supply including drinking water & water for fire fighting system and sewage system	0.2 + 0.8 * Labour
10	Parking sheds, Rain water Harvesting systems & land scaping etc.,	0.2 + 0.8 * Labour
11	Foundations	0.20 * 0.20 * Diesel + 0.10 * Labour + 0.30 * Cement + 0.20 * Structural Clay

11.4 Validation

The PV formulae used in the model for different components /material, erection, foundations & concreting are as followed by CTU. These are slightly different than that of IEEMA but are reasonable, rationally designed for subject matter of study.

9. ACCURACY AND CONFIDENCE LEVELS OF MODEL

9.1 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.

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

10. DEVELOPING/REVISION OF DRAFT FORMATS OF PROJECT COSTS

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.