Generation Cost Estimation and comparison For 250 MW Suratgarh Thermal Power Station (STPS)

Bharat modi[1], Umesh kumar[2]

[1] Electrical engineering ,SKIT,
Jaipur, Rajasthan, India

[2] Power system, SKIT,
Jaipur,Rajasthan, India

Abstract

Suratgarh thermal power station is the first super thermal plant of Rajasthan, India . It has installed capacity of 1500 mw, which is highest in the state. There are total six unit of each 250 MW. The purpose of this study is to calculate tariff for 250 MW. Tariff is calculated on the basis of capacity (or cost) charge (fixed cost) and energy charge (variable cost). The various components of capacity charge on which the tariff depends are return on equity, interest on capital loan, depreciation, interest on working capital, operation & maintenance cost, cost of secondary oil. The components of energy charge are primary fuel costs, secondary fuel oil consumption and auxiliary energy consumption. Tariffs are classified into Nominal, Discount and Levelized tariff.

Keywords: Electricity tariff, Plant load factor, fixed and variable cost.

1. Introduction:

The generation cost of power station in India is regulated by the Central Electricity Regulatory Commission (CERC). The Central Electricity Regulatory Commission (CERC) of India had notified new tariff regulations on January 19, 2009 for the next regulatory period financial year 2009 to 2014. The new regulations were applicable to all power generating stations (except stations based on non-conventional energy sources) and transmission licensees, except those entities which are determined through bidding process in accordance with the guidelines issued by the Central Government.

According to new tariff regulation law , the rights of determination of tariffs, for the power generated by central, state and private power generating stations, based on specific terms and conditions has been given to the Central Electricity Regulatory Commission.

2. Regulatory Norms for calculations of Power Tariff

Tariff for power generated by various power stations is decided on the basis of following cost

2.1. Capacity charge or fixed cost

2.2. Energy charge or variable cost

2.1. Components of Capacity Charges/ Fixed Charge:

2.2. Table 1. Components of Capacity Charges for FY 20013-2014

2.3. **Component of Capacity Charges/ fixed cost**		**FY 2009-2014**
a	Return on Equity	15.50%
b	Interest on Capital Loan	As per actual
c	Depreciation	5.28%
d	Interest on Working Capital	Based on normative parameters
e	Operation & maintenance cost	Based on normative parameters
f	Cost of Secondary Oil	Based on normative parameters

(a) Return on Equity (RoE)

CERC has specified a Pre-Tax RoE of 15.5% for the tariff period FY 2009-14. Further, it has allowed an

additional RoE of 0.5% for projects commissioned after April 2009 within specific timelines. The additional RoE act as an incentive for a project developer to achieve time-bound milestones.

(b) Interest on Capital Loan

The CERC has specified a debt-equity ratio of 70:30 as the funding mix for the capital cost of a project of overall plant. The interest on debt funds is recoverable as part of the tariff. The Tariff Regulations allows retention of 33.33% of the benefits, if any, arising out of re-financing of loans; earlier such benefits were required to be passed on entirely to the beneficiaries.

(c) Depreciation

The Tariff regulations for the period FY 2009-14 the CERC has selected deprecation rate of 3.6% for thermal power projects (based on a 25-year project life and 90% of the capital cost), the CERC has increased the depreciation rate to 5.28% for most components of the project.

(d) Interest on Working Capital

The working capital for a thermal power station is given in table 2 for FY 2009-2014

Components		FY 2009-14
1	Coal Stock	1½ Months for Pit Head 2 Months for Non-Pit Head
2	Secondary Fuel Oil Stock	2 Months
3	Maintenance Spares	20% of O&M Costs For Coal Based Power plant
4	Sales Receivables	2 Months
5	O&M expenses	1 Month

(e) Operations & Maintenance Costs (O&M)

The Central Electricity Regulatory Commission has specified O&M Costs for thermal power stations on the normative parameters (Rs. lakh/MW), depending on the class of the machine which are installed in the power station. The normative O&M expenses allowed are given in table 3

Rs Lakh/MW	200/210/250 MW	300/330/350 MW	500 MW	600 MW and Above
2009-10	18.20	16.00	13.00	11.70
2010-11	19.24	16.92	13.75	12.37
2011-12	20.34	17.88	14.53	13.08
2012-13	21.51	18.91	15.36	13.82
2013-14	22.74	19.99	16.24	14.62

(f) Cost of Secondary Fuel Oil (SFO)

As per Tariff regulations for the period FY 2009-14, The Central Electricity Regulatory Commission included the cost of SFO. Projects are able to recover the cost of SFO on the basis of normative consumption norms specified by the regulator and the plant availability factor during of plant in the year.

2.2. Energy Charges (for recovery of Primary fuel costs)

Energy charges for thermal power stations are linked to the normative operational parameters as specified by the regulator. The normative parameters are given in table 4 for STPS during the year 2013-2014 are given below

S.NO.	NORMS FOR OPERATION	FY2013-14
1	Plant availability factor	85%
2	Secondary fuel oil consumption	0.86ml/kwh
3	Secondary coal consumption	0.679kg/kwh

4	Heat rate(kcal/kwh)	2617
5	Load power factor (LPF)	71.61%
6	Fly ash utilization	87.29%

3. General Concepts & Definitions in reference to Tariff calculation

3.1 Auxiliary energy consumption:

The energy consumed by auxiliary equipment of the generating station, and transformer losses within the generating station, expressed as a percentage of the sum of gross energy generated at the generator terminals of all the units of the generating station.

3.2 Date of Commercial Operation' or 'COD':

The date declared by the generating company after demonstrating the maximum continuous rating or the installed capacity through a successful trial run after notice to the beneficiaries, from zero hour of which scheduling process as per the Indian Electricity Grid Code is fully implemented, and in relation to the generating station as a whole, the date of commercial operation of the last unit or block of the generating station.

3.3 Declared capacity:

Declared capacity defined by the capability to deliver ex-bus electricity in MW declared by such generating station in relation to any time-block of the day or whole of the day, duly taking into account the availability of fuel or water, and subject to further qualification in the relevant regulation.

3.4 Gross calorific value:

It is defined by the heat produced in kcal by complete combustion of one kilogram of solid fuel or one liter of liquid fuel or one standard cubic meter of gaseous fuel, as the case may be.

3.5 Gross station heat rate:

The heat energy input in kcal required to generate one kWh of electrical energy at generator terminals of a thermal generating station.

3.6 Infirm power:

Electricity injected into the grid prior to the commercial operation of a unit or block of the generating station.

3.7 Installed capacity:

The summation of the name plate capacities of all the units of the generating station or the capacity of

The generating station approved by the Commission from time to time.

3.8 Operation and maintenance expenses:

The expenditure incurred on operation and maintenance of the project, or part thereof, and includes the expenditure on manpower, repairs, spares, consumables, insurance and overheads.

3.9 Plant availability factor (PAF):

PAF defined by the average of the daily declared capacities for all the days during that period expressed as a percentage of the installed capacity in MW reduced by the normative auxiliary energy consumption.

3.10 Conversion of MW into Million Units (MUs):

1 MW = (1MW x 365days x 24hours x PLF x 1000) / 10,00,000

3.11 Tariffs:

There are three types of tariffs which are used for calculation

- Nominal tariff
- Discount Tariff
- Levelized Tariff

Nominal Tariff:

The nominal tariff calculated at for each year (fixed cost + variable cost)

Discount Tariff: The tariff calculated at present value of the future tariffs. This is done by discounting future tariffs by discount rate .

Discount tariff = Nominal tariff x Discount factor

Levelized tariff:

The tariff calculated for all years. This is a simple tariff representing the tariffs throughout the plant

life. In concept, this is "Weighted Mean" of all tariffs with weights as discounting factors.

Levelized Tariff = (Nominal Tariff *i* x Discount Rate *i*)/Discount rate

Where, *i* varies from 1 to n.

n is the life of plant in years

1. The nominal tariff for the next year calculated by individually calculating for each year taking into consideration of future value of oil, coal etc.

2. Otherwise, we can escalate the nominal tariff for 1st year taking appropriate escalation factors.

Tariff calculations for a 250 MW Thermal Power station

S. No	Particulars	Normative Parameters
1	Plant Capacity	250MW per unit
2	Capital cost	6 Cr/MW
3	Debt equity ratio	70:30
4	Return on equity	15.50%
5	Interest on loan	10%
6	Working capital(10% of capital cost)	150Cr
7	Interest on Working capital	10%
8	Rate of Depreciation	5.28%
9	O&M cost	14.62%
10	Plant Load Factor	71.61%(in 21014)
11	Plant Availability Factor	85%
12	Specific Oil Consumption	0.86ml/kwh
13	Price of Oil	Rs. 35000/kl
14	Gross Calorific value	10000kcal/l
	of Oil	
15	Station Heat Rate	2617kcal/kg
16	Cost of Coal	Rs. 2000/tonnes
17	Auxiliary Power consumption	6.5%
18	Plant load factor	80.44% (in 2013)
19	Plant Life	25 yrs
20	Gross Calorific value of Coal	3800kcal/kg

*Data as per CERC Tariff Regulations for FY 2009-14

Calculations:

Fixed Cost Component calculations:

(1) Return on equity

Capital cost = 250MW x 6Cr./MW = Rs.1500 Cr.

Debt/Equity ratio = 70:30

Hence Equity = 1500x 0.30 = Rs. 450 Cr.

Debt = 1500x 0.70 = Rs. 1050 Cr.

Return on Equity (ROE) = (15.50x450)/100

= Rs.69.75 Cr

2) Interest on loan:

10% of debt. = 0.1x1050 = Rs. 105 Cr

3) Interest on working capital:

10% of WC = 0.1x150 (10% of total cost)

= Rs. 15 Cr

4) Depreciation:

5.28% of capital cost = (5.28x1500)/100

=Rs. 79.2 Cr

5) O&M cost: O & M cost

For 250 MW = 22.74 lakh/MWx250

= Rs.56.85Cr

6) Total fixed cost

Total addition of above calculation

= 1 + 2+ 3+ 4+ 5

= 162.75+105+15+79.2+56.85

= Rs. 418.8 Cr

Total Power Generation = (250x 365 x 24 x 71.61 x 1000) / 1,0,00,000

= 1568.25 M Units

Hence fixed cost per unit =418.8 Cr / 1568.25MU

= Rs. 2.67055/ unit

Variable cost calculation:

Calculation of variable cost on the basis of :

i) Specific oil consumption = 0.86ml/KWh

ii) Cost of oil consumption = Specific Oil consumption x Cost of Oil/litre

= (0.86ml/KWh x 35000) / 1000

= Rs. 0.02975/ kWh

iii) Heat contribution of oil

= Gross calorific value of Oil x Specific Oil consumption

= 10,000 x 0.86 ml/kWh

= 8.6kcal/kWh

iv) Station Heat Rate

= Heat contribution of Oil + Heat contribution of coal

Therefore, Heat contribution of Coal = Station Heat Rate – Heat contribution of Oil

= 2617-8.6
= 2608.4 Kcal/kWh

5) Specific Coal consumption

= Heat contribution of coal / Gross calorific value of coal
= 2617/3800
= 0.688 Kg/KWh

(6) Cost of Specific Coal consumption

= Specification Coal consumption x Cost of Coal
=. (0.688Kg.x 2000 Rs) / kWh x Tonnes
= (0.688 Kg.x 2000 Rs) / kWh x 1000Kg
= Rs 1.376 /KWh

Hence, Total Variable Cost per Unit:

= Cost of Specific Oil consumption + Cost of Specific Coal consumption
= Rs. (0.2975 + 1.376) / kWh
= **Rs. 1.40575 /kWh**

a) The variable cost calculated above is the variable cost of generation .

b) 6.5% of the Power generated is consumed in Auxiliary. So, in Calculating Power available Exbus we have to subtract 6.5% of Available Power.

c) **Variable cost per unit at bus bar**

= Variable cost per unit / (1 − % Auxiliary consumption)
= 1.40575 / (1− 0.065)
= **Rs 1.503475/kWh**

Nominal Tariff calculation:

Nominal Tariff = (Total Fixed Cost / Unit) + (Total variable cost (Ex-bus)/Unit)

= Rs (2.67055+1.503475)/Unit
= **Rs. 4.174025/Unit**

4. Conclusion:

The fixed cost and the variable cost of the power generated by STPS of 250 MW were found to be Rs 2.67055 and Rs. 1.503475respectively. Hence the total generation cost would be Rs. 4.174025/unit in 2013-14 at PLF 70.61% whereas Rs. 3.880865/unit in 2012-13 at PLF 80.44%.

Acknowledgments

The authors are thankful to Suratgarh thermal power station , Rajasthan, India.

References:

[1] R. K. Rajput, Power Plant Engineering: Laxmi Publications, Delhi, (Edition 3) 2006.
[2] P.K.Nag, Heat Power Engineering: (Edition 5) 2007.
[3] Cen PEEP volume 2009
[4] Annual report of STPS 2013-14.
[5] Annual report of STPS 2012-13.

Bharat modi B-TECH, M-TECH From IIT Kanpur, Reader at SKIT Jaipur, India.

Umesh kumar B-TECH, M-TECH is pursuing from SKIT Jaipur, India.