Cost Appraisal of Chhabra Thermal Power Station (250 MW)

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Abstract

The Central Electricity Regulatory Commission (CERC) has the power of deciding the tariff for electricity generated by various power stations. Tariff is calculated on the basis of capacity 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. Tariff calculations for 250 MW thermal power plants have been discussed in this paper.

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

Objective

This paper aims to present the cost appraisal of thermal power station at Chhabra of 250 MW. Cost appraisal is done with the help of costing tools (fixed and variable costs) and Regulatory Norms for power plants given by Central Electricity Regulatory Commission (CERC).

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Introduction

Chhabra Thermal Power Plant is one of Rajasthan's coal fired power plants. It is situated at Chowki Motipura (Village) of tehsil Chhabra in Rajasthan's Baran district. Planned capacity of power plant is 2650MW at the end of 12th Five year plan. The first and 2nd unit at Chhabra super thermal power plant having capacity of 250 MW each was set up at a cost of Rs. 2350 crs. by Lodha Construction Company Manak Chowk (Chandramohan Lodha Civil Engineer). Chhabra is set to become a power generation hub in the state as in the second phase two more units with a capacity of 250 MW each will be installed. Table 1 shows the commissioning and status of various units of this Plant.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Unit no.</th>
<th>Installed Capacity (MW)</th>
<th>Date of commissioning</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAGE-I</td>
<td>1</td>
<td>250</td>
<td>October 2005</td>
<td>Running</td>
</tr>
<tr>
<td>STAGE-I</td>
<td>2</td>
<td>250</td>
<td>May 2010</td>
<td>Running</td>
</tr>
<tr>
<td>STAGE-II</td>
<td>3</td>
<td>250</td>
<td>December 2013</td>
<td>Running</td>
</tr>
<tr>
<td>STAGE-II</td>
<td>4</td>
<td>250</td>
<td>July 2014</td>
<td>Running</td>
</tr>
<tr>
<td>STAGE-III</td>
<td>1</td>
<td>660</td>
<td>2016</td>
<td>EPC by L&amp;T MHI</td>
</tr>
<tr>
<td>STAGE-IV</td>
<td>2</td>
<td>660</td>
<td>2016</td>
<td>EPC by L&amp;T MHI</td>
</tr>
</tbody>
</table>

The Electricity Act (Supply) 1948 has been replaced by Electricity Act 2003 by Government of India. According to this act, 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 CERC. Section 61 of the Act empowers the Commission to specify and regulate the terms and conditions for determination of tariff in accordance with the provisions of the said section along with the National Electricity Policy and Tariff Policy. As per the Electricity Act 2003, the CERC in March 2004 and January 19, 2009, had put forth tariff regulations for the FY 2004-09 and FY 2009-14 respectively and on expiry of this, CERC had notified new tariff regulations.
regulations in the month of January 2014 for the next regulatory period FY 2014-19. The new regulations were applicable to all power generating stations (excluding 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.

**Review of Literature**

Many studies have been conducted in India and abroad related to working and costing aspects of Thermal Power Plants. Sharma and Tewari (2015) investigates the impact of various factors affecting coal-fired power plant economics of 210 MW subcritical unit situated in north India for electricity generation. Cost analysis of the plant was carried out on the basis of total capital investment, operating cost and revenue. Hosseini and Hasanpour (2011) analyses the performance of the Iranian thermal power plant by working out the technical efficiency using the mathematical model of data envelopment analysis (DEA). The purpose of this study was to estimate efficiency and productivity changes in the 48 thermal power plants in Iran during the period 2002-2008.

**Regulatory Norms for calculations of Power Tariff**

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

(a) Fixed Cost i.e. capacity charge
(b) Variable Cost i.e. Energy charge

- **Components of Capacity Charges/ Fixed Charge**

  **Table: 2 Components of Capacity Charges (Fixed Cost) for FY 2014-19**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Component of Capacity Charges</th>
<th>FY 2014-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Return on Equity</td>
<td>15.50%</td>
</tr>
<tr>
<td>b.</td>
<td>Interest on Capital Loan</td>
<td>As per actual</td>
</tr>
<tr>
<td>c.</td>
<td>Depreciation</td>
<td>5.28%</td>
</tr>
</tbody>
</table>
d. Interest on Working Capital | Based on normative parameters

e. Operation & Maintenance Cost | Based on normative parameters

f. Cost of Secondary Fuel 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 2014-19. Further, it has allowed an additional ROE of 0.5% for projects commissioned after April 2014 within specific timelines. The additional ROE allowed by CERC is acting as an incentive for a project developer to achieve time-bound milestones. On the other hand, the Tariff Regulations does not allow utilities to recover tax on income such as unscheduled interchange (UI) and incentive income from beneficiaries.

(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. The interest on debt funds is recoverable as part of the tariff. Tariff Regulations allows retention of 1/3rd 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

In the Regulations for the earlier tariff periods, the CERC followed the concept of Advance against Depreciation (AAD) in case where the normal depreciation rates (notified by the regulator) were not sufficient to meet the debt repayment obligation of the utility. Tariff regulations for the period FY 2009-14 the CERC has removed the concept of AAD and at the same time increased the depreciation rates applicable for projects as against the earlier depreciation 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.

Table: 3 Working Capital for Thermal Power Station

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Components</th>
<th>FY 2014-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Coal Stock</td>
<td>1½ Months for Pit Head</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Months for Non-Pit Head</td>
</tr>
<tr>
<td>2.</td>
<td>Secondary Fuel Oil Stock</td>
<td>2 Month</td>
</tr>
<tr>
<td>3.</td>
<td>Maintenance Spares</td>
<td>20% of O&amp;M Costs - Coal Based</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30% of O&amp;M Costs - Gas Based</td>
</tr>
<tr>
<td>4.</td>
<td>Sales Receivables</td>
<td>2 Month</td>
</tr>
<tr>
<td>5.</td>
<td>O&amp;M expenses</td>
<td>1 Month</td>
</tr>
</tbody>
</table>

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

The CERC has specified O&M Costs for thermal power stations on the normative parameters (Rs.’ Lacs/MW), depending on the type of machine installed by the power station. The normative O&M expenses allowed are given in table:

Table: 4 Operations & Maintenance Costs for Different Capacity Power Plants

(In Rs.’ Lacs/MW)

<table>
<thead>
<tr>
<th>Financial Year</th>
<th>200/210/250 MW Sets</th>
<th>300/330/350 MW Sets</th>
<th>500 MW Sets</th>
<th>600MW Sets and above</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-15</td>
<td>23.90</td>
<td>19.95</td>
<td>16.00</td>
<td>14.40</td>
</tr>
<tr>
<td>2015-16</td>
<td>25.40</td>
<td>21.21</td>
<td>17.01</td>
<td>15.31</td>
</tr>
<tr>
<td>2016-17</td>
<td>27.00</td>
<td>22.54</td>
<td>18.08</td>
<td>16.27</td>
</tr>
<tr>
<td>2017-18</td>
<td>28.70</td>
<td>23.96</td>
<td>19.22</td>
<td>17.30</td>
</tr>
<tr>
<td>2018-19</td>
<td>30.51</td>
<td>25.47</td>
<td>20.43</td>
<td>18.38</td>
</tr>
</tbody>
</table>

(f) Cost of Secondary Fuel Oil

As per Tariff regulations for the period FY 2014-19, the CERC has included the cost of SFO as part of Auxiliary Fuel Consumption (AFC).
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 the year.

**General Concepts & Definitions in Reference to Tariff calculation**

(a) **Auxiliary Energy Consumption**

Quantum of 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.

(b) **Date of Commercial Operation’ or ‘COD’**

The date declared by the generating company after demonstrating the maximum continuous rating (MCR) or the installed capacity (IC) through a successful trial run after notice to the beneficiaries, from 0000 hour of which scheduling process as per the Indian Electricity Grid Code (IEGC) is fully implemented, and in relation to the generating station as a whole, the date of commercial operation of last unit or block of the generating station.

(c) **Declared Capacity**

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 the day, duly taking into account the availability of fuel or water, and subject to further qualification in relevant regulation.

(d) **Gross Calorific Value**

The heat produced in kcal by complete combustion of one kilogram of solid fuel or one litre of liquid fuel or one standard cubic meter of gaseous fuel, as the case may be.
(e) **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.

(f) **Infirm Power**

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

(g) **Installed Capacity**

Summation of name plate capacities of all the units of generating station or capacity of generating station (reckoned at the generator terminals) approved by the Commission from time to time.

(h) **Operation and Maintenance Expenses**

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

(i) **Plant Availability Factor (PAF)**

Average of the daily declared capacities (DCs) for all the days during that period expressed as a percentage of the installed capacity in MW reduced by the normative auxiliary energy consumption.

(j) **Conversion of MW into Million Units (MUs)**

\[
1 \text{MUs} = \frac{1 \text{MW} \times 365 \text{days} \times 24 \text{hours} \times \text{PLFx} \times 1000}{10,00,000}
\]

(k) **Tariffs**

- Nominal Tariff
- Discount Tariff
- Levelized Tariff

**Nominal Tariff**

The 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 (given by CERC)

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.

\[
\text{Levelized tariff} = \frac{\sum \text{Nominal Tariff }_i \times \text{Discount Rate }_i}{\text{Discount Rate }_i}
\]

Where, \( i \) varies from 1 to \( n \) and \( n \) is the life of plant in years.

1. The nominal tariff for the next year may be 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 Plants are given in table 5.

Table: 5 Normative Parameters of 250 MW Thermal Power Station

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Particulars</th>
<th>Normative parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant Capacity</td>
<td>250MW</td>
</tr>
<tr>
<td>2</td>
<td>Capital cost</td>
<td>Rs.6 Cr/MW</td>
</tr>
<tr>
<td>3</td>
<td>Debt equity ratio</td>
<td>70:30</td>
</tr>
<tr>
<td>4</td>
<td>Return on equity</td>
<td>15.50%</td>
</tr>
<tr>
<td>5</td>
<td>Interest on loan</td>
<td>10%</td>
</tr>
<tr>
<td>6</td>
<td>Working capital(10% of capital cost)</td>
<td>Rs.150Cr</td>
</tr>
<tr>
<td>7</td>
<td>Interest on Working capital</td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td>Rate of Depreciation</td>
<td>5.28%</td>
</tr>
</tbody>
</table>
Cost Appraisal of Chhabra Thermal Power Station (250 MW)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>O&amp;M cost</td>
<td>Rs.23.90 Lacs/MW</td>
</tr>
<tr>
<td>10</td>
<td>Plant Load Factor</td>
<td>85%</td>
</tr>
<tr>
<td>11</td>
<td>Plant Availability Factor</td>
<td>85%</td>
</tr>
<tr>
<td>12</td>
<td>Specific Oil Consumption</td>
<td>0.86 ml/kwh</td>
</tr>
<tr>
<td>13</td>
<td>Price of Oil</td>
<td>Rs. 35000/kl</td>
</tr>
<tr>
<td>14</td>
<td>Gross Calorific Value of Oil</td>
<td>10000kcal/l</td>
</tr>
<tr>
<td>15</td>
<td>Station Heat Rate</td>
<td>2425kcal/kg</td>
</tr>
<tr>
<td>16</td>
<td>Cost of Coal</td>
<td>Rs. 2000/tones</td>
</tr>
<tr>
<td>17</td>
<td>Auxiliary Power Consumption</td>
<td>6.5%</td>
</tr>
<tr>
<td>18</td>
<td>Plant Life</td>
<td>25 yrs</td>
</tr>
<tr>
<td>19</td>
<td>Gross Calorific value of Coal</td>
<td>3800kcal/kg</td>
</tr>
<tr>
<td>20</td>
<td>Plant Load Factor in FY 2014-15</td>
<td>65.37%</td>
</tr>
</tbody>
</table>

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

Calculations

Fixed Cost component calculations:

**1) Return on equity**

Capital cost = $250\text{MW} \times 6 \text{ Cr/MW} = \text{Rs. 1500 Cr.}$

Debt/Equity ratio = 70:30   Hence Equity = $1500 \times 0.30 = \text{Rs. 450 Cr.}$

Debt = $1500 \times 0.70 = \text{Rs. 1050 Cr.}$

Return on Equity (ROE) = \frac{15.50 \times 450}{100} = \text{Rs.69.75 Cr}

**2) Interest on loan:**

10% of debt = $0.1 \times 1050 = \text{Rs. 105 Cr}$

**3) Interest on working capital:**

10% of WC = $0.1 \times 150 \text{ (10% of total cost)} = \text{Rs. 15 Cr}$
(4) **Depreciation:** 

\[ \text{5.28\% of capital cost} = \frac{5.28 \times 1500}{100} = \text{Rs. 79.20 Cr} \]

(5) **O&M cost:**

O&M cost for 250 MW = 23.90\times250 = \text{Rs. 59.75Cr}

(6) **Total fixed cost**

\[ \text{= S. No.( 1 + 2 + 3 + 4 + 5)} \]

\[ \text{= 69.75 + 105 + 15 + 79.20 + 59.75 = Rs. 328.70 Cr} \]

(a) **Fixed cost per unit at actual PLF 65.37\%**

Total Power Generation = \[ \frac{250 \times 365 \times 24 \times 65.37 \times 1000}{10,00,000 \times 100} = 1431.60 \text{ M Units} \]

Hence, fixed cost per unit = \[ \frac{328.70 \text{ Cr}}{1431.60 \text{ MUs}} = \text{Rs. 2.29603/ Unit} \]

(b) **Fixed cost per unit at Normative PLF 85.00\%**

Total Power Generation = \[ \frac{250 \times 365 \times 24 \times 85 \times 1000}{10,00,000 \times 100} = 1861.50 \text{ M Units} \]

Hence fixed cost per unit = \[ \frac{328.70 \text{ Cr}}{1861.50 \text{ MUs}} = \text{Rs. 1.76578/ Unit} \]

**Variable Cost Component calculations:**

(1) **Specific oil consumption** = 0.86ml/kwh

(2) **Cost of oil consumption**

\[ = \text{Specific oil consumption} \times \text{Cost of oil/litre} \]

\[ = (0.86\text{ml/KWh} \times 35000)/(1000\times1000) = \text{Rs. 0.0301/ kwh} \]

(3) **Heat contribution of oil**

\[ = \text{Gross calorific value of oil} \times \text{Specific oil consumption} \]

\[ = 10,000 \times 0.86\text{ml/KWh} = 8.6 \text{ kcal/ kwh} \]
(4) Station Heat Rate

\[ \text{Station Heat Rate} = \text{Heat contribution of oil} + \text{Heat contribution of coal} \]

Therefore, Heat contribution of Coal = Station Heat Rate − Heat contribution of oil

\[ = 2425 - 8.6 = 2416.40 \text{ kcal/kwh} \]

(5) Specific coal consumption = \( \frac{\text{Heat contribution of coal}}{\text{Gross contribution of coal}} \) = \( \frac{2416.40}{3800} \) = 0.636 kg/kwh

(6) Cost of Specific Coal consumption

\[ \text{Cost of Specific Coal consumption} = \text{Specific coal consumption} \times \text{Cost of Coal} \]

\[ = \frac{0.636 \times 2000}{\text{KWh} \times \text{Tones}} = \frac{0.636 \times 2000}{\text{KWh} \times 1000 \text{ kg}} = 1.272 / \text{kwh} \]

Hence, Total Variable cost per unit:

\[ = \text{Cost of Specific oil consumption} + \text{Cost of Specific Coal consumption} \]

\[ = \text{Rs. (0.0301 + 1.272)} / \text{kwh} = \text{Rs. 1.3021 / kwh} \]

(a) 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 Ex-bus we have to subtract 6.5% of available power.

(c) Variable cost per unit at bus bar

\[ = \frac{\text{Variable cost per unit}}{1 - \% \text{ Auxiliary Consumption}} \]

\[ = \frac{1.3021}{1 - 0.065} = \text{Rs. 1.39262 / kwh} \]

Nominal Tariff calculation:

Nominal Tariff = \([\{\text{Total Fixed Cost / Unit}\} + \{\text{Total variable cost (Ex-bus)/Unit}\}]\)
Conclusion

The fixed cost per unit and the variable cost per unit of the power generated by CTPS of 250 MW were found to be Rs 2.29603 and Rs. 1.39262 respectively. Hence, the total generation cost would be Rs. 3.68865/unit at 65.37% plant load factor (PLF). If plant achieves the normative load factor i.e. 85% then fixed cost per unit will be reduced to Rs 1.76578 per unit and variable cost per unit will remain same. The total generation cost will be reduced to Rs 3.15840 and overall saving of Rs 0.53025 will be achieved to operate a plant on normative plant load factor (PLF). So, it is advised to management of thermal plant to chase the normative plant load factor in this manner they not only control and reduce the costing as well as they will also reduce their losses substantially.

References

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