COST ANALYSIS
**Trend of Actual and Deflated Cost**

The generation of electricity in India is done by the State Electricity Boards, on the advice and directions of the State Governments and Central Government in that respect. Power supply being a public utility, maximising profit is not the objective. Adjustment of output with reference to cost or price is also not possible. The only objective function of State Electaricity Board could thus be one of minimising the cost of output at various levels of operations. It is hypothesised that the increasing operating cost is responsible for the poor financial resultls of the Electricity Boards.

There are two types of operating costs in electricity industry namely the cost of generation and cost of transmission and distribution. In the present study the cost comparisons have been made on time scale, because the methodology envisaged for the study necessarily demands such comparison as it is not a comparison between cross section in the industry.

Therefore, in a time series analysis the impact of inflation factor has to be sorted out to make the data about prices and cost comparable. In the present study the period of comparison is of ten years starting from 1975-1976 to 1984-85.
Therefore, for segregating the influence of inflation the cost and prices have been deflated by the following method.

For calculating the real prices we have divided the cash prices (current prices) by an appropriate price index and multiplied by hundred.

This chapter aims to discuss the impact of inflationary factor on the two categories of operating expenses, namely, generation and transmission and distribution. For studying the cost of generation we have selected only steam power generation. The hydro power generation has not been included in the analysis on account of following reasons.

Firstly, there are practical difficulties in segregation of costs of electricity generation in a Multipurpose River Project. Secondly, the cost of erection and maintenance of dam is borne by the State Government. Thus this cost is not accounted by the State Electricity Boards.

**Trend Of Cost Of Generation (Steam Power)**

The cost of generation of electricity is the result of several variables which are as follows.
1) Installed / derated capacity,
2) Units of power generated,
3) Age of boilers and generators,
4) maximum demand on system,
5) Thermal efficiency
6) Quantity and quality of coal consumed,
7) The costs of inputs including salaries and wages, cost of maintenance, administrative and other overhead expenses.

The cost of generation is dependent upon the above mentioned variables.
The actual cost of generation is made up of following cost elements.
1) Cost of fuel,
2) Salaries and wages in respect of steam power generation,
3) Repairs and maintenance cost,
4) Stores and miscellaneous expenses, consisting of lubricating and transformer oil, water, bricks cement, paints etc.

The table No.2.1 shows the continuous increasing trends in cost. In 1975-76 the total cost of generation was Rs.3792.92 lakhs and it has increased to Rs.34227.49 lakhs in 1984-85. There has been an increase of Rs. 30434.57 during the period of ten years. The percentage increase in the cost of generation in 1984-85 over
### Table No. 2.1

**Actual cost of Generation (Steam Power)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Cost (Rs.)</th>
<th>Percentage Increase (+) or Decrease(-) as compared to preceding year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>379282005</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>475094144</td>
<td>+25.26</td>
</tr>
<tr>
<td>1977-78</td>
<td>621060324</td>
<td>+30.72</td>
</tr>
<tr>
<td>1978-79</td>
<td>740355919</td>
<td>+19.21</td>
</tr>
<tr>
<td>1979-80</td>
<td>938575504</td>
<td>+34.86</td>
</tr>
<tr>
<td>1980-81</td>
<td>1511269255</td>
<td>+51.34</td>
</tr>
<tr>
<td>1981-82</td>
<td>1905148059</td>
<td>+26.06</td>
</tr>
<tr>
<td>1982-83</td>
<td>2439038845</td>
<td>+28.02</td>
</tr>
<tr>
<td>1983-84</td>
<td>3202011246</td>
<td>+31.28</td>
</tr>
<tr>
<td>1984-85</td>
<td>3422748593</td>
<td>+06.89</td>
</tr>
</tbody>
</table>
Cost of Generation (Steam)  
(Actual & Deflated)

Rupees  
(Times 10E9)

4.00
3.00
2.00
1.00
0.00

Years
+ Actual ◇ Deflated
1974-75 has been 802.40 percent. The increasing trend in cost of generation has ranged between 6.89 percent to 51.34 percent during the period under reference. In 1976-77 it was 25.28 percent and has increased to 30.72 percent in 1977-78. In the next year it has declined to 19.21 percent and followed by an increase of 34.86 percent and 51.34, 28.02 and 31.28 percent in the respective years from 1979-80 to 1982-83. In the last year of the study, that is, in 1984-85 there is marginal increase of 6.89 percent over the previous year. During this period the lowest percentage increase is 6.89, and the highest is 51.34 percent. In 1980-81 the cost of generation was increased because of the strike of Sub-Ordinate Engineers Association in the M.S.E.B.

Per Unit Actual Cost Of Generation:-

In order to have a meaningful comparision the total generation cost has been restated in per unit cost of generation as shown in Table No. 2.2 It is
<table>
<thead>
<tr>
<th>Year</th>
<th>Per unit cost (Paise/kwh)</th>
<th>Percentage Increase (+) or Decrease(-) as compared to per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>9.5</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>9.1</td>
<td>-4.21</td>
</tr>
<tr>
<td>1977-78</td>
<td>10.3</td>
<td>+13.18</td>
</tr>
<tr>
<td>1978-79</td>
<td>12.13</td>
<td>+17.77</td>
</tr>
<tr>
<td>1979-80</td>
<td>13.40</td>
<td>+11.21</td>
</tr>
<tr>
<td>1980-81</td>
<td>16.43</td>
<td>+21.79</td>
</tr>
<tr>
<td>1981-82</td>
<td>18.84</td>
<td>+14.67</td>
</tr>
<tr>
<td>1982-83</td>
<td>21.01</td>
<td>+15.76</td>
</tr>
<tr>
<td>1983-84</td>
<td>26.07</td>
<td>+19.53</td>
</tr>
<tr>
<td>1984-85</td>
<td>28.53</td>
<td>+01.76</td>
</tr>
</tbody>
</table>
obvious from table No.2.2 that the trend in per unit cost has also been increasing over a period. In 1975-76 it was 9.5 paise per KWH followed by a marginal decline of 0.4 paise per unit in 1976-77. From 1977-78 to 1984-85 the per unit cost has shown an ever increasing trend. It has increased from 9.1 paise per unit in 1984-85. The average increase in the per unit cost during ten years has been 16.42 paise per unit. The increase in the per unit cost in the last four years of the study has been more than the average increase during the period. The percentage increase in the per unit cost has been in the range of 1.76 percent in 1984-85 to 21.79 percent in 1980-81. The per unit cost has been increasing throughout the period except in 1976-77 and 1979-80 when it has decreased to 4.21 percent and 11.21 percent. In 1981-82, 1982-83, 1983-84 and 1984-85 a declining trend has been noticed. The data clearly bring out that the total cost of generation for the period have been increasing not because of increased output but due to some other factors.

Trend Of Deflated Cost Of Generation:-

In the preceding pages it has been observed that
the trend in the actual prices of generation. These fluctuations might have been caused either by changes in input prices or by other non-price factors including the efficiency of plant operation, quality of maintenance and the performance of administration.

An attempt has been made here to isolate the impact of factors other than input prices. The actual costs have been deflated at wholesale price index of 1970-71. The resulting trend of cost thus reflects the extent of impact of non-price factors on cost of generation.

The changes or fluctuations in the deflated costs have been calculated for the period under reference. It has reflected the impact of non-price factors in varying degrees. It is evident from table No. 2.3 that the deflated costs have showed year to year fluctuations during the period. In 1976-77 the increase in percentage of deflated cost is 18.75 and it has gone up
### Table No. 2.3

**Trend of Deflated cost of Generation (Steam Power)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Deflated cost (Rs.)</th>
<th>Percentage Increase (+) or Decrease(−) as compared to preceding year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>173192896.347</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>205668460.806</td>
<td>+18.75</td>
</tr>
<tr>
<td>1977-78</td>
<td>265410334.871</td>
<td>+29.05</td>
</tr>
<tr>
<td>1978-79</td>
<td>302186089.387</td>
<td>+13.86</td>
</tr>
<tr>
<td>1979-80</td>
<td>352853534.982</td>
<td>+18.86</td>
</tr>
<tr>
<td>1980-81</td>
<td>426912218.926</td>
<td>+20.99</td>
</tr>
<tr>
<td>1981-82</td>
<td>445128051.170</td>
<td>+ 4.22</td>
</tr>
<tr>
<td>1982-83</td>
<td>530225835.870</td>
<td>+19.12</td>
</tr>
<tr>
<td>1983-84</td>
<td>646870958.790</td>
<td>+22.00</td>
</tr>
<tr>
<td>1984-85</td>
<td>660762276.640</td>
<td>+02.15</td>
</tr>
</tbody>
</table>
to 29.05 percent in 1977-78 and has followed by a decline of 13.86 percent in 1978-79. In the year 1979-80 and 1980-81 it again has increased to 16.77 and 20.99 percent respectively. It has come down to 4.27 percent in 1981-82. In this year the percentage has come down because of the improvement in the efficiency of the non-price factors. Again in next two years there has been an increase in the percentage of cost by 19.12 and 22.00 percent in 1982-83 and 1983-84 respectively. But in 1984-85 the performance of non-price factors was improved due to which it came down to 2.15 percent. Normally the deflated costs should have a change at a lower rate than the actual cost. Throughout the period the deflated cost moved more or less in the same direction as changes in actual costs. The deflated cost increases are of lower orders as compared to the actual cost increases in all the years. Even though both the curves of both the prices move in the same direction but both the cost curves do not move parallel to each other.

Per Unit Deflated Cost Of Generation:—
Per unit deflated cost of generation had different nature as compared to per unit actual cost of generation.
It appears from the table No. 2.4 that the trend in the per unit deflated cost is mild. The trend in the per unit deflated cost is gradual whether it is increasing or decreasing.

In 1975-76 the per unit deflated cost of generation is 4.31 paise per unit (KWH). It has decreased by 3.92 paise per unit and 9.05 paise per unit in 1976-77 and 1977-78 over the previous year. It has increased by 4.42 paise and 5.00 paise per unit in 1977-78 and 1978-79 respectively. From 1979-80 to 1981-82 there has been a declining trend in the per unit deflated cost of generation. The percentage rate of declining per unit cost is in the increasing order. Whereas the per unit actual cost of the same years has increased by 11.21 percent, 21.79 and 14.67 percent. It is clear from this, that the non-price factors have not
<table>
<thead>
<tr>
<th>Year</th>
<th>Per Unit Cost (Paise/KWH)</th>
<th>Percentage increase(+) or decrease (-) in Per unit Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>4.31</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>3.92</td>
<td>-09.05</td>
</tr>
<tr>
<td>1977-78</td>
<td>4.42</td>
<td>+12.76</td>
</tr>
<tr>
<td>1978-79</td>
<td>5.00</td>
<td>+13.12</td>
</tr>
<tr>
<td>1979-80</td>
<td>4.8</td>
<td>-04.00</td>
</tr>
<tr>
<td>1980-81</td>
<td>4.6</td>
<td>-04.17</td>
</tr>
<tr>
<td>1981-82</td>
<td>4.40</td>
<td>-04.35</td>
</tr>
<tr>
<td>1982-83</td>
<td>4.74</td>
<td>+07.73</td>
</tr>
<tr>
<td>1983-84</td>
<td>5.47</td>
<td>+15.40</td>
</tr>
<tr>
<td>1984-85</td>
<td>5.31</td>
<td>-02.93</td>
</tr>
</tbody>
</table>
influenced the cost of power generation. Again in 1982-83 and 1983-84 the per unit deflated cost has increased to 4.74 paise per unit and 5.47 paise per unit. The increase in the percentage has been 7.73 and 15.4 percent which is lower than the per unit actual cost of generation.

The per unit deflated cost is decreased by 2.93 percent over 1983-84 whereas in the same year the actual cost has increased by the 1.76 percent over previous year.

During the period under study the per unit deflated costs and per unit actual cost have moved in opposite directions in the first four years of the study. In the last six years the changes in per unit deflated costs are either milder or marginal. The per unit deflated cost has ranged between 3.92 paise per unit to 5.47 paise per unit. The fluctuations are mostly of small order as compared to per unit actual cost. The per unit deflated cost is nearer to the average per unit deflated cost except in 1983-84 and 1984-85 when it is 5.47 and 5.31 paise per unit. The average per unit deflated cost is 4.70 paise per unit whereas the average per unit actual cost is 16.42 paise per unit.

It is obvious from the above discussion that the
per unit deflated cost has been influenced by the non price factors whereas at the same time there are wide fluctuations in the per unit actual cost. It means that the input prices have influence on the cost of generation.

In 1976-77, 1979-80, 1980-81, 1981-82 and 1984-85 there is decrease in the percentage of per unit deflated cost whereas in all the years under study there is increase in the percentage of per unit actual cost of generation. It is obvious from the above discussion that the price behaviour can not be explained unless one considers the impact of input prices on the cost of generation.

**Trend Of Transmission And Distribution Cost**

The cost of transmission and distribution is also dependent on various variables. They are as follows.

1) The units of power sold,
2) Connected load,
3) Number of sub-stations,
4) Area covered (served)
5) Transmission and distribution loss,
6) Quality of repairs and replacements
7) Cost of inputs including wages and salaries.
8) Cost of maintenance inputs.
9) Administrative expenses and other overheads.

In this section it is proposed to examine the behaviour of transmission and distribution costs over a period of time. The trend in the above costs has been analysed without considering the inflationary factor and later on by deflating the cost by appropriate wholesale price index, the price impact has been removed. Thus the deflated cost indicates the impact of non-price factors on transmission and distribution costs.

The cost of transmission and distribution includes cost elements like items of transmission of high or extra high voltage, distribution of high, medium and low voltage. The items of expenditure included are --

a) Operation and maintenance cost

b) Salaries and wages including gratuities and allowances,

c) Maintenance cost of building and structure of transmission plants,

d) Depreciation,

e) General establishment charges regarding, transmission and distribution,

f) Expenses regarding public lighting and consumers' servicing, collecting and billing etc.
It is evident from the table No.2.5 that the cost of transmission and distribution of actual price have been fluctuated at varying degrees throughout the period under reference.
### Table No.2.5

**Actual Cost of transmission & Distribution**  
(Rs. in Lakhs)

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Cost</th>
<th>Percentage increase (+) or decrease (-) as compared to preceding year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>382419186</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>448407565</td>
<td>+17.26</td>
</tr>
<tr>
<td>1977-78</td>
<td>538584400</td>
<td>+20.11</td>
</tr>
<tr>
<td>1978-79</td>
<td>654774706</td>
<td>+21.57</td>
</tr>
<tr>
<td>1979-80</td>
<td>757253112</td>
<td>+15.65</td>
</tr>
<tr>
<td>1980-81</td>
<td>760894900</td>
<td>+00.48</td>
</tr>
<tr>
<td>1981-82</td>
<td>1131513586</td>
<td>+48.66</td>
</tr>
<tr>
<td>1982-83</td>
<td>1256906017</td>
<td>+11.26</td>
</tr>
<tr>
<td>1983-84</td>
<td>1317431000</td>
<td>+04.65</td>
</tr>
<tr>
<td>1984-85</td>
<td>1600923038</td>
<td>+21.52</td>
</tr>
</tbody>
</table>
Cost of Transmission & Distribution
(Actual & Deflated)

Rupees (Times 10E9)

Years
+ Actual  • Deflated
In 1975-76 the absolute cost is Rs.3824.19 lakhs and it has raised to Rs.16009.23 lakhs in 1984-85. There has been a rise of Rs.12185.04 lakhs in transmission and distribution cost in the span of ten years. The increase in cost comes to 318.63 percent. It means every year the cost has increased on an average of 31.86 percent. In 1976-77 to 1978-79 the cost was increased by 17.26, 20.11 and 21.57 percent over the previous years. In 1979-80 and 1980-81 the cost was increased at declining rate of 15.65 percent and 0.48 percent over previous years. In 1981-82 the actual cost was increased by 48.66 percent over 1980-81. It was the highest percent increase in cost of transmission and distribution. In 1982-83 and 1983-84 there was an increase of 11.26 and 4.65 percent but in the last year the rate of percentage of cost was increased to 21.52.

The trend of cost of transmission and distribution was between 0.48 percent to 48.66 percent. The lowest percentage of cost was in 1980-81 and the highest was in 1981-82. In 1981-82, the increase in cost by 48% is due to increase in expenditure on account of salaries and wages due to settlement
between the sub-ordeinate Engineers and Maharashtra state Electricity Board.

**Per Unit Actual Cost Of Transmission & Distribution**

Table No.2.6 depicts the actual per unit transmission and distribution cost for ten years. The per unit actual cost of transmission and distribution has ranged between 5.1 paise per unit in 1976-77 to 9.32 paise per unit in 1984-85. It has increased by 69.45 percent in 1984-85 over 1975-76. In 1975-76 the per unit cost was 5.5 paise per unit and it has decreased to 5.1 paise and 5.4 paise per unit in the succeeding two years over 1975-76. The percentage of per unit cost in 1976-77 has been decreased by 7.27 percent over 1975-76. The per unit cost of transmission and distribution shows wide fluctuations.

From table No.2.6 it is clear that there has been an increase in the percentage of per unit cost throughout the period of study except in 1976-77, 1980-81, and
**Table No. 2.6**

**Per Unit Actual Cost of Transmission & Distribution**

<table>
<thead>
<tr>
<th>Year</th>
<th>Per Unit Cost (Paise/KWH)</th>
<th>Percentage increase (+) or decrease (-) Per Unit Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>5.5</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>5.1</td>
<td>-07.27</td>
</tr>
<tr>
<td>1977-78</td>
<td>5.4</td>
<td>+05.88</td>
</tr>
<tr>
<td>1978-79</td>
<td>6.06</td>
<td>+12.22</td>
</tr>
<tr>
<td>1979-80</td>
<td>6.90</td>
<td>+13.86</td>
</tr>
<tr>
<td>1980-81</td>
<td>5.70</td>
<td>-17.39</td>
</tr>
<tr>
<td>1981-82</td>
<td>7.98</td>
<td>+39.65</td>
</tr>
<tr>
<td>1982-83</td>
<td>8.20</td>
<td>+03.02</td>
</tr>
<tr>
<td>1983-84</td>
<td>7.76</td>
<td>-05.37</td>
</tr>
<tr>
<td>1984-85</td>
<td>9.32</td>
<td>+20.10</td>
</tr>
</tbody>
</table>
Per Unit Cost Of Trans. & Distri.
(Actual & Deflated)

Years
+ Actual  ○ Deflated
1983-84 where it has been decreased by 7.27, 17.39 and 5.37 percent respectively. The lowest percentage increase is 3.02 and the highest is 39.65 in 1981-82. The maximum decline in per unit cost over previous year is 17.39 in 1980-81. In this year the actual cost is also the lowest. In the following year it has increased by 39.65 percent over previous year but in 1979-80 it is 15.36 percent. Average per unit cost comes to 6.79, paise for the period under study.

**Deflated Cost Of Transmission & Distribution:**

The actual cost of transmission and distribution has been deflated at 1970-71 whole sale price index in order to isolate the impact of factors other than input prices. This exercise is necessary to find out the extent of impact of non price factors on the rising trend of costs. The deflated cost has generally showed a rising trend in most of the years throughout the period under study as shown in Table No. 2.7.
<table>
<thead>
<tr>
<th>Year</th>
<th>Deflated cost</th>
<th>Percentage Increase (+) or Decrease(−) as compared to preceding year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>1,746,206,23.740</td>
<td>−</td>
</tr>
<tr>
<td>1976-77</td>
<td>1,941,158,29.000</td>
<td>+11.16</td>
</tr>
<tr>
<td>1977-78</td>
<td>2,301,642,73.000</td>
<td>+18.57</td>
</tr>
<tr>
<td>1978-79</td>
<td>2,672,549,82.040</td>
<td>+16.11</td>
</tr>
<tr>
<td>1979-80</td>
<td>2,675,806,04.950</td>
<td>+00.12</td>
</tr>
<tr>
<td>1980-81</td>
<td>2,149,420,84.750</td>
<td>−19.67</td>
</tr>
<tr>
<td>1981-82</td>
<td>2,643,723,28.500</td>
<td>+23.00</td>
</tr>
<tr>
<td>1982-83</td>
<td>2,736,752,21.090</td>
<td>+03.52</td>
</tr>
<tr>
<td>1983-84</td>
<td>2,661,476,76.770</td>
<td>−02.75</td>
</tr>
<tr>
<td>1984-85</td>
<td>3,030,585,01.540</td>
<td>+16.12</td>
</tr>
</tbody>
</table>
The comparison of the rates of increase between actual costs and deflated costs show that the actual costs have always been more than the deflated costs throughout the period of the study. In 1976-77 the percentage increase in the deflated cost is 11.16. The increasing trend in deflated cost has continued upto 1978-79. In 1979-80 the increase in the deflated cost has been only to the extent of 0.12 percent over previous year. In 1980-81 and 1983-84 the absolute figure of deflated cost have declined. Therefore, the percentage of deflated cost in these two years have been -19.76 (minus) and -2.75 (minus) over previous years. In 1979-80 and 1982-83 there has been a marginal increase in the percentage of deflated cost. The declining percentages in 1980-81 and 1983-84 broadly indicate improvement in the performance or the influence of input prices on the cost of transmission and distribution. The change in the percentages in actual cost and deflated cost have gone in opposite directions in 1980-81 and 1983-84. In both years the actual costs have increased but the deflated costs have decreased. The fluctuations in the rates of increase or decrease in deflated costs from year to year reflect a change in the impact of nonprice factors.
Per Unit Deflated Cost Of Transmission & Distribution:

It is clear from the table No.2.7 that the per unit deflated cost of transmission and distribution have milder fluctuations. In the first five years of the decade the per unit cost has ranged between 2.2 paisa per unit to 2.5 paisa per unit. In the remaining five years it has decreased and has ranged between 1.5 paisa per unit to 1.86 paisa per unit. The percentage decrease in per unit deflated cost in 1984-85 comes to 28 percent over 1975-76. Whereas the percentage increase in per unit actual cost is 69.45 percent in 1984-85 over 1975-76. The average per unit deflated
Table No.2.8

<table>
<thead>
<tr>
<th>Year</th>
<th>Per Unit Cost (Paise/KWH)</th>
<th>Percentage increase (+) or decrease (-) in Per unit Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-76</td>
<td>2.50</td>
<td>-</td>
</tr>
<tr>
<td>1976-77</td>
<td>3.20</td>
<td>-12.00</td>
</tr>
<tr>
<td>1977-78</td>
<td>2.30</td>
<td>+04.50</td>
</tr>
<tr>
<td>1978-79</td>
<td>2.50</td>
<td>+06.70</td>
</tr>
<tr>
<td>1979-80</td>
<td>2.40</td>
<td>-04.00</td>
</tr>
<tr>
<td>1980-81</td>
<td>1.60</td>
<td>-33.33</td>
</tr>
<tr>
<td>1981-82</td>
<td>1.86</td>
<td>+16.25</td>
</tr>
<tr>
<td>1982-83</td>
<td>1.78</td>
<td>-04.30</td>
</tr>
<tr>
<td>1983-84</td>
<td>1.57</td>
<td>-11.80</td>
</tr>
<tr>
<td>1984-85</td>
<td>1.80</td>
<td>+14.65</td>
</tr>
</tbody>
</table>
cost of transmission and distribution is less than half of the actual per unit cost. In the four years namely, 1979-80, 1980-81, 1982-83 and 1983-84 there is declining trend in the percentages of per unit deflated cost. In the remaining years the percentage of per unit cost has increased between 4.5 and 16.25 percent.

In this study for cost comparisons immediate preceding year has been selected as the base instead of fixed base. This method is thought to be more appropriate as the impact of inflationary factor is minimum as compared to a remote base.
Statistical Cost Analysis Of Power Generation

The generation of electricity is done by the respective State Government and the Central Government in that respect. Maximisation of profit is not allowed being a public utility. Adjustment of output with reference to costs or prices is also not possible. The objective function of State Electricity Boards could thus be one of minimising the cost at various hypothetical levels of output. Here we have tried to estimate the parameters of cost function by using least square method. The attempt made here is that of a time series study. There are so many variables which affects the cost of output. They are factors like obsolescence of plant, change of management techniques, production methods, total units of power generated, installed capacity, maximum demand on system, coal consumed and time. Since all these factors may not move in unison at the same pace and they are not likely to throw up spectacular results in the same year. It is safe to assume that their combined effect is slow and smooth over time. Therefore, the time as an additional explanatory variable in the cost function is taken.
In a log linear cost function, the implicit average cost function would be either rising, falling or remain constant. This is obviously inconsistent with the 'U'-shaped average cost curve in theory. For example, the short run average variable cost may have a flat stretch where plants are set up with a reserve capacity. Or again, the long run average cost curve may be 'L' shaped if managerial diseconomies can be avoided or can be more than compensated by production economies. Moreover, in the case of thermal (steam)power generation, while the energy costs vary not with output but with the peakload. The peakload on the supply system depends on variety of customers' diversity and size of the undertaking. The diversified nature of customers is a contributing factor in having peakload on the system. The effect of diversity factor is more significant in the case of small undertaking as compared to large units.

The higher utilisation of installed capacity naturally increases the total cost of generation but generation of more units ultimately reduces the average cost of generation.

The $L$ term in the equation can not be exactly interpreted as a constant term denoting fixed
costs, because it is not a simple linear equation where the term is an intercept. Therefore, this term may have different interpretations -

a) It is a residual factor which takes care of over or under estimation of total cost by the explanatory variables.

b) The minimum output necessary for incurring any fixed cost.

The unexpected negative sign in case of fixed cost and independent variables can be explained in terms of the high multi-collinearity between these variables.

Multi-regression log linear equations are constructed with total cost of generation \( Y \) as a function of -

1) Power generated \( X_1 \),

2) Installed capacity \( X_2 \),

3) Maximum demand on the system \( X_3 \),

4) Coal consumed \( X_4 \) and

5) Time trend \( X_5 \)

Hence the regression equation is:

\[
Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + X
\]

Where

\( \beta_1, \beta_2, \beta_3, \beta_4, \beta_5 \) are the co-efficients of the respective variables.
$X_1, X_2, X_3, X_4, X_5$ and $X$ are the independent variables and $\bar{X}$ is the mean effect of omitted variables including the fixed costs. The corresponding log function is:

$$\log Y = \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \log \bar{X}$$

In steam power generation 15 multi-regression log linear equations are constructed. Out of 15 equations 7 equations are selected on the basis of significance of variables. Out of the equations chosen (table no. 2.9) $\beta_1$ is significant in two cases, $\beta_2$ in three cases and $\beta_3, \beta_4$ and $\beta_5$ are significant in one case each.
Table 2.9

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Estimation Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y = Cost Of Generation</td>
<td>Log-Linear</td>
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</tbody>
</table>

M.S.E.B. 1975-85 (yearly observations)

Equations:

1) \[ Y = -10.49 + 1.6356X1 + 0.9373X2 + 1.1637X3 - 1.496X4 \]

\[
\begin{align*}
& (1.799) \quad (0.4361) \quad (0.7947) \quad (2.15) \\
& (t=1.02) \quad (t=2.15) \quad (t=1.46) \quad (t=0.6927) \\
& R^2 = 0.993 \quad F = 189.47
\end{align*}
\]

2) \[ Y = -13.176 + 1.0265X1 + 0.5028X2 + 1.2459X3 - 0.1706X5 \]

\[
\begin{align*}
& (0.7394) \quad (0.4666) \quad (0.6491) \quad (0.2475) \\
& (t=1.388) \quad (t=1.077) \quad (t=1.467) \quad (t=0.6882) \\
& R^2 = 0.993 \quad F = 189.30
\end{align*}
\]

3) \[ Y = -17.18 + 0.8898X1 + 1.5646X3 + 0.7858X4 - 0.3407X5 \]

\[
\begin{align*}
& (1.7645) \quad (0.8987) \quad (1.8089) \quad (0.1937) \\
& (t=0.5042) \quad (t=1.74) \quad (t=0.434) \quad (t=1.759) \\
& R^2 = 0.992 \quad F = 159
\end{align*}
\]

4) \[ Y = -11.96 + 0.4243X2 + 1.1783X3 + 1.0646X4 - 0.1477X5 \]

\[
\begin{align*}
& (0.6453) \quad (0.9108) \quad (1.0483) \quad (0.2922) \\
& (t=0.6575) \quad (t=1.2937) \quad (t=1.0156) \quad (t=-0.5053) \\
& R^2 = 0.992 \quad F = 164.86
\end{align*}
\]
5) \[ Y = 9.2891 + 0.6326X_1 + 0.7346X_2 + 0.9505X_3 \]
\[ (0.4482) \quad (0.3090) \quad (0.7002) \]
\[ (t=1.4115) \quad (t=2.3774) \quad (t=1.3575) \]
\[ R^2 = 0.993 \quad F = 276.438 \]

6) \[ Y = -6.676 + 1.2773X_1 + 0.9298X_2 - 0.2709X_4 \]
\[ (1.9184) \quad (0.4758) \quad (2.1727) \]
\[ (t = 0.6658) \quad (t = 1.9542) \quad (t = -0.1247) \]
\[ R^2 = 0.991 \quad F = 211.564950 \]

7) \[ Y = -6.340914 + 1.0038X_1 + 0.9007X_2 + 0.0128X_5 \]
\[ (0.8071) \quad (0.4146) \quad (0.2332) \]
\[ (t=1.2436) \quad (t=2.1725) \quad (t=0.0547) \]
\[ R^2 = 0.991 \quad F = 211.119334 \]

8) \[ Y = -8.9772 + 0.6856X_1 + 0.9919X_3 + 0.8315X_4 \]
\[ (0.361) \quad (0.7793) \quad (0.5650) \]
\[ (t=1.8999) \quad (t=1.2728) \quad (t=1.1179) \]
\[ R^2 = 0.992 \quad F = 250.564640 \]

9) \[ Y = -7.777057 + 0.9854X_1 + 1.2213X_3 + 0.0950X_5 \]
\[ (0.3345) \quad (0.9122) \quad (0.1687) \]
\[ (t=2.9460) \quad (t=1.3389) \quad (t=0.5626) \]
\[ R^2 = 0.991 \quad F = 218.066049 \]

10) \[ Y = -6.042048 + 1.3291X_1 + 1.0049X_2 - 0.4721X_4 + 0.0400X_5 \]
\[ (2.1340) \quad (0.7701) \quad (2.8206) \quad (0.3025) \]
\[ (t=0.6228) \quad (t=1.3050) \quad (t=-0.1674) \quad (t=0.1324) \]
\[ R^2 = 0.991 \quad F = 132.695793 \]
11) \[ Y = -10.366346 - 0.3498X_1 + 1.1437X_3 + 1.6168X_4 \]

\[
(1.8791) \quad (1.0062) \quad (2.02770)
\]

\[ t = -0.1862 \quad (t = 1.1367) \quad (t = 0.7983) \]

\[ R^2 = 0.987 \quad F = 156.807387 \]

12) \[ Y = -18.674360 + 1.6200X_1 + 1.7777X_3 - 0.3627X_5 \]

\[
(0.4999) \quad (0.7002) \quad (0.1736)
\]

\[ t = 3.2409 \quad (t = 2.5387) \quad (t = -2.0866) \]

\[ R^2 = 0.992 \quad F = 245.423585 \]

13) \[ Y = -10.619932 - 0.1126X_1 + 2.5049X_4 - 0.2510X_5 \]

\[
(1.9299) \quad (1.7534) \quad (0.2160)
\]

\[ t = 0.0583 \quad (t = 1.4286) \quad (t = -1.1819) \]

\[ R^2 = 0.987 \quad F = 157.863429 \]

14) \[ Y = -5.890703 + 0.7567X_2 + 1.1276X_4 + 0.0055X_5 \]

\[
(0.6244) \quad (1.1044) \quad (0.2818)
\]

\[ t = 1.2119 \quad (t = 1.0211) \quad (t = 0.195) \]

\[ R^2 = 0.980 \quad F = 196.885146 \]

15) \[ Y = -15.517050 + 1.4167X_3 + 1.6546X_4 - 0.3017X_5 \]

\[
(0.7950) \quad (0.5156) \quad (0.1682)
\]

\[ t = 1.7820 \quad (t = 3.2090) \quad (t = 1.8156) \]

\[ R^2 = 0.992 \quad F = 242.337 \]

16) \[ Y = -12.8404 + 1.7501X_1 + 0.7153X_2 + 1.3056X_3 - 1.0487X_4 - 0.1187X_5 \]

\[
(1.9851) \quad (0.7381) \quad (0.9429) \quad (2.6260) \quad (0.3008)
\]

\[ t = 0.8616 \quad (t = 0.9691) \quad (t = 1.3847) \quad (t = 0.3993) \quad (t = 0.3948) \]

\[ R^2 = 0.9937 \quad F = 126.0190 \]

[Figures in parenthesis show the std. error.]
[The value of T is at 5% level.]
In the first equation where all '5' explanatory variables are included. All these variables are not significant at 5 percent level of freedom though \( R^2 \) is significant. In equation no.'2' where \( X \) has been excluded, there the installed capacity is significant. When there is an increase in installed capacity by one percent then the cost of generation increases by 0.94 percent. The independent variables \( X_1 \) and \( X_3 \), that is, units generated and demand on power system have positive effect but they are not significant. But variable \( X_4 \), i.e., coal consumed has shown negative sign. That means when there is increase in coal consumed by one percent it results in decreasing the cost of generation by 1.496 percent.

In this equation \( R \) is 0.993.

In equation no.'3' the significant independent variable is again \( X \), that is, installed capacity by one percent results in increasing the cost of generation by 0.735 percent. The variables \( X_1 \) and \( X_3 \) are having positive effect on cost of power generation but they are not significant. \( R \) is 0.993 as in equation no.'2'.

The explanatory variable no.'2', that is, installed capacity is significant in equation no.4. In this
equation three variables namely, units generated, installed capacity and time have been included. out of these three variables, only installed capacity is significant and other two have positive effect but they are not significant. Co-efficient of correlation is \(0.981\).

The equation no. '5' has been included three variables, namely, units generated \(X_1\), demand on system \(X_2\), and time \(X_5\). Here the units generated is significant. When there is an increase in units generated it results in increasing the cost of power generation by \(0.98\) percent. Co-efficient of correlation is \(0.991\).

In equation no.6 three independent variables, namely, units generated \(X_1\), demand on system \(X_1\), (X_2), and time \(X_5\) have been included. In this equation all the three variables are significant.

The variable \(X_1\) is highly significant. One percent increase in units generated and demand on system have resulted in increasing the cost of power generation by 1.62 and 1.78 percent respectively.

The variable \(X_5\) is significant but its values have got negative effect.

The last equation that is seventh has also included three variables, namely, demand on system \(X_3\),
coal consumed \( (X_4) \), and time \( (X_5) \). Here only \( X_4 \)
that is, coal consumed is highly significant. The
variable \( X_3 \) have positive effect but it is not
significant. And \( X_5 \) has shown negative effect, that
means if time increases the cost of generation
declines with the time.

The seven (7) equations discussed above leads us to
following conclusions:

1) When the total cost of generation as a function
of power generated, installed capacity, maximum
demand on system, coal consumed and time trend
fails to explain the behaviour of cost. Because no
correlation co-efficient is significant at '5'
percent value of 't'. It means there exists a
multi-collinearity and the cost of power
generation appears to be a mongrel cost function.

2) In the equation no.2,3, and 4, the installed
capacity appears to be significant as an
explanatory variable for cost behaviour. And
those results appear to be quite relevant as higher
the installed capacity more would be the cost of
generation. Because higher installed capacity
denotes not only high fixed cost but simultaneous
increase in recurring cost to maintain fixed
assets.
3) The consumption of coal has shown negative coefficient in equation 2 which is apparently absurd. But in equation 7 the coefficient of regression is positive and significant. It means when power generated and installed capacity are excluded from the explanatory variables then it becomes more relevant and significant. Possibly the increasing power generated and the higher capacity of the understanding to generate electricity gives better returns and generate economies of scale.

4) The time trend is not giving a consistent results. Therefore, the exclusion of time trend appears to be most relevant in explaining the cost equations.

5) The first variable namely, power generated has always been positive and significant only in two equations, that is, equation 5 and 6. It means that there is positive correlation between cost of generation and power generated.
The cost of electricity has two main cost components, namely, generation and transmission and distribution. In the preceding section the generation cost has been analysed. This section proposes to discuss transmission and distribution cost by applying the technique of log linear equation. The behaviour cost of transmission and distribution can be explained by number of independent variables. But in present model power sold \((X_1)\), connected load \((X_2)\), transmission and \((X_3)\) and time trend \((X_4)\) have been selected to explain the behaviour of Transmission and distribution cost.

The regression equation is as follows

\[
\log Y = \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \log X
\]

Where

\[
\beta_1, \beta_2, \beta_3, \beta_4\text{ and } \beta\text{ are co-efficient of the respective variables and } X\text{ is the mean effect of omitted variables including fixed cost.}
\]

From the above model eleven equations having different combinations of independent variables have been calculated.

In the eleven equation constructed so far the fixed
cost is effective. In six equations the fixed cost has shown negative sign. The negative sign of fixed cost implies that with increase in the size of the establishment there is a decrease in the cost of transmission and distribution.
Table 2.10

Dependent Variables  
Y = Cost Of Transmission & Distribution  

<table>
<thead>
<tr>
<th></th>
<th>Estimation Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log-Linear</td>
</tr>
</tbody>
</table>

M.S.E.B.  
1975-85 (Yearly Observations)

Equations:

1) \( Y = -0.0856 - 5.9296X1 + 4.3047X2 + 3.5406X3 + 0.3353X4 \)
   \( (3.3514) \ (2.4740) \ (2.7608) \ (0.5012) \)
   \( (t = -1.7693) \ (t = 1.7399) \ (t = 1.2824) \ (t = 0.6691) \)
   \( R^2 = 0.9006 \quad F = 11.3247 \)

2) \( Y = -8.450070 - 6.2907X1 + 4.7350X2 + 4.6353X3 \)
   \( (3.1517) \ (2.2763) \ (2.1189) \)
   \( (t = -1.9960) \ (t = 2.0801) \ (t = 2.1876) \)
   \( R^2 = 0.892 \quad F = 16.466367 \)

3) \( Y = 12.318387 - 2.6081X1 + 2.3992X2 + 0.7162X4 \)
   \( (2.2381) \ (2.0817) \ (0.1218) \)
   \( (t = -1.1653) \ (t = 1.1525) \ (t = 1.8861) \)
   \( R^2 = 0.868 \quad F = 13.139790 \)

4) \( Y = -2.593963 - 0.4154X1 + 1.8762X2 \)
   \( (2.0474) \ (2.3136) \)
   \( (t = -0.2029) \ (t = 0.8109) \)
   \( R^2 = 0.805 \quad F = 14.477087 \)
5) \( Y = -3.561679 - 0.2827X1 + 2.1052X3 \\
    (1.5451) \quad (2.1073) \)
\[ (t=-0.1894) \quad (t=0.9990) \]
\[ R = 0.814 \quad F = 15.278144 \]

6) \( Y = 12.049776 - 0.3222X1 + 0.64333X4 \\
    (1.0610) \quad (0.4298) \)
\[ (t=-0.3036) \quad (t=1.4967) \]
\[ R = 0.839 \quad F = 18.192312 \]

7) \( Y = -3.3928 + 0.5780X2 + 1.0315X3 \\
    (1.0973) \quad (1.3243) \)
\[ (t=0.5268) \quad (t=0.7789) \]
\[ R = 0.820 \quad F = 15.920682 \]

8) \( Y = 7.155418 + 0.2495X2 + 0.4286X4 \\
    (0.9869) \quad (0.3545) \)
\[ (t=0.7523) \quad (t=1.2092) \]
\[ R = 0.838 \quad F = 18.105074 \]

9) \( Y = 9.340319 - 0.0168X3 + 0.5203X4 \\
    (1.7320) \quad (0.5144) \)
\[ (t=-0.0097) \quad (t=1.0115) \]
\[ R = 0.837 \quad F = 17.910630 \]

10) \( Y = 8.412813 + 0.3047X2 - 0.2346X3 + 0.1781X4 \\
     (1.1697) \quad (2.0395) \quad (0.5758) \)
\[ (t=0.2605) \quad (t=-0.150) \quad (t=0.0304) \]
\[ R = 0.838 \quad F = 10.372973 \]
11) \[ Y = -8.450070 + 6.2907X1 + 4.7350X2 + 4.6353X3 \]
\[
\begin{align*}
(3.1517) & & (2.2763) & & (2.1189) \\
(t=-19960) & & (t=2.0801) & & (t=2.1876)
\end{align*}
\]
\[ R = 0.892 \quad F = 16.466367 \]

12) \[ Y = 9.713247 - 0.6011X1 + 0.6557X3 + 0.5620X4 \]
\[
\begin{align*}
(1.5745) & & (2.5534) & & (0.5598) \\
(t=-0.3818) & & (t=0.2568) & & (t=1.0040)
\end{align*}
\]
\[ R = 0.840 \quad F = 10.531626 \]

[ Figures in parenthesis show the std. error. ]
[ The value of T is at 5% level. ]
When all the variables are included in the equation, no variable appears to have significant causal relationship with the cost of transmission and distribution. But as compared to other equations the $R^2$ is very high. It means this equation has better explanatory aspect but no individual variable establishes strong causal relationship.

In equation no. '2' when the time factor is removed the equation becomes significant and variables, namely, connected load and transmission and distribution losses appeared to be significant. The weakest variable in all the equations appears to be power sold. The calculated value of 't' is lowest and not at all significant. But the co-efficient has always been negative. It means increasing power sold reduces cost of transmission and distribution. This factor though not significant affects the cost of transmission and distribution in its own way and increase in the sales of electricity would definitely result in reducing the cost of transmission and distribution. If the influence of this factor is considered with the other variable namely, transmission and distribution losses will give better insight in understanding in the cost of
transmission and distribution. Atleast in one equation the transmission and distribution losses appear to be significant. In other equations have higher calculated value of 't' as compared to the 't' values of other co-efficient though it may not be significant. The variable namely, transmission and distribution losses have positive co-efficient in all the equations wherever this variable has been included in the equation. It means transmission and distribution losses increase the transmission and distribution cost. Whenever there is increase in power sold the transmission losses would reduce the cost of transmission and distribution. These two variables also appear to have auto correlation.

The variable "connected load" is significant only in one equation. The co-efficient of regression is positive in all the equations wherever this variable have been included. This variable appears to be powerful explanatory variable after transmission and distribution losses.

The last variable, namely, time trend is not significant in all the equations wherever it had been included.
In short connected load and transmission and distribution losses are the most relevant variables in the cost of transmission and distribution. Out of these two the transmission and distribution loss appears to be more effective and any savings in these losses will significantly reduce the cost of transmission and distribution.
References


3) Ibid :- 


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