Estimation of Generation Cost of Electricity at 500 MW Thermal Power Plant

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ABSTRACT
Determination of generation cost for a power plant is the process of estimation of the price of electricity produced by the plant. For coal based thermal power generating stations the Central Electricity Regulation Commission (CERC) has been adopting a two-part tariff comprising of capacity charges and energy charges. Determination of generation cost affects the financial viability of the sector and the affordability and quality of consumer services. Moreover estimation of generation cost also provides chance for improvement of efficiency of a power plant by identifying the areas of energy losses, and thereby reducing the generation cost of electricity. The present work describes computation of generation cost of electricity for a thermal power plant of 500 MW capacity comprising of 2X250 MW units, as per guidelines for determination of tariff by CERC. Capacity charges for recovery of annual fixed costs and energy charges for recovery of primary fuel costs were determined in the study; and the generation cost was calculated to be Rs. 4.91/Unit of electricity.

Keywords *- Capacity charges, energy charges, generation cost, tariff, 500 MW*

I. INTRODUCTION

Electricity is a basic human need and is an essential requirement for all facets of our life. It is a critical infrastructure on which the socio-economic development of the country depends. Supply of electricity at reasonable rate to rural population, and availability of reliable and quality power at competitive rates to industry is essential to make it globally competitive and to enable it to exploit the tremendous potential of employment generation. All power plants in India have their different electricity generation costs depending on their location, age, maintenance practices and operation efficiency. The direct cost of electricity produced by a thermal power station is the result of cost of fuel, capital cost for the plant, operation and maintenance cost, and factors like ash handling and disposal. Indirect, social or environmental costs such as the economic value of environmental impacts, or environmental and health effects of the complete fuel cycle and plant decommissioning, are not usually assigned to generation costs for thermal stations in utility practice. In India Central Electricity Regulation Commission (CERC) regulates the tariff of generating companies and it has been adopting a two-part tariff system comprising of capacity charges (for recovery of annual fixed cost) and energy charges (for recovery of primary fuel costs). Tariff in respect of a generating station may be determined for the whole of the generating station or stage or generating unit or block thereof [1].

II. MATERIAL AND METHODS

In the present study the generation cost was calculated for a 500 MW capacity coal based thermal power plant comprising of 2X250 MW units. For the computation of generation cost the regulations of CERC for determination of tariff for the period of 01.04.2014 to 31.03.2019 were followed.

Regulatory Norms for Computation of Tariff

For coal based thermal power generating stations the two-part tariff computation system comprises of:
i) Capacity Charges (for recovery of Annual Fixed Costs)
ii) Energy Charges (for recovery of Primary Fuel Costs)

(1) Components of Capacity Charges/Annual Fixed Charge (AFC)

The Capacity charges are derived on the basis of annual fixed cost. The annual fixed cost (AFC) of a generating station consists of the following components:
(a) Return on equity;
(b) Interest on loan capital;
(c) Depreciation;
(d) Interest on working capital; and
(e) Operation and maintenance expenses

(2) Energy Charges

Energy charges are derived on the basis of the landed fuel cost (LFC) of a generating station and consist of the following costs:
(a) Landed Fuel Cost of primary fuel; and
(b) Cost of secondary fuel oil consumption:

III. RESULTS

The generation cost of the plant was determined in the present study as per the following observations and calculations:
Table 1 . Parameters for determination of tariff of the plant for FY 2017-18

Sr. No.	Particulars	Normative parameters
1.	Capacity of plant	500 MW
2.	Capital cost	3484.12 Cr
3.	Debt equity ratio*	70:30
4.	Return on equity*	15.5% = 162.01
5.	Interest on loan	200.28 Cr
6.	Working capital	439.53 Cr
7.	Interest on working capital	12.80% = 56.26 Cr
8.	Depreciation rate	4.92 % = 171.42 Cr
9.	Operation and maintenance cost	143.50
10.	Plant load factor	80
11.	Plant availability factor	85

(*Data as per CERC Tariff Regulations for FY 2014-19)

Annual capacity (fixed) charges components calculation

Capital cost 3484.12 Cr
Debt Equity Ratio 70:30
Equity 30 X 3484.12/100 = 1045.23 Cr
Debt 70 X 3484.12/100 = 2438.88 Cr
(a) Return on Equity 15.5% of equity
=162.01 Cr

(b) Interest on term loan
Table 2. Particulars for calculation of interest on term loan

Opening loan balance	1718.01 Cr
Repayments	171.42 Cr
Closing loan balance	1546.59 Cr
Average loan balance	1632.30 Cr

Weighted average rate of interest 12.27%
Interest amount 200.28 Cr

(c) Interest on working capital
Table 3. Particulars for calculation of interest on working capital

Cost of coal	136.37 Cr
Cost of secondary fuel oil	0.89 Cr
Operation and maintenance expenses	11.96 Cr
Maintenance spares	28.70 Cr
Receivables	261.62 Cr
Total	439.53 Cr

Rate of interest on working capital 12.80%
Interest on working capital 56.26 Cr

(d) Depreciation
Table 4. Particulars for calculation of depreciation

Opening capital cost	3484.12 Cr
Additions	0
Closing capital cost	3484.12 Cr
Average capital cost	3484.12 Cr

Rate of depreciation 4.92%
Depreciation for the year 171.42 Cr

(e) Operation and maintenance expenses 28.70 lakh/MW/Yr
=28.70 X 500
= **143.50 Cr**

(f) Total Fixed Cost = Return on equity + Interest on term loan + Interest on working capital + Depreciation + Operation and maintenance expenses
= 162.01 + 200.18 + 56.26 + 171.42 + 143.50 Cr
= 733.47 Cr
(Less) Non tariff income 0.50 Cr
= 732.97 Cr

Table 5. Calculation of total fixed cost for FY 2017-18

Sr. No.	Particulars	Annual Fixed Charges (in Crores)
1.	Return on equity	162.01
2.	Interest on term loan	200.28
3.	Depreciation	171.42
4.	Operation and maintenance expenses	143.50
5.	Interest on working capital	56.26
6.	Total	733.47
7.	Less: Non-tariff income	0.50
8.	Annual capacity (fixed) charges	732.97

To convert MW into MU
1 MU= 1 MW X 365 days X 24 hours X PLF X Availability Factor X $1000/10^6$
500 MW= 500 X 365 X 24 X 80 X 85 X $1000/10^6$
=2978.4 MU
=2978.4 X 10^6 Unit

Fixed cost/Unit = 732.97/2978.4
= **Rs. 2.46**

Variable cost components calculation

(a) Specific oil consumption = 0.50 ml/kWh
= 0.5 X 10^{-3} l/kWh

(b) Cost of specific oil consumption = Specific oil consumption X cost of oil/l
= 0.5 X 10^{-3} X 35.831
= **Rs 0.017 /unit**

(c) Heat contribution of oil = Gross calorific value of oil X Specific oil consumption
= 1000 X 0.5 X 10^{-3}
= 5 kCal/kWh

(d) Station heat rate = Heat contribution of oil + Heat contribution of coal
Heat contribution of coal = Station heat rate - Heat contribution of oil
= 2449.50 – 5
= 2444.50 kCal/kWh

(e) Specific coal consumption = Heat contribution of coal/ Gross calorific value of oil
= 2444.5/3828.39
= 0.6385 kg/kWh

(f) Cost of specific coal consumption = Specific coal consumption X cost of coal
= 0.6385 kg/kWh X 3489.63 Rs/MT
= Rs 2.228 /unit

(g) **Total variable cost** = Cost of specific coal consumption + Cost of specific oil Consumption
= 2.228 + 0,017
= Rs 2.245/ unit

The variable cost calculated above is variable cost of generation. 8.5 % of power generated is consumed in auxiliary, so in calculating power available ex-bus we have to subtract 8.5% of available power.

(h) **Variable cost/unit ex-bus** = Variable cost per unit/ (1- % auxiliary consumption)
= 2.245/(1-0.085)
= Rs 2.454/unit

Table 6. Particulars for calculation of variable cost of energy production for FY 2017-18

Sr. No.	Particulars	Value
1.	Installed capacity (MW)	500
2.	Normative annual plant availability factor (%)	85
3.	Gross generation (MUs)	3723
4.	Auxiliary consumption (%)	8.5
5.	Net generation (MUs)	3406.55
6.	Gross station heat rate (kCal/kWh)	2449.50
7.	Specific fuel oil consumption (ml/kWh)	0.50
8.	Weighted average GCV of oil (kCal/l)	10000
9.	Weighted average GCV of coal (kCal/kg)	3828.39
10.	Weighted average landed cost of coal (Rs/MT)	3489.63
11.	Weighted average price of oil (Rs/kl)	35831
12.	Heat contribution from oil (kCal/kWh)	5.00
13.	Heat contribution from coal (kCal/kWh)	2444.50
14.	Specific coal consumption (kg/kWh)	0.6385
15.	Rate of energy charges from oil (Rs/unit)	0.017
16.	Rate of energy charges from coal (Rs/unit)	2.228
17.	Total variable charges (Rs/unit)	2.246
18.	Total variable cost (ex-bus) (Rs/unit)	2.454

Generation cost calculation:
Generation cost = (Total Fixed Cost/Unit) + (Total variable cost Ex-bus/Unit)
= Rs (2.46 + 2.45)/Unit
= Rs. 4.91/Unit

IV. CONCLUSION

In the present study the total fixed cost/unit was found to be Rs.2.46; while total variable cost/unit was found to be

Rs.2.45.Thus the generation cost per unit was calculated to be Rs. 4.91. Motghare and Cham (2014) reported the generation cost of a 660 MW thermal power plant to be Rs. 3.05/Unit [2]. As per the executive summary report of Central Electricity Authority, Ministry of Power, Government of India (Jan 2017), the rate of sale of power from coal based thermal power plants for the year 2014-15 ranged from Rs. 1.58/Unit to Rs. 7.12/Unit [3]. It can be concluded that the generation cost varies due to factors like location, age, maintenance practices and operation efficiency of the power plant, and a detailed study of generation cost components provide an opportunity to improve the efficiency of the power plant thereby reducing the generation cost of electricity.

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REFERENCES

[1] Central Electricity Regulatory Commission, Regulation 21, FY 2014-2019 http://cercind.gov.in/2014/regulation/ reg21.pdf

[2] V.S. Motghare; Cham R.K. (2014), Generation Cost Calculation for 660 MW Thermal Power Plants, - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 10, pp 660-664.

[3] Central Electricity Authority, Executive Summary (Jan 2017) http://www.cea.nic.in/reports/monthly/executive summary/2017/exe_summary-01.pdf