



# ***BENCHMARKING STUDY ON UPPTCL'S TRANSMISSION BUSINESS***

***Benchmarking Report on UPPTCL's Transmission business as per the requirement of National Tariff Policy and Uttar Pradesh Electricity Regulatory Commission Regulations 2014***

***Prepared For: Uttar Pradesh Power Transmission Corporation Limited***

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# Preface

*As per the provisions of Uttar Pradesh Electricity Regulatory Commission (Multi Year Transmission Tariff) Regulations, 2014, each transmission licensee has to conduct Benchmarking Study under supervision of Hon'ble Commission and submission of Benchmarking Report to Hon'ble Commission.*

*UPPTCL produced its first Benchmarking Report that provides an in-depth survey and analysis of the quality of electricity supply. In producing this Report, UPPTCL seeks to provide valuable information regarding various technical and operational parameters in seven comparable State Transmission Utilities having similar transmission network configuration and geographical area and comparable international transmission utilities, with associated recommendations for good regulatory practices that could be adopted in Uttar Pradesh.*

*Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) is committed to promoting well-functioning and competitive energy markets in Uttar Pradesh in order to ensure that consumers receive the best quality of supply. In this Report, the Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) focuses to **benchmark the capex, opex and operational performance of UPPTCL's Transmission Business with seven comparable State Transmission Utilities having similar transmission network configuration and geographical area and one comparable international transmission utility.***

*The benchmarking techniques adopted in this report are based on statistical methods and present a broad picture of the performance of UPPTCL vis-à-vis the other transmission utilities on different operational and technical parameters. We hope Uttar Pradesh Electricity Regulatory Commission will find the data being submitted in this Report suitable and helpful for further regulatory analysis*

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## Abbreviations

<b>Shortened term</b>	<b>Full title</b>
<b>A &amp; G</b>	<i>Administrative &amp; General Expenses</i>
<b>AP Transco</b>	<i>Transmission Corporation of Andhra Pradesh</i>
<b>ARR</b>	<i>Annual Revenue Requirement</i>
<b>BSPTCL</b>	<i>Bihar State Power Transmission Corporation Company Limited</i>
<b>CAPEX</b>	<i>Capital Expenditure</i>
<b>CERC</b>	<i>Central Electricity Regulatory Commission</i>
<b>CPI</b>	<i>Consumer Price Index</i>
<b>DA</b>	<i>Dearness Allowance</i>
<b>EA</b>	<i>Electricity Act</i>
<b>EC</b>	<i>Energy Charges</i>
<b>FR</b>	<i>Feasibility Report</i>
<b>FY</b>	<i>Financial Year</i>
<b>GETCO</b>	<i>Gujarat Electricity Company Limited</i>
<b>GFA</b>	<i>Gross Fixed Assets</i>
<b>KM/Km</b>	<i>Kilometre</i>
<b>KPTCL</b>	<i>Karnataka Power Transmission Corporation Limited</i>
<b>KV</b>	<i>Kilo Volts</i>
<b>KVA</b>	<i>Kilo Volt Ampere</i>
<b>KW</b>	<i>Kilo Watt</i>
<b>KWH</b>	<i>Kilo Watt Hour</i>
<b>MoP</b>	<i>Ministry of Power</i>
<b>MSETCL</b>	<i>Maharashtra State Electricity Transmission Company Limited</i>
<b>MPPTCL</b>	<i>Madhya Pradesh Power Transmission Company Limited</i>
<b>MU</b>	<i>Million Units</i>
<b>MVA</b>	<i>Mega Volt Ampere</i>
<b>MW</b>	<i>Mega Watt</i>
<b>MYT</b>	<i>Multi Year Tariff</i>
<b>OPEX</b>	<i>Operating Expenditure</i>
<b>O&amp;M</b>	<i>Operation &amp; Maintenance</i>
<b>PTCUL</b>	<i>Power Transmission Corporation of Uttarakhand Limited</i>
<b>R &amp; M</b>	<i>Repairs and Maintenance</i>
<b>RVPN</b>	<i>Rajasthan Rajya Vidyut Prasaran Nigam Limited</i>
<b>SERCs</b>	<i>State Electricity Regulatory Commissions</i>
<b>STU</b>	<i>State Transmission Utility</i>
<b>T&amp;D</b>	<i>Transmission &amp; Distribution</i>
<b>UPERC</b>	<i>Uttar Pradesh Electricity Regulatory Commission</i>
<b>UPPTCL</b>	<i>Uttar Pradesh Power Transmission Corporation Limited (UPPTCL)</i>
<b>WPI</b>	<i>Wholesale Price Index</i>
<b>WC</b>	<i>Working Capital</i>

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## Executive summary

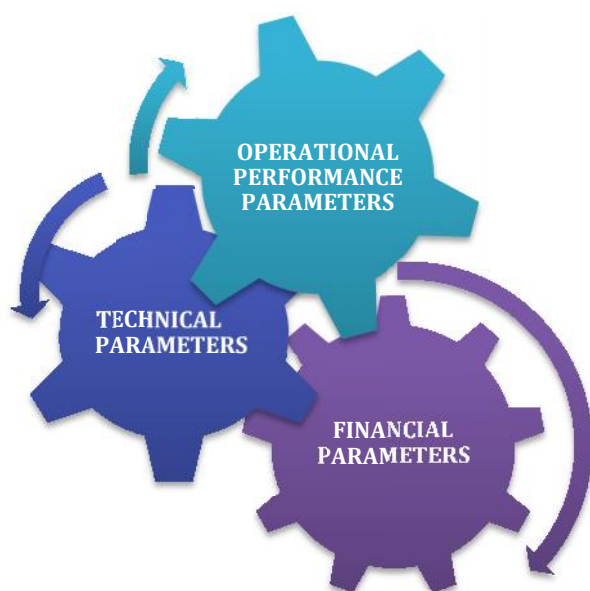
### **Why was this report created and who is it for?**

This report was created to ensure a deeper understanding of the role and commercial viability of State Transmission utilities. Power sector reforms are transforming the structure and operating environment of the electricity industries across many countries. The central aim of the reforms has been to introduce competition and market-oriented measures in the generation and supply activities of the sector. Increasingly, power sector reforms also attempt to improve the efficiency of the natural monopoly segments of the industry, namely, electricity distribution and transmission through regulatory reforms. This study is primarily concerned with this latter aspect of the reforms.

Regulatory reform of transmission utilities generally involves moving away from traditional rate of return regulation towards incentive-based regulation. A number of incentive-based regulation models have been proposed in the literature. These models are generally not attributed to theoretical advances in regulatory economics, rather, they reflect dissatisfaction with incentive signals and performance of rate of return regulation and the need for alternative approaches. **Therefore purpose of the study is to examine the scope for and identify the main issues in the use of national & international benchmarking of UPPTCL for the regulation and price controls.** The aim of benchmarking is to reveal performance variations amongst the regulated state transmission utilities, identifying the most efficient state transmission utilities in the sector and to benchmark UPPTCL's transmission business.

### **What methodologies/techniques were considered in the study?**

For conducting this benchmarking report following Financial and Technical parameters has been considered which are to be benchmarked accordingly following input and output parameters has been considered while carrying out this benchmarking study:



**Figure 1: Parameters for Benchmarking**

In Electricity Transmission sector for conducting the Benchmarking Study following input & output measures are generally required:

Input Parameters:	Output Parameters:
Capital Expenditure (Capex)	Total electricity deliveries (kWh)
Operating Expenditure (Opex)	System capacity
Overhead Transmission/ Distribution network	Line Length
Other Assets	Transmission Losses



For conducting this benchmarking study at least two feasible benchmarking techniques most relevant in context of UP from the list below were to be selected.

- A. Partial Performance Indicator (PPI) Method
- B. Total Factor Productive (TFP) Method
- C. Econometric Method
- D. Stochastic Frontier Analysis (SFA) Method
- E. Data Envelopment Analysis (DEA) Method
- F. Any Other technique adopted in India

### ***How was this study prepared?***

This study was prepared by a broad coalition of **seven comparable State Transmission Utilities having similar transmission network configuration and geographical area and comparable international transmission utilities**, including regulatory authorities.

States covered for benchmarking have been selected from various regions of India to get the best result by measuring each STU's efficiency in delivering network services to customers. Ranking have been given to the STUs according to their relative efficiency of providing services in accordance with service standard obligations. Following three techniques have been chosen to carry out this study:

- a) Partial Performance Indicator (PPI) Method***
- b) Econometric Method***
- c) Corrected Ordinary Least Squares (COLS) Method***

Each of the above technique uses different mathematical/statistical methods for relating outputs to inputs. Chapter 2 contains references to further reading on these techniques used in this report which will inform consumers/regulators/ stake holders about the relative efficiency of UPPTCL.

### ***What are the key findings?***

By this benchmarking report UPPTCL may have Comparative information on the performance of various states transmission utilities contributes to the benchmark of UPPTCL's O&M and capital expenditures which in turn should allow better management decisions and help UPPTCL become more commercially sustainable over time along with following findings:

- *Identify high performing State Utilities*
- *Enable STUs to learn from peers that are delivering their services more efficiently*
- *Generate additional incentives for STUs to improve their efficiency.*

# 1. Chapter 1: Introduction



## 1.1 Background

Electricity plays a vital role in the economic development and productivity of any economy. Electricity directly or indirectly has an impact on most aspects of society including employment, health, education, culture etc.

UPPTCL is taking a leading position in the utilization of the most up-to-date transmission technologies including HVAC transmission, integration standards and advanced system planning tools. Now, as per the provisions of the Electricity Act, 2003, National Tariff Policy and Uttar Pradesh Electricity Regulatory Commission (Multi Year Transmission Tariff) Regulations, 2014, UPPTCL is conducting the Benchmarking Study of UPPTCL's transmission business under supervision of Hon'ble Commission.

The focus of benchmarking of best practices in transmission is to identify technologies leading to greater efficiency in the bulk power system, an increase in system utilization and a reduction in system losses that would otherwise flow to the end user. Reducing T&D losses will allow utilities to generate less power and thereby lower the industry's carbon footprint.

For conducting the benchmarking study, data was collected for the last three financial years i.e. since FY 2013-14 and future benchmarking exercises has been designed in part to provide selected power transmission sector data for the bench marking initiatives to improve Indian Power transmission sector.

## 1.2 Objective of the Study

The objective of the study is to assess the role and commercial viability and benchmark the various costs of transmission network in light of the projected development of the UPPTCL transmission business towards 2022. There are several key objectives behind this benchmarking study:

- *To provide a baseline of indicators based on last three years operational data, against which to measure future changes in technical and financial performance of UPPTCL.*

- To benchmark the UPPTCL capital, O&M and operational performance parameters to achieve desired policy objectives including minimum service standards for delivering electricity economically and reliably.

### 1.3 Scope of work of the study

In general the scope of services covers preparation of Benchmarking Report on UPPTCL's Transmission business as per requirements of National Tariff Policy and Uttar Pradesh Electricity Regulatory Commission (Multi Year Transmission Tariff) Regulations, 2014. Collection of relevant data from various sources including TRANACOs/ERCs/LDCs/ DISCOMs of other states having similar network configuration and geographical area.

Financial and Technical parameters are to be benchmarked and accordingly following input and output parameters shall be considered while carrying out benchmarking study:

#### A. Benchmarking of Financial Parameters-

**Parameter A1:** Operation and Maintenance expenses- Benchmarking of Operation & Maintenance (O&M) expenses. Under this head, analysis is to be carried out separately for following three subheads of expenses:

- Employee Expenses.
- A&G Expenses
- R&M Expenses

Benchmarking of total O&M Expenses is to be carried out in Rs. Lakh/ckt. km, Rs. Lakh/MVA, and Rs. Lakh/bay for Lines, Transmission Capacity and Bays respectively at various voltage levels.

#### Table 1: Benchmarking of O&M at different voltage level

Transmission Lines

Rs. Lakh/Ckt Km

HVDC (Rs. Lakh)

765 KV

400 KV

220 KV

132 KV

Transformation Capacity

Rs. Lakh/MVA

Bays

Rs. Lakh/bay

765KV

400 KV

220 KV

132 KV

**Parameter A2:** Capital Expenditure- Under this head there shall be the following categories:

- i. 765 KV S/C Transmission line
- ii. 400 KV D/C Quad Transmission line
- iii. 400 KV D/C Triple Transmission line
- iv. 400 KV D/C Twin Transmission line
- v. 400 KV S/C Twin Transmission line
- vi. 220 KV D/C Twin Transmission line
- vii. 220 KV D/C Transmission line
- viii. 220 KV S/C Transmission line
- ix. 132 KV D/C Transmission line
- x. 132 KV S/C Transmission line
- xi. New 132 KV AC Sub Station
- xii. New 220 KV AC Sub Station
- xiii. New 400 KV AC Sub Station
- xiv. New 765 KV AC Sub Station
- xv. Any other (which is required and considered as important).

The benchmarking of Capital Expenditure will have to be carried out with respect to Transmission Capacity (MVA), Line Length (ckt-km), Numbers of Bays, GFA (in crore), Energy Handled (MUs) and Peak Demand Handled (MW).

## **B. Benchmarking of Technical parameters-**

**Parameter B1:** Intra State Transmission Losses- Consolidated and at various voltage levels.

**Parameter B2:** A.C. System Availability-

- Comparison of Voltage wise Transmission Network (Lines, S/s, Bays etc.) existing as on date.
- Voltage wise Transmission Losses and A.C. System Availability for the transmission network.

## **C. Benchmarking of Operational Performance Parameter-**

Benchmarking of voltage level wise overloaded feeders, overloaded transformers and failure of transformers.

## 2. Chapter 2: The benchmarking methodologies /techniques

Benchmarking focuses on the improvement of any given business process by exploiting "**best practices**" rather than merely measuring the best performance. Best practices are the cause of best performance and to benchmark the Opex & Capex in energy networks following five alternative benchmarking methods –namely *Partial Performance Indicator (PPI) Method*, *Total Factor Productive (TFP) Method*, *Econometric Method*, *Stochastic Frontier Analysis (SFA) Method*, *Data Envelopment Analysis (DEA) Method*, *Corrected Ordinary Least Squares (COLS) Method* has been used in the regulation of energy networks. Detailed overview of these techniques is as follows:

### **Partial Performance Indicator (PPI) Method**

**Partial-performance-indicator (PPI)** method involves the use of trend or ratio analysis on part (but not all) of a business's inputs or outputs to allow judgments or comparisons to be made on some aspects of the productivity or efficiency performance of comparable businesses or an industry average.

*This method is generally benchmark the performance of the Gas & electricity utilities.*

At a basic level, PPI can be expressed in the following terms:

$$PPI = \text{input measure} / \text{Output measure}$$

The key assumptions of the PPI measure is that a linear relationship exists between the input and output measured and that any change in the input can be explained by a change in the output (or vice versa).

#### **Data Requirements:**

In such method data collected should be on consistent basis across the business as PPI method is a linear relationship method therefore unavailability of inconsistent data in PPI method may likely to be a flawed one benchmarking.

#### **Advantages:**

- Generally easy to compute and simple to interpret.
- It is a comparison of following certain aspects of efficiency & productivity performance:
  - Across Different business at a single point in time i.e. **Cross sectional analysis**
  - Across Time for the some business or industry i.e. **Time series analysis**
  - Both i.e. **Panel Data Analysis**

#### **Disadvantages:**

As PPIs assume a linear relationship between the input and output measures and also assume that any change in the input measure can be described by a change in the output measure which cannot be possible in every case. *For example, a utility may have a relatively high or*

*low unit cost simply because it faces input prices or serves customers that are different from those for utilities operating in other regions. Because of this, they may present problems in providing a meaningful comparison of businesses in different operating environments.*

**Other countries where the PPI Method has been adopted:**

S.No.	Regulator / State	Electricity distribution businesses	Regulatory application
1	Independent pricing and Regulatory Tribunal (New South Wales) - Australia	<ul style="list-style-type: none"> <li>• EnergyAustralia</li> <li>• Integral Energy</li> <li>• Country Energy</li> </ul>	The benchmarking results were used, among other things, to test the reasonableness of the opex and capex allowance for 2004-05 to 2008-09.
2	Independent Competition and Regulatory Commission (Australian capital Territory) – ICRC - Australia	<ul style="list-style-type: none"> <li>• ActewAGL</li> </ul>	The benchmark ratios were used by the ICRC and its consultants to test the conclusions about ActewAGL's total opex allowance for 2004-05 to 2008-09, rather than as a device for arriving at these conclusions.

### **Total Factor Productive (TFP) Method**

**Total Factor Productivity (TFP)** – a ratio of a measure of total output to a measure of total input use – measures the overall productivity change, which cannot be captured in a partial performance indicator examining the relationship between one output and a single factor of production. The TFP method is best used to measure **productivity performance** of a business or a group of businesses over time.

TFP analysis can be used as an informative tool under the current building-block approach to cross-check the reasonableness of a business's forecast demand and costs and thus that of the implied productivity growth potential. ***For example, under certain conditions historical productivity growth experienced by comparable utilities in a subsector provides a reasonable benchmark for past and prospect productivity performance for the utility under consideration.***

***“Total factor productivity (TFP) growth is defined as output growth net of input growth.”***

There are a number of alternative methods for measuring TFP growth. These include:

- (I) **Non-parametric approaches such as index numbers and Data Envelopment Analysis (DEA), and**

## (II) Parametric approaches such as Stochastic Frontier Analysis (SFA) and econometric cost-function models.

### INDEX-NUMBER-BASED TFP:

Index-number-based TFP is commonly used for measuring productivity growth when there are a limited number of observations available.

The index-number approach applies the chosen index number formula to construct input and output quantity indices. **The TFP growth is then defined as the difference between the rate of output quantity growth and input quantity growth.** This approach is known as 'growth accounting'; i.e., productivity growth is the residual or technical change, from output growth after accounting for input growth.

A general Form of TFP index, as defined is as follows:

In the Cobb-Douglas production function, total factor productivity is captured by the variable A:

$$Y = AK^{\alpha}L^{\beta}$$

where, Y represents TOTAL OUTPUT

A represents TOTAL FACTOR PRODUCTIVITY

K represents CAPITAL INPUT

L represents LABOR INPUT

$\alpha$  and  $\beta$  represents TWO INPUT'S RESPECTIVE SHARE OF OUTPUT

Considering the case of firm G in the previous example used in DEA technique, i.e.,

Capital input= 16 crores

Labor input= 400

Output= 1 MW

$$Y = A K^{\alpha} L^{\beta}$$

$$10^6 = A (16 * 10^7)^{0.5} 400^{0.5}$$

A= 12.5

Total factor productivity comes out to be 12.5 which can be compared to different year's total factor productivity and the business growth is judged

### Data Requirements:

The index-number-based TFP method requires **price and quantity information** on input and output **for two or more businesses or time periods.**

### Advantages:

- The index-number-based TFP can be used to measure productivity change either over time or across businesses.
- All inputs can be accounted for conceptually.
- This approach is relatively simple and transparent, and the results are readily reproducible.

### Disadvantages:

- The approach can be information-intensive as it requires not only quantity information, but also price (or revenue/cost share) information to compute the TFP index.
- As a non-parametric technique, it cannot produce confidence intervals and other statistical tests

#### Other countries where the TFP Method has been adopted:

S.No.	Country / State	Electricity distribution businesses	Regulatory application
1	NSW (Australia), New Zealand, the UK and the US	6 electricity distribution businesses in NSW (1995-96 to 1997-98)	Tornqvist TFP index was computed for NSW distributors as part of the sensitivity analysis.
2	Australia	Electricity distribution (1999 to 2003)	The report considered that comprehensive performance analysis enabled effective benchmarking of electricity distribution businesses.

### **Data Envelopment Method (DEA)**

Data Envelopment Analysis (DEA) is a technique that compares the efficiency and productivity of businesses that produce similar outputs using similar inputs. Unlike other parametric techniques, DEA does not require any assumptions about the shape of the underlying production function or cost function. Information about the shape of the real-world production technology is inferred from observations of the input-output combinations used by the businesses.

At the heart of DEA is a set of assumptions about how observed input-output combinations from real-world businesses can provide information about the set of possible input-output combinations available to the businesses in the industry. That is, this approach relies on data in relation to the output levels of businesses in the industry and the amount of inputs to produce that output (**the ‘input-output combinations’**). Sophisticated mathematical techniques are employed to calculate efficiency levels for each business, given their relative scale, output levels, output mix, and use of inputs. That is, possible ‘input-output combinations’ are derived and compared with actual input-output combinations so that the business-specific level of efficiency is calculated. Different approaches to DEA differ in the assumptions about the space of feasible input-output combinations from observations of the actual input output combinations achieved by individual businesses.

***“Data Envelopment Analysis (DEA) measures the relative efficiencies of organizations with multiple inputs and multiple outputs. The organizations are called the decision-making units, or DMUs. DEA assigns weights to the inputs and outputs of a DMU that give it the best possible efficiency.”***



The DEA method constructs a space of feasible input-output combinations starting from observed input-output combinations of sample businesses. Different DEA approaches make different assumptions in extrapolating from specific observed input output combinations to the set of all possible feasible input-output combinations.

If a business produces the vector of  $N$  outputs  $y = (y_1, y_2, y_3, \dots, y_n)$  using the vector of  $M$  inputs  $x = (x_1, x_2, x_3, \dots, x_n)$ , the input-output combination  $f = (y, x)$  is said to be feasible. A sample of such observations yields a set of discrete feasible input-output combinations  $f^1, f^2, \dots, f^s$ , where  $S$  is the number of businesses.

From this observed set of feasible input-output combinations, the next step is to extrapolate to the full space of feasible input-output combinations. The most common approach to DEA is to assume:

- Free disposability: If  $(y, x)$  is a feasible combination then so is  $(y^i, x^i)$  where  $y^i \leq y$  and  $x^i \geq x$  and
- Scalability and combinability of peer observations: If  $(y^i, x^i)$  is a set of feasible combinations, then so is  $(\sum_i \pi^i x^i, \sum_i \pi^i y^i)$  where, under the assumption of constant returns-to-scale (CRS), the weights of peer observations in forming the surface of feasible input-output combination  $\pi^i_s$  are allowed to be any non-negative real number.

Other assumptions may include:

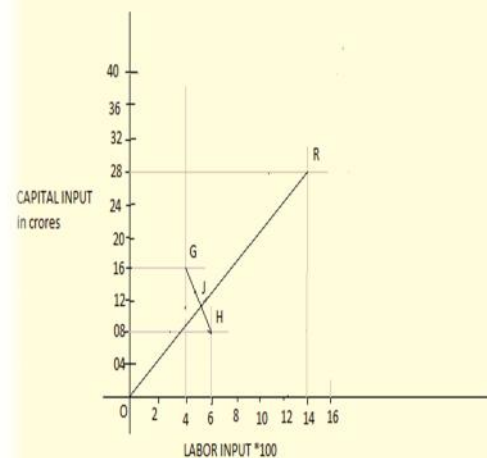
- the businesses have decreasing returns-to-scale (DRS), where the weights are allowed to be any non-negative real number which sums to less than or equal to one; or
- the businesses have variable returns-to-scale (VRS) where the weights are allowed to be any non-negative real number which sum to the value of one.

Given the set of feasible input-output combinations constructed, the DEA score for a business under an input-oriented model is a measure of how much, for a given set of outputs, the inputs used by the business could be proportionally scaled down while still remaining within a space of feasible input-output combinations. Alternatively, the output-oriented approach asks how much the output of the business could be scaled up, holding the inputs constant, while still remaining within the space of feasible input-output combinations.

*DEA models can be input and output oriented, and within this framework, one can take either a Constant Return to Scale (CRS) or a Variable Return to Scale (VRS).*

Consider 3 power plants  $G, H$  and  $R$  of output of 1 MW of output from each of them. The capital cost of  $G$  is 16 crores,  $H$  is 8 crores and  $R$  is 28 crores. The labor input of  $G$  is 400,  $H$  is 600 and  $R$  is 1400. The graphical representation is as follows:

**Since  $H$  is the lowest output point among the three firms, so a perpendicular is drawn from the point  $H$  which intersect  $OR$ .**



**Figure 2: Efficiency calculation**

**GH is the EFFICIENT FRONTIER LINE which is defined as** different combinations of input produce different levels of return. The **efficient frontier** represents the best of these input combinations -- those that produce the maximum expected return for a given level of risk.

From the above graph we can obtain the following efficiencies of a plant with respect to others:-

**Technical efficiency** of firm R relative to efficient frontier is given by

$$\eta_T = \frac{OJ}{OR}$$

$$\text{Now, } OJ = \sqrt{11^2 + 5^2} = \sqrt{121 + 25} = \sqrt{146} = 12.07$$

$$OR = \sqrt{28^2 + 14^2} = \sqrt{784 + 196} = \sqrt{980} = 31.3$$

$$\text{Therefore, technical efficiency} = \frac{OJ}{OR} = \frac{12.07}{31.3} = 38.56 \%$$

**Table 2: Input-Output Combination**

Total operational cost	Electricity delivered
Duration of energy interruptions	Number of consumers
Losses	Length of lines

### Advantages:

- It is a non-parametric approach, i.e., there is no need to specify a functional form.
- It is possible to use physical rather than financial input and output measures in DEA.
- Reduced data requirements make the analysis easier.

### Disadvantages:

- DEA neglects the possibility of errors in the measurement of the output and input variables. As a result, the DEA measure is sensitive to the presence of outliers or errors in the measurement of the data.
- DEA does not easily control for differences in business conditions.
- A related disadvantage is that it is not possible to know what sample size is required to obtain a reasonable estimate of relative efficiencies.

### Other countries where the DEA Method has been adopted:

S.No.	Country / State	Electricity distribution businesses	Return to scale assumption
1	NSW (Australia) – Electricity distribution – 1995 – 1998	Electricity distribution businesses in NSW	VRS, CRS
2	Texas (United States – US) – Electricity distribution – 1983	Electricity distribution (1983)	CRS

## Econometric Method

As its name suggests ***Econometric approach to benchmarking that allows for the role of environmental factors affecting production and cost.***

A central task of any utility regulator is the determination of a level of revenue which is sufficient for a business, operating under a given incentive framework and operating environment, to cover the costs of delivering a given set of outputs. In order to carry out this task, the regulator must form a view about the cost structure underlying the industry. This assessment may be captured by the use of a 'cost function', which shows the output-cost relationship for a cost-minimizing business. That is, by modeling the technology in place, the output quantities, the input prices, and the operating conditions in which the business operates, a minimum-cost function yields the periodic costs incurred by an efficient business to deliver those services in that environment.

Therefore, the econometric modeling of the cost function requires information on: **the cost incurred the range of services that the businesses produce (in quantity), the prices for inputs, and the operating environmental conditions.**

The econometric approach to benchmarking estimates a common benchmark cost function for a set of businesses.

Given a vector of outputs  $Y = (y_1, y_2, y_3, \dots, y_N)$ , a vector of input prices  $w = (w_1, w_2, w_3, \dots, w_N)$  and a vector of environmental variables  $z = (z_1, z_2, z_3, \dots, z_N)$ , a benchmark cost function reflects the annualized costs of an efficient business at a given point in time as a function of  $y$ ,  $w$ , and  $z$ :

$$\hat{C}(y, w, z)$$

This approach suggests that the difference between the actual cost incurred by a business and the corresponding cost given by the benchmark cost function is management-controllable inefficiency. By assuming a multiplicative inefficiency term, the cost inefficiency of the business is:

$$e = C / \hat{C}(y, w, z)$$

Where  $C$  denotes the actual cost and represents the level of inefficiency.

The Cobb - Douglas functional form has been chosen as the cost function as given below:

$$Y = A K^\alpha L^\beta$$

Taking logarithm of both sides we get the following equation:

$$\ln Y = a + \alpha \ln K + \beta \ln L$$

The following five steps are required for the 'benchmark cost function' approach:

### (1) The selection of variables which reflect:

Outputs produced by the businesses;

Input prices paid by those businesses; and  
Environmental conditions that affect the production costs.

Collectively, these variables capture all factors that systematically affect the costs of the businesses and that are beyond management control.

**(2) The selection of the type of cost function (the ‘functional form’);**

**(3) The selection of an estimation method that sets out a way to estimate the specified cost function that best fits the available data;**

**(4) The compilation of data in relation to costs, outputs, prices, and environmental variables for a set of comparable businesses; and**

**(5) The estimation process and the interpretation of the residual the difference between the estimated and actual costs for each business as a measure of the inefficiency of that business.**

This approach has been criticized as one cannot automatically conclude that the entire residual or residual difference is due to relative cost inefficiency. Therefore, in regulatory applications of conventional econometric approach to benchmarking, the regulator is confronted with the challenge to ensure that the model specifications are correct and the cost data are of high quality and relatively free of non-systematic impacts.

### **Data Requirements:**

As noted earlier, the estimation of a benchmark cost function requires information in relation to the cost, the volume of outputs, the input prices, and the environmental factors which affect the production cost of individual businesses. The data may cover a number of businesses at a particular time point (cross-sectional data), a business or an industry over a number of time periods (time-series data), or a number of businesses over a number of time periods (panel data).

A key issue in econometrically estimating a benchmark cost function is the selection of the explanatory variables. That is, the selection of the input, output, and environmental variables. These variables, as a group, are factors that systematically affect the benchmark costs of the sampled businesses and the subject industry.

It is noted that the set of explanatory variables required to account for the differences in the cost performance of firms may differ from sample to sample. Any environmental conditions common to all of the sampled businesses can be omitted from the analysis as their cost impact can be captured in the intercept term. For example, this might apply to costs associated with: labour undertaking national service obligations; nationally prevailing weather conditions; or the prices of inputs with low transportation costs which are procured in a national or international market. Conversely, the greater the heterogeneity in the conditions faced by the businesses in the sample the larger the number of explanatory variables it may be necessary to include.

### **Advantages:**

- The conventional econometric approach to benchmarking reveals information about the average industry cost structures, but measuring cost inefficiency relative to businesses operating on or close to a deterministic frontier.

- The econometric approach to benchmarking also allows for the role of environmental factors affecting production and cost. To the extent that relevant exogenous factors are explicitly modeled, the estimated residual is net of the factors that are out of management control but affecting costs and thus attributable to management controlled inefficiencies.

### Disadvantages:

- A potential shortcoming of the conventional econometric method is that there is no explicit separation of statistical noises from the true 'inefficiencies'. Rather than statistically decomposing between random error and inefficiency like SFA, the conventional approach may require a judgment call for the scope of true inefficiency relative to the measured residual.
- Compared to the non-parametric DEA approach, the econometric approach to benchmarking requires additional assumptions. For example, the econometric approach assumes that the functional form of the cost function used in the analysis is capable of modeling the cost structure of the sampled businesses.

### Other countries where the Econometric Method has been adopted:

S.No.	Country / State	Electricity distribution businesses	Estimation Method
1	Switzerland – Electricity distribution – 1988-1996	Electricity distribution businesses	COLS
2	UK – Electricity distribution	Electricity distribution	COLS

### Stochastic Frontier Analysis (SFA) Method

Stochastic Frontier Analysis (SFA) is an extended econometric method that can be used in cost benchmarking analysis. SFA enables the estimation of a cost frontier, from which actual costs incurred by businesses can be compared. SFA is similar to other econometric cost models in that it specifies a functional form that relates costs to outputs, input prices, and environmental factors. However, it differs from traditional econometric approaches in two main ways. First, SFA focuses on estimating the cost frontier representing the minimum costs rather than estimating the cost function representing the 'average' business. Second, SFA aims to separate the presence of random statistical noise from the estimation of inefficiency.

SFA has been applied by a limited number of energy regulators. Germany and Finland have applied the SFA method to assess the relative cost efficiency of energy businesses and Sweden has applied SFA to assess industry-wide productivity changes over time.

The production costs can be represented by:

$$\ln C_i = \ln^{\wedge} C(y_i, w_i, z_i) = \ln f(y_i, w_i, z_i; \alpha) + u_i$$

for some choice of the parameters. The dependent variable, C, is the costs of business i and  $u = \ln(e) > 0$  represents the inefficiency term, assuming that the variables in the model fully

capture the cost differences between businesses. The vector of independent variables,  $y_i$ ,  $w_i$  and  $z_i$  represent output quantities, input prices and business conditions respectively. These are the cost drivers of business  $i$ .

When statistical noise is included explicitly under SFA, the model becomes:

$$\ln C_i = \ln \hat{C}(y_i, w_i, z_i) = \ln f(y_i, w_i, z_i; \alpha) + v_i + u_i$$

This approach suggests that the differences between the observed costs and the estimated efficient costs for a business are captured by the sum of the two separate terms,  $v_i + u_i$ .

The term  $v_i$  captures the effect of random factors such as unusual weather conditions and unexpected variations in labour or machinery performance. This term is assumed to be symmetric and normally distributed with mean zero and variance  $\sigma^2$ .

The SFA method requires a number of assumptions regarding the:

- **Functional form of the cost function;**
- **Distribution of each of the error terms; and**
- **Independence between the error terms and variables in the model.**

***\*SFA cost functions are commonly estimated using Cobb-Douglas or translog functional forms.***

The SFA approach also requires the following independence assumptions. First, the terms  $v_i$  and  $u_i$  are independent of each other. Second, each of the terms is independent of the explanatory variables. Violation of these independence assumptions may lead to biased results. This is because, in the case where  $u_i$  is correlated with  $w_i$ , the inefficiency error term will be affected by variation in the cost drivers. However, where  $u_i$  is correlated with  $v_i$ , it will be affected by statistical noise. The possible correlation of  $u_i$  with environmental factors may lead to the environmental factors ( $z_i$ ) being excluded from the estimation of the cost function and instead included as explanatory variables when estimating the mean of the one-sided inefficiency term,  $u_i$ .

Finally, as with other econometric methods, if some cost drivers, or business-specific heterogeneity, are not taken into account in the model specification, then this can create bias in the inefficiency estimates.

### **Data Requirements:**

Estimation of an SFA cost model requires the following information at the business level:

- **Costs, such as opex, capex or both;**
- **Quantities of each output produced;**
- **Input prices; and**
- **Factors that capture the operating environments that may affect costs.**

Estimation of the SFA cost model is more computationally demanding than the equivalent specification under the conventional econometric method. This is because of the estimation of the two separate error terms in the SFA model. This requires additional data compared to the econometric approach.

The SFA model can be estimated using either cross-sectional or panel data. As discussed previously, cross-sectional data are data for many businesses collected at the same point in time. Panel data are also data for many businesses collected for multiple time periods. Compared with cross-sectional data, models using panel data are preferred as they are more likely to distinguish random statistical noise from systematic differences in businesses' costs because of managerial inefficiency.

**Advantages:**

- The statistical significance and magnitude of each cost driver variable within the model may be assessed. Further, the error terms may be examined to determine the appropriateness of assumptions made in relation to the error terms. This is not possible with non-parametric models such as DEA or PPI;
- The results distinguish random statistical noise from management controllable inefficiencies. That is, some of the variation from the estimated cost frontier will be due to random statistical noise which is beyond the control of the business and therefore is excluded from the measure of inefficiency. This is not possible with either OLS or DEA; and
- Using panel data, it smoothest out differences between businesses that are occurring at one point in time but may not impact on dynamic differences between the businesses over a longer term.

**Disadvantages:**

- High information requirements for all the costs, input prices and environmental factors that may affect the business. The omission of key costs drivers in the model may lead to biased results. This information requirement is comparable to other econometric models but greater than the DEA or PPI approaches;
- A large number of data point is required to facilitate the decomposition of the unexplained cost variation into random and efficiency-related components;
- A specific functional form of the cost function must be selected. Misspecification may lead to biased results;
- The assumption that  $u_i$  is independent of  $w_i$  or  $v_i$  If this assumption is not true, the results are likely to be biased;
- Outliers in the data may affect the estimation of the curvature of the cost frontier. In this case, estimates are likely to be biased, particularly where the sample size is small.

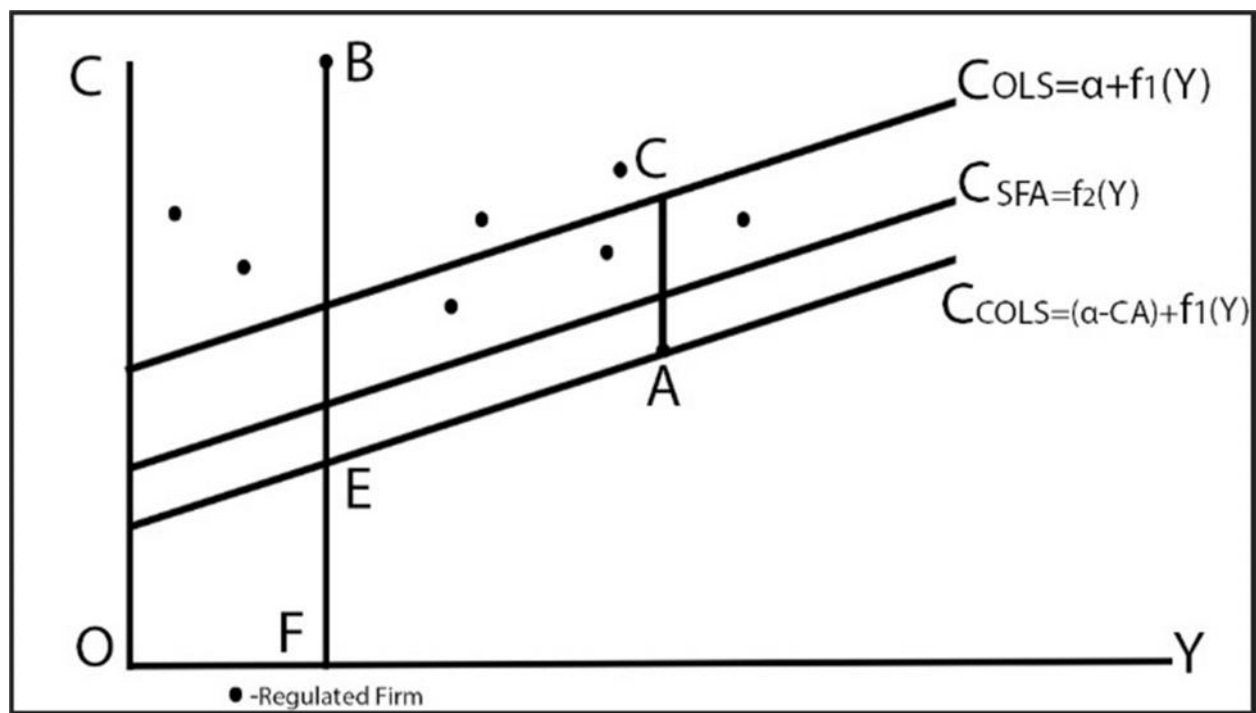
**Other countries where the SFA Method has been adopted:**

S.No.	Country / State	Electricity distribution businesses	Estimation Method
1	12 US and 9 Japan electricity utilities 1982 to 1997	Electricity distribution businesses	MLE
2	12 electricity distribution businesses in England and Wales 1980-81 to 1992-93	Electricity distribution businesses	MLE

## Corrected Ordinary Least Square (COLS) Method

An alternative frontier method to measure relative efficiency of firms is to use statistical methods to 'estimate' the best practice frontier and efficiency scores. COLS is one such method based on regression analysis. Similar to DEA, the method estimates the efficiency scores of firms on a 0 to 1 scale. The regression equation is estimated using the OLS technique and then shifted to the efficient frontier by adding the absolute value of the largest negative estimated error from that of the other errors.

Figure 2 illustrate a COLS model with one cost input  $C$  and one output  $Y$ . The cost equation  $C_{OLS} = \alpha + f_1(Y)$  is estimated using OLS regression and then shifted by  $CA$  to  $C_{COLS} = (\alpha - CA) + f_1(Y)$  on which the most efficient firm  $A$  lies. The efficiency score for an inefficient firm such as  $B$  is then calculated as  $EF/BF$ .



**Figure 3: Graphical Presentation of COLS Method**

**Other countries where the COLS Method has been adopted:**

S.No.	Country / State	Electricity distribution businesses	Estimation Method
1	Switzerland – Electricity distribution – 1988-1996	Electricity distribution businesses	COLS
2	UK – Electricity distribution	Electricity distribution businesses	COLS



## 3. Chapter 3: National & International transmission utilities overview

### 3.1 The Regional Context

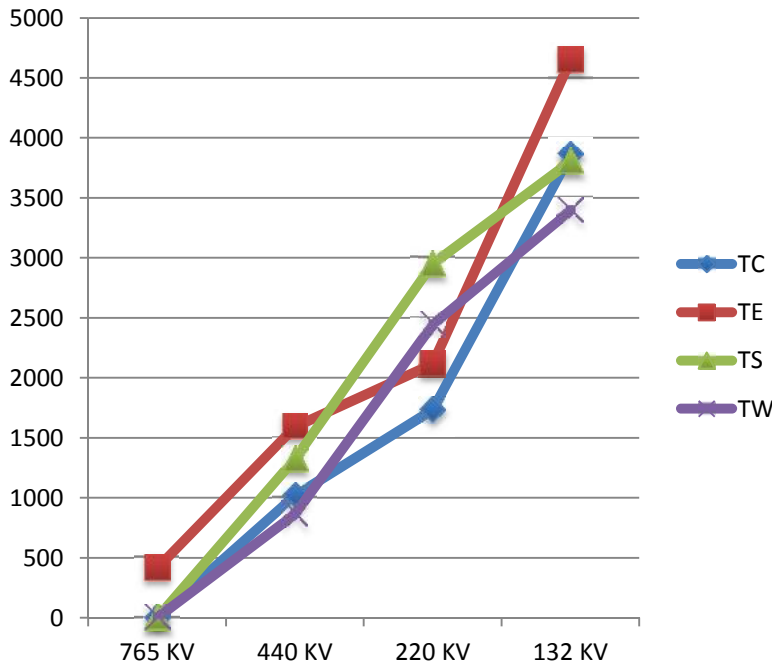


In conducting the benchmarking study of Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) business, UPPTCL focuses on **benchmark the capex, opex and operational performance of UPPTCL's Transmission Business with seven comparable State Transmission Utilities having similar transmission network configuration and geographical area and one comparable international transmission utility** to undertake planning and coordination of activities of the power system and the works connected with among other Generation, Transmission, Distribution electricity requirements in the state of Uttar Pradesh and ensure quality of electricity supply, which constitutes an essential tool in the overall supervision of well-functioning energy markets. The seven Indian State Transmission Utilities and one international Transmission Utility approved by the UPERC are as follows:

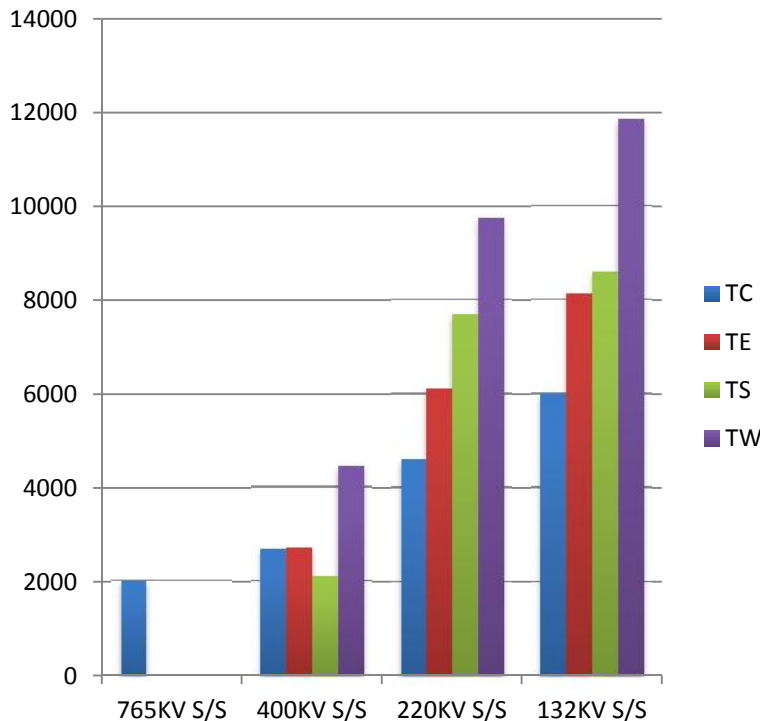
1. Uttarakhand
2. Bihar
3. Madhya Pradesh
4. Maharashtra
5. Rajasthan
6. Karnataka
7. Andhra Pradesh
8. National Grid (UK – International Utility)

However, due to the recent bifurcation of the state of Andhra Pradesh the required information from the STU of Andhra Pradesh was not readily available. Hence, instead of Andhra Pradesh the state of Gujarat has been considered for carrying out the benchmarking study.

Further, instead of National Grid, UK Australia Transmission utilities have been considered for the benchmarking study instead of National Grid, UK as the data required for this study was easily available from these utilities.



**Figure 4: Total Transmission Length handled by the UPPTCL**



**Figure 5: Total MVA capacity installed by the UPPTCL**

## UPPTCL AT A GLANCE

Uttar Pradesh Power Transmission Corporation Limited (UPPTCL), a Transmission Company (TRANSCO), was incorporated under the Companies Act, 1956 by an amendment in the 'Object and Name' clause of the Uttar Pradesh Vidyut Vyapar Nigam Limited. Further, Government of Uttar Pradesh (GoUP), in exercise of power under the Section 30 of the EA 2003, vide notification No. 122/U.N.N.P/24-07 dated 18th July, 2007 notified Uttar Pradesh Power Transmission Corporation Limited as the "State Transmission Utility" of Uttar Pradesh & was entrusted with the responsibilities of planning and development of an efficient and economic intra-State transmission system, providing connectivity and allowing open access for use of the intra-State transmission system in coordination, among others, licensees and generating companies. In doing so, it is guided by the provisions of the UP Electricity Grid Code, 2007, UPERC (Terms and Conditions for Open Access) Regulations, 2004, and UPERC (Grant of Connectivity to intra-State Transmission System) Regulations, 2010 as amended from time to time. Basic details of UPPTCL as on date are as follows:

**Total Transmission Line: 35275 Km**

**Total MVA: 78126 MVA**

**Transmission Losses: 3.67%**

**Numbers of bays: 3304 Numbers**

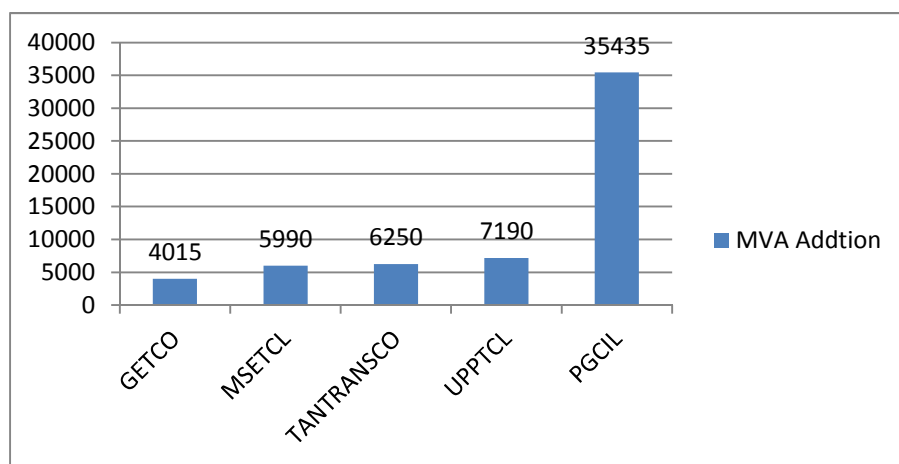
**System Availability: 99.75%**

## Top 5 Performers in Indian Transmission Sector (FY 2016-17) (As per Tarang Newsletter):

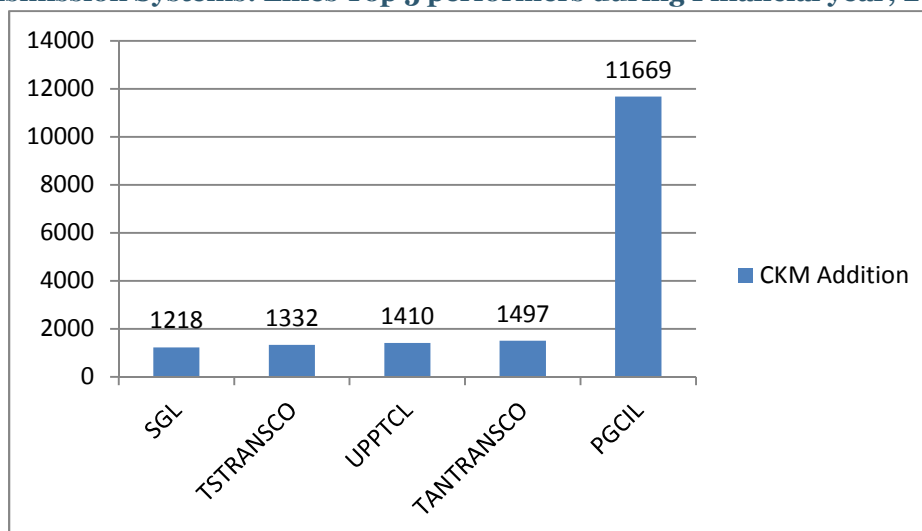
Power Grid Corporation of India Limited (PGCIL) emerged as top performer in the category of Substations and Transmission Lines with commissioning of 35,435 MVA transformation capacity and line length of 11,669 CKM during the Financial Year 2016-17.

U.P. Power Transmission Corporation Limited (UPPTCL) and Tamil Nadu Transmission Corporation Limited (TANTRANSCO) for emerged as top performers amongst States by commissioning of 7,190 MVA transformation capacity and 1,497 CKM Transmission Lines respectively in the category of Intra-State Transmission Systems during the Financial Year 2016-17.

### Transmission Systems: Substations Top 5 performers during Financial year, 2016-17



### Transmission Systems: Lines Top 5 performers during Financial year, 2016-17



### 3.2 The Participating State Transmission Utilities (STUs)

## Maharashtra State Electricity Transmission Company limited,



MSETCL, a wholly owned corporate entity under the Maharashtra Government, was incorporated under the Companies Act, in June, 2005 after restructuring the erstwhile Maharashtra State Electricity Board to transmit electricity from its point of Generation to its point of Distribution.

It owns and operates most of Maharashtra's Electric Power Transmission System. MSETCL operates a transmission network of 43730 Circuit KM of transmission lines and 633 EHV Substations with 110814MVA transformation capacity. This infrastructure constitutes most of the inter regional as well as intra regional electric power transmission system in the State. Today, MSETCL is the largest state transmission utility in the country.

The company also has the distinction of being the only power utility in the state sector to own HVDC lines. The Company operates a 752 km long, 1500 MW, 500 KV bi-polar HVDC line from Chandrapur to Padghe. This has been marked as a major success as electric power is generated in east Maharashtra, due to easy availability of coal, whereas the bulk use of power is in the western part of Maharashtra in and around cities such as Mumbai, Pune and Nashik. The power losses are very low in the HVDC line.

### Key Highlight of MSETCL

**MSETCL, The largest electric power transmission utility in state sector in India.**

**Total Transmission Line: 43730 CKms**

**MVA: 110814 MVA**

**Transmission Losses: 3.89%**

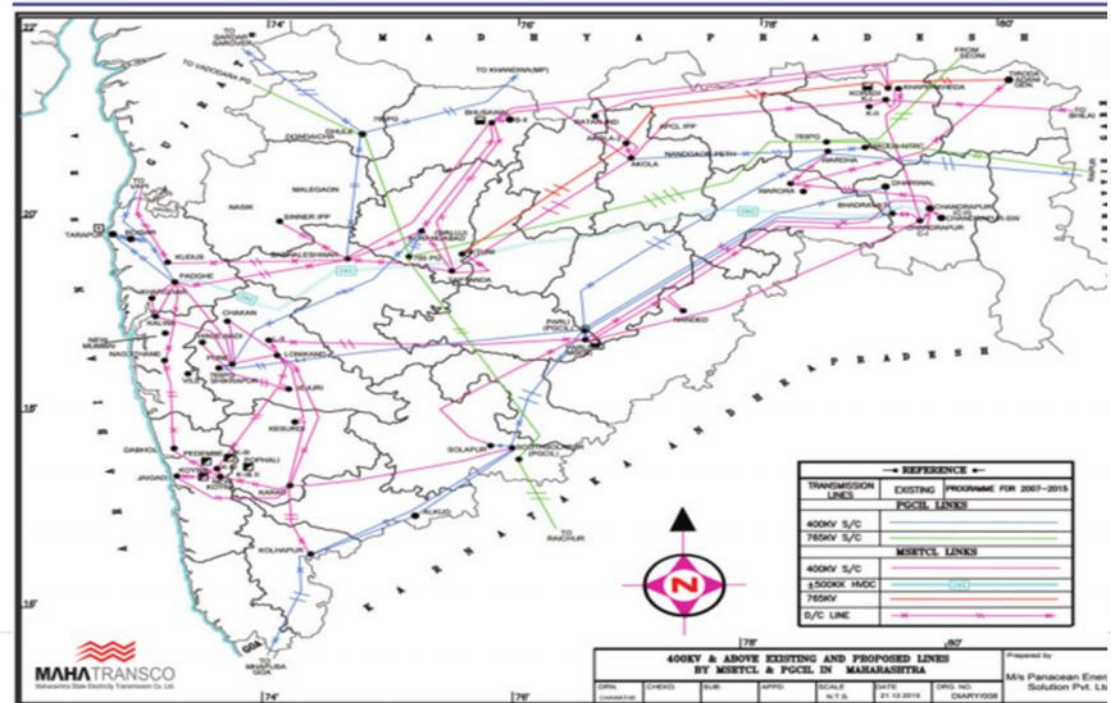
**Numbers of EHV Substations: 633 Numbers**

**Transmission System Capability: 21000MW**

**System Availability: 99.72%**

**Energy Handled: 136215MU**

**Numbers of Employees: 16859**



**Table 3: Achievement of MP during the last fifteen numbers**

## **M.P. Power Transmission Company Limited**

M.P. Power Transmission Company was incorporated on 22nd November, 2001 and it formally began its operations under an Operation & Management Agreement executed with MPSEB on 1st July, 2002, which provided for undertaking all activities relating to intra-state transmission of electricity for and on behalf of MPSEB. Further, in exercise of the powers conferred by sub-section (1) of Section 39 of Electricity Act, 2003, GoMP has nominated this Company as the State Transmission Utility w.e.f. 01.06.2004.

S.N.	Financial-Year	No. of Substation at the end of F.Y.	Total MVA Capacity at the end of F.Y.	No. of Power Transformers at the end of F.Y.	Transmission line Ckt KM at the end of F.Y.	Transmission Loss (%)	Transmission Capacity (MW)	Transmission System Availability (%)	Maximum Demand met during the year (MW)
1	2002-03	146	17115	356	17623	7.93	3890		4652/04.11.2002
2	2003-04	162	19469	388	18048	6.12	4500		4984/18.01.2004
3	2004-05	177	21813	420	19311	5.62	5000		5241/12.11.2004
4	2005-06	185	23175	433	19872	5.23	5563	98.41	5780/01.11.2005
5	2006-07	199	24871	470	20949	5	6011	98.96	6109/21.12.2006
6	2007-08	205	26015	491	21667	4.09	7220	99.02	6501/09.11.2007
7	2008-09	216	29078	521	22964	4.09	7483	98.16	7019/27.11.2008
8	2009-10	228	32040	557	24622	4.19	8200	98.82	6215/21.01.2010
9	2010-11	242	34232	588	26469	3.74	8546	99.13	8331/28.02.2011
10	2011-12	248	35564	607	27119	3.51	8809	99.23	8546/03.03.2012
11	2012-13	256	37750	624	27825	3.3	10600	99.44	9484 /12.11.2012
12	2013-14	275	41163	669	29009.77	3	12317	99.43	9758/14.12.2013
13	2014-15	292	45457	711	30194.99	2.82	12600	99.35	9832 / 09.12.2014 at 09.00 Hrs.
14	2015-16	314	49349	760	31364.08	2.88	14100	98.16	10841/25.12.2015
15	2016-17 (upto 31.01.2017)	328	53076	806	32212.66	-	-	-	11421/dtd.23.12.2016

### **Transmission Losses**

**The Transmission loss level in the company has been brought down to the level of 2.88% in the year 2015-16, which is significantly lower than erstwhile loss level of 7.93% as prevailing at the time of company's inception in the year 2001-02. Similarly, the Transmission capacity has been brought up to the level of 12600 MW during 2015-16 from the level of 3980 MW in the year of company's inceptions. These parameters indicate the volume of Transmission System strengthening & expansion program under taken in the part 13-14 years.**

# Rajasthan Rajya Vidyut Prasar an Nigam Limit (RVPN)



Under the provision of the Electricity Act, 2003, RVPN has been declared as State Transmission Utility (STU) by Govt. of Rajasthan w.e.f 10.06.2003. Section 39(1) of this act, prohibits the STU to undertake business of trading of electricity, however RVPN continued its function of transmission of bulk power from generating stations to inter-phase point of Discoms from 1st April 2004. Now the Distribution Companies are directly contracting with Generating Companies in accordance to the share allocated by the State Government. RVPN has been discharging wheeling of power and transmission of electricity only.

RVPN Provides the pathway for power within whole of Rajasthan. RVPN owns, builds, maintains and operates the high-voltage electric transmission system that helps to keep the lights on, businesses running and communities strong. RVPN also owns the shared generating projects as representative of erstwhile RSEB.

**Table 4: RVPN System at a Glance**

S.No.	Particulars	As on 31-DEC-2016 (Prov.)
<b>1</b>	<b>Installed Generating Capacity (in MW)</b>	
1.1	Owned(RVUN)	5957.35
1.2	Private Sector	3356.00
1.3	Partnership project	853.44
1.4	Central Sector	2811.04
1.5	Non-Conventional Energy Source(NCES)	4916.35
	<b>Total</b>	<b>17894.18</b>
2	Peak Demand in MW (2015-16)	10961
3	Total Energy Available (LU) (2015-16)	755677.479
<b>4</b>	<b>No. of EHV GSS</b>	<b>As on 31-JAN-2017 (Prov.)</b>
4.1	765 kV	2
4.2	400 kV	11
4.3	220 kV	115
4.4	132 kV	402
	<b>Total</b>	<b>530</b>
5	765 kV Lines (Ckt.Kms.)	425.5
6	400 kV Lines (Ckt.Kms.)	3937.33
7	220 kV Lines (Ckt.Kms.)	14225.43
8	132 kV Lines (Ckt.Kms.)	16512.39

# Power Transmission Corporation of Uttarakhand Ltd.

As per the provisions of Electricity Act, 2003, the State Government separated power transmission business from UPCL which was left only with distribution of electricity. A new company by the name & style of Power Transmission Corporation of Uttarakhand Ltd. was created to handle power transmission business and registered as a Government Company under Section 617 of Companies Act, 1956 on 27th May, 2004. It started functioning w.e.f. 1st June, 2004

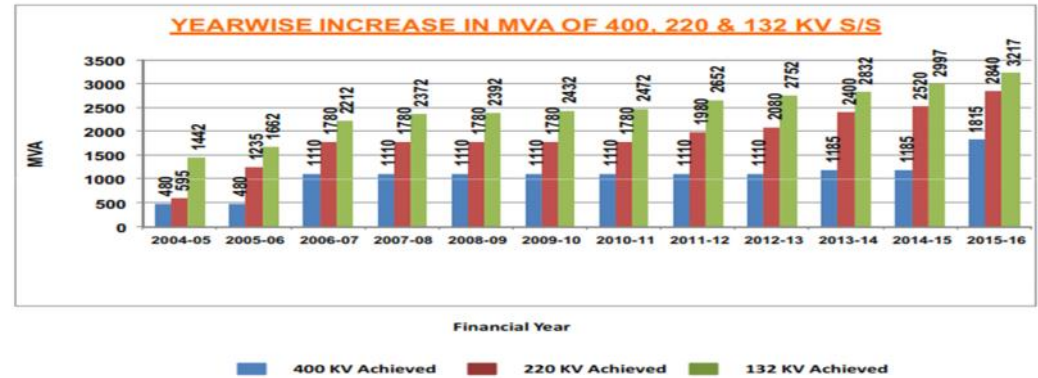


Figure 7: Year wise increase in MVA capacity of Uttarakhand

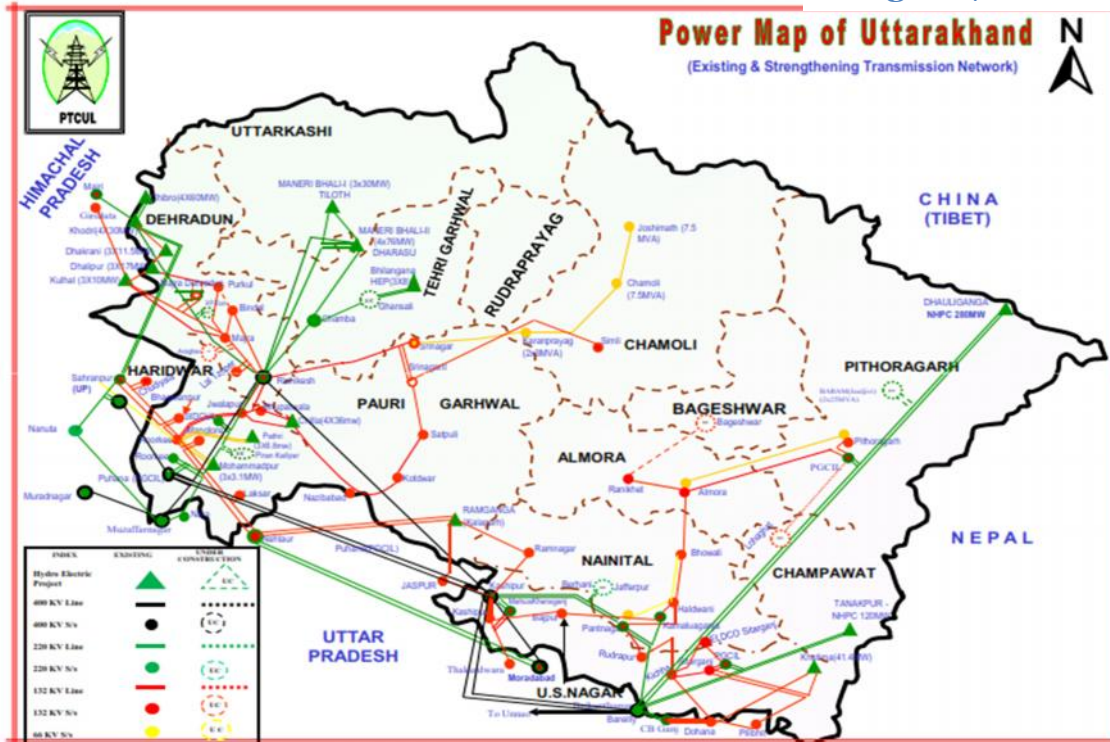


Figure 8: Power Map of Uttarakhand

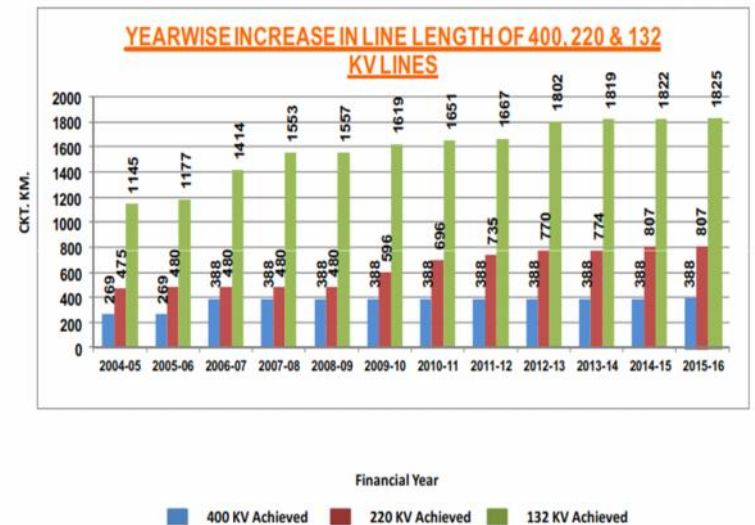


Figure 9: Year wise increase in Line Length capacity of Uttarakhand

## Bihar State Power Transmission Company Limited

Bihar State Power Transmission Company Limited, a wholly Owned corporate entity under Bihar Government was incorporated under the Companies Act. 1956 on 1st Nov. 2012 after restructuring of erstwhile Bihar State Electricity Board.

Presently the company is carrying on intra state transmission and wheeling of electricity under license issued by the Bihar Electricity Regulatory Commission. The company is also discharging the functions of State Load Dispatch Centre from its Head-Quarter, 4th floor, Vidyut Bhawan, Patna.

BSPTCL operates a transmission network of 6182 Kms. of 132 K.V. Lines & 1663 Kms. of 220 K.V. lines & 75 Kms of 400 K.V. Line as well as 97 Nos. of operational EHV sub- stations with 7360 MVA Transformation Capacity.

## Achievement of Bihar

Bihar is a state in the eastern part of India. It is the 13th-largest state of India,

- Nos. of GSS increased from 45 nos. to 95 Nos.
- The total Transformation capacity of BSPTCL has reached 3450 MVA at 220/132 K.V. level from 2950 MVA.
- BSPTCL's capacity to evacuate power has reached 3100 MW from 2600 MW and its mission is to make it to 3500 MW by August 2014 and 4500 MW by Aug. 2015.
- Total transmission line length increased to 7731.902 CKM from 6628.17 C-Km, which includes transmission line at 132 K.V., 220 K.V. and 400 K.V. level individual line length are, 5993.932 CKM, 1662.97 CKM & 75 CKM respectively.

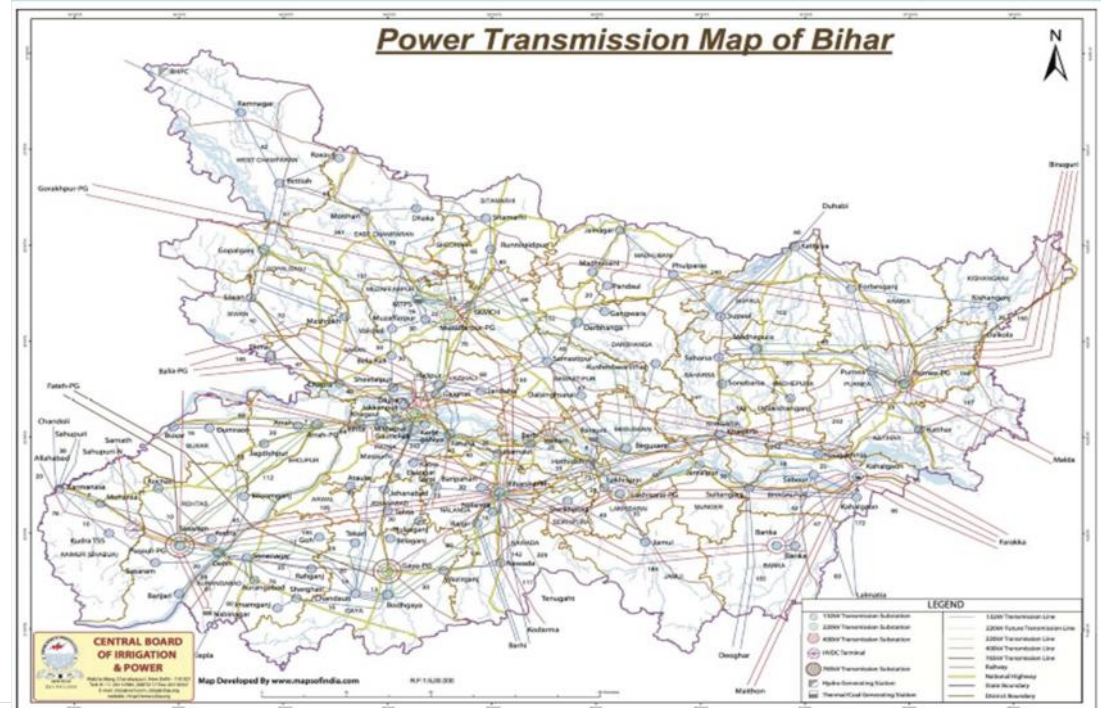


Figure 10: Power Transmission Map of Bihar



# Karnataka Power Transmission Corporation Limited



○ Karnataka Power Transmission Corporation Limited is a registered company under the Companies Act, 1956 was incorporated on 28-7-1999 and is a company wholly owned by the Government of Karnataka with an authorised share capital of Rs. 1455 crores. KPTCL was formed on 1-8-1999 by carving out the Transmission and Distribution functions of the erstwhile Karnataka Electricity Board.

○ Karnataka Power Transmission Corporation Limited is mainly vested with the functions of Transmission of power in the entire State of Karnataka and also Construction of Stations & Transmission Lines and maintenance of 400/220/110/66 KV Sub-Stations. Many new lines and Sub-Stations were added & existing stations were modified in the Transmission network. It operates under a license issued by Karnataka Electricity Regulatory Commission.

○ KPTCL has 4 No. 400 KV Station, 97 No. of 220 KV Station, 385 No. of 110 KV Station and 602 No. of 66 KV Station. The Total Transmission Line in CKMs is 34251 as on 31.03.2016.

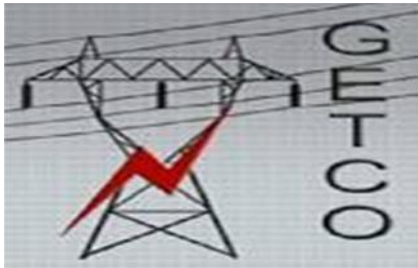
**Table 5: Karnataka Power Sector at a Glance**

Power Sector at a Glance	
Installed Capacity	17893.4 MW
Number of Consumers	2.22 Crs.
Length of Tr. Lines	43176.475 Ckms
Numbers of Stations	1444
Numbers of DTCs	655168
HT Lines in CKMS	298565.83
LT Lines in CKMS	525255.94

**Table 6: Karnataka Voltage Level, No. of Sub-stations & Transmission line details**

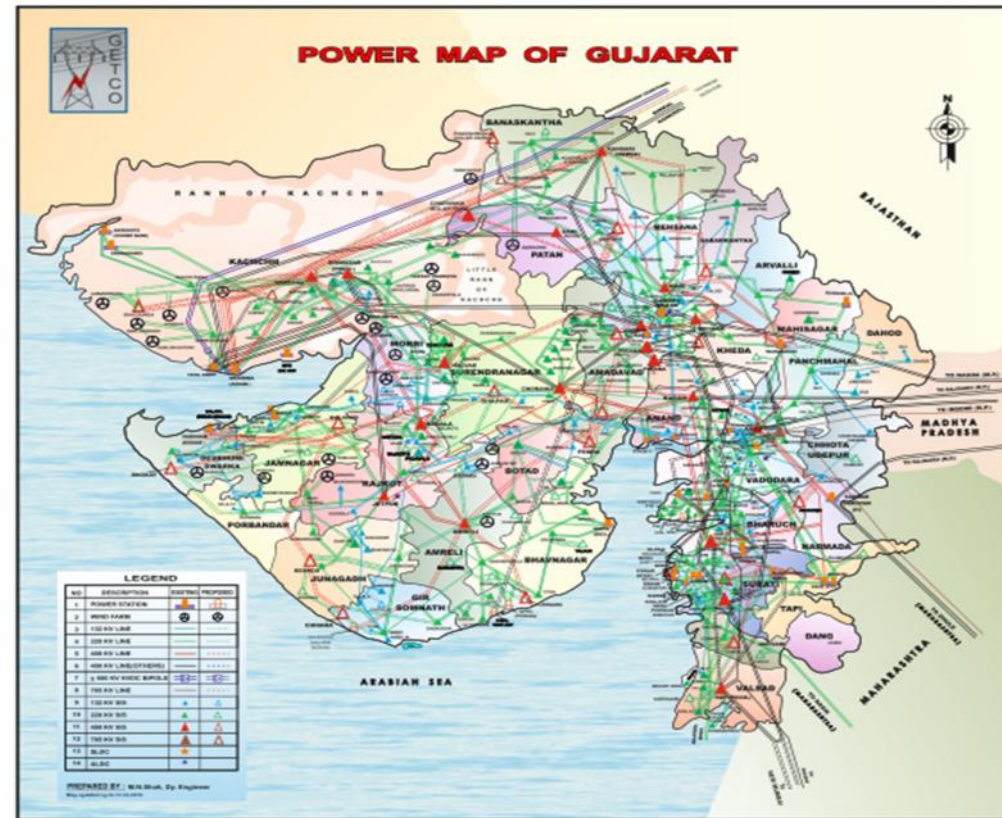
Voltage Level	Number of Stations	Tr. Line in Ckms
400 KV	4	2683.324
220 KV	97	10970.369
110 KV	389	10236.820
66 KV	605	10457.923
33 KV	349	8828.039
<b>Total</b>	<b>1444</b>	<b>43176.475</b>

# Gujarat Energy Transmission Company Limited (GETCO)



Gujarat Energy Transmission Corporation Limited (GETCO) was set up in May 1999 and is registered under the Companies Act, 1956. The Company was promoted by erstwhile Gujarat Electricity Board (GEB) as its wholly owned subsidiary in the context of liberalization and as a part of efforts towards restructuring of the Power Sector.

GETCO derives its revenue by recovery of transmission charges from the transmission system users which includes DISCOMS, IPP / CPP / MPP or open access user. GETCO has entered into an internal arrangement with GUVNL & DISCOMS whereby GUVNL is entrusted with the responsibility of collecting the transmission charges from the distribution companies through the mechanism of the differential Bulk Supply Tariff and pays it forward to GETCO under the Transmission Services Agreement



**Figure 11: Gujarat Transmission Network**

S.No.	Particulars	As on 31-DEC-2016
1	Peak Demand in MW (2015-16)	14982
2	Total Energy Available (LU) (2015-16)	84889.83
3	No. of EHV GSS	
4	Total (Ckt.Kms.)	55465
5	Total Transformer Capacity MVA	91544

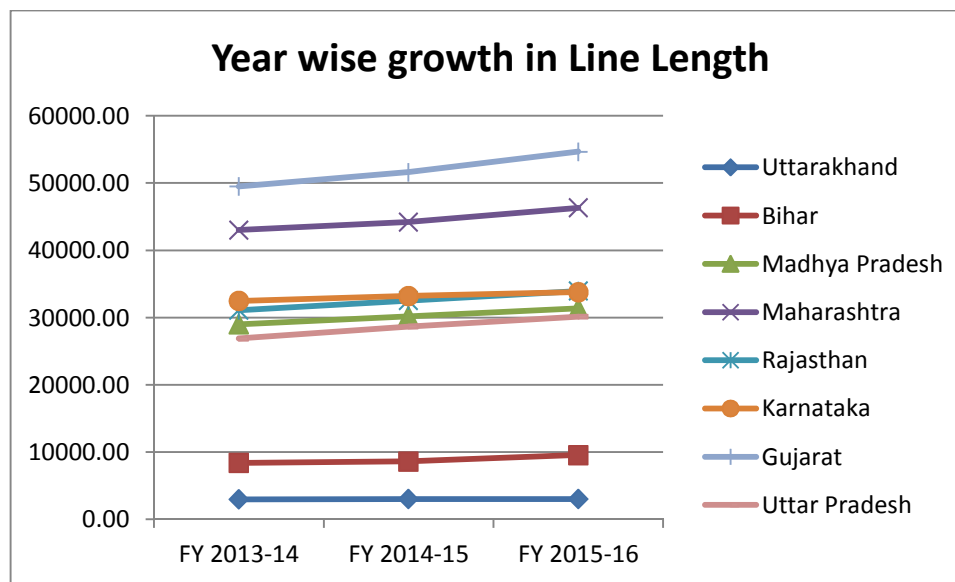
### 3.3 Transmission System Network Details:-

#### A. Line Length

The details of the line length (Ckm) of UPPTCL and STUs of seven states chosen for the benchmarking study is given below:

**Table 8: Line Length (Ckm)**

S.No.	State	FY 2013-14	FY 2014-15	FY 2015-16
1	Uttarakhand	2981.00	3017.00	3020.00
2	Bihar	8394.00	8617.00	9573.90
3	Madhya Pradesh	29009.77	30194.99	31364.08
4	Maharashtra	43019.81	44207.00	46317.00
5	Rajasthan	31092.40	32514.17	33959.92
6	Karnataka	32471.00	33204.00	33794.00
7	Gujarat	50131.56	52531.56	55456.56
8	Uttar Pradesh	26876.00	28678.00	30151.00



**Figure 12: Line Length (Ckm)**

It can be seen that the largest network in terms of line length is in Gujarat followed by Maharashtra. Uttar Pradesh is placed at no. 5.

**Table 9: Voltage wise Line Length (Ckm) (FY 2015-16)**

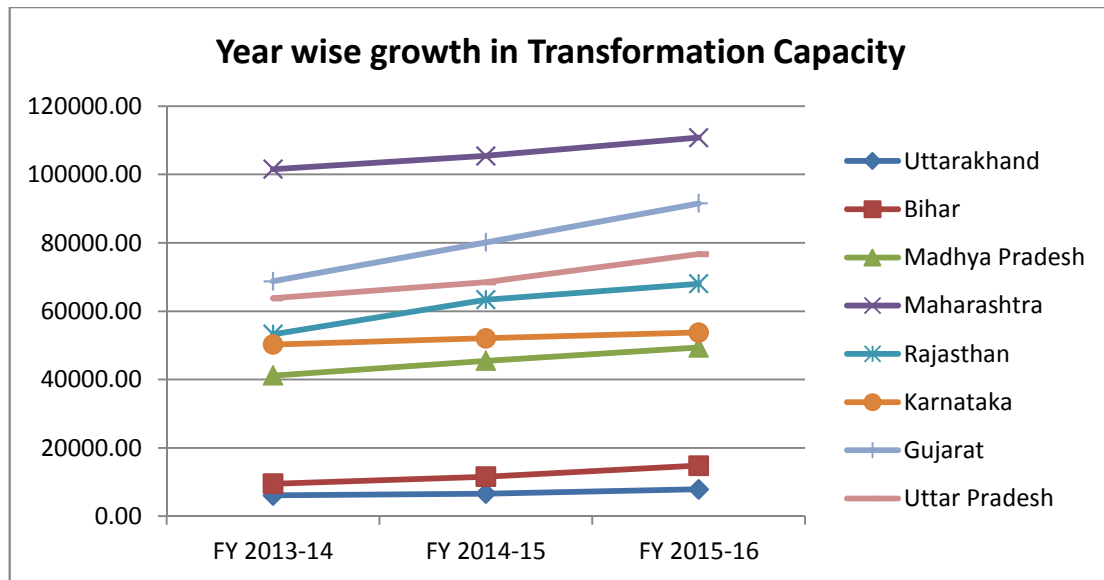
Sl.No.	Particulars	Uttarakhand	Bihar	Madhya Pradesh	Maharashtra	Rajasthan	Karnataka	Gujarat	Uttar Pradesh
	Voltage level	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual
1	765 KV	-	-	-	-	425.50	-	-	413.56
1	700 KV	-	-	-	-	-	-	-	-
2	500 KV	-	-	-	1504.00	-	-	-	-
3	400 KV	388.00	-	3074.45	8225.00	3628.65	2683.00	4300.80	4798.58
4	220 KV	807.00	2125.64	12139.76	16326.00	13724.68	10498.00	17846.73	9238.35
5	132 KV	1825.00	7448.26	16088.87	14554.00	16181.09	-	5332.36	15699.83
6	110 KV	-	-	-	1737.00	-	10171.00	-	-
7	100 KV	-	-	-	701.00	-	-	-	-
8	66 KV	-	-	61.00	3270.00	-	10442.00	27907.67	-
9		-	-	-	-	-	-	69.00	-
	<b>Total</b>	<b>3020.00</b>	<b>9573.90</b>	<b>31364.08</b>	<b>46317.00</b>	<b>33959.92</b>	<b>33794.00</b>	<b>55456.56</b>	<b>30150.32</b>

**B. Transformation Capacity**

The details of the transformation capacity (MVA) of UPPTCL and STUs of seven states chosen for the benchmarking study are given below:

**Table 10: Transformation Capacity (MVA)**

S.No.	State	FY 2013-14	FY 2014-15	FY 2015-16
1	Uttarakhand	6097.00	6582.00	7872.00
2	Bihar	9499.00	11560.00	14779.90
3	Madhya Pradesh	41163.00	45457.00	49349.00
4	Maharashtra	101547.00	105434.00	110815.00
5	Rajasthan	53249.00	63378.50	68036.00
6	Karnataka	50221.85	52081.50	53734.90
7	Gujarat	68730.00	80113.00	91544.00
8	Uttar Pradesh	63791.00	68465.00	76725.00



**Figure 13: Transformation Capacity (MVA)**

It can be seen that the largest transformation capacity is in Maharashtra followed by Gujarat. Uttar Pradesh is placed at no. 3.

**Table 11: Voltage wise Transformation Capacity (MVA) (FY 2015-16)**

Sl.No.	Particulars	Uttarakhand	Bihar	Madhya Pradesh	Maharashtra	Rajasthan	Karnataka	Gujarat	Uttar Pradesh
	Voltage level	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual
1	765 KV	-	-	-	-	6000.00	-	-	2000.00
2	700 KV	-	-	-	1500.00	-	-	-	-
3	500 KV	-	-	-	3582.00	-	-	-	-
4	400 KV	1815.00	-	7350.00	23395.00	8410.00	4575.00	13505.00	11955.00
5	220 KV	2840.00	5750.00	20010.00	49748.00	33046.00	21327.50	28690.00	28190.00
6	132 KV	3217.00	9029.90	21969.00	26779.00	20580.00	-	8275.00	34580.50
7	110 KV	-	-	-	2280.00	-	12396.00	-	-
8	100 KV	-	-	-	2678.00	-	-	-	-
9	66 KV	-	-	20.00	853.00	-	15436.40	41074.00	-
	<b>Total</b>	<b>7872.00</b>	<b>14779.90</b>	<b>49349.00</b>	<b>110815.00</b>	<b>68036.00</b>	<b>53734.90</b>	<b>91544.00</b>	<b>76725.50</b>

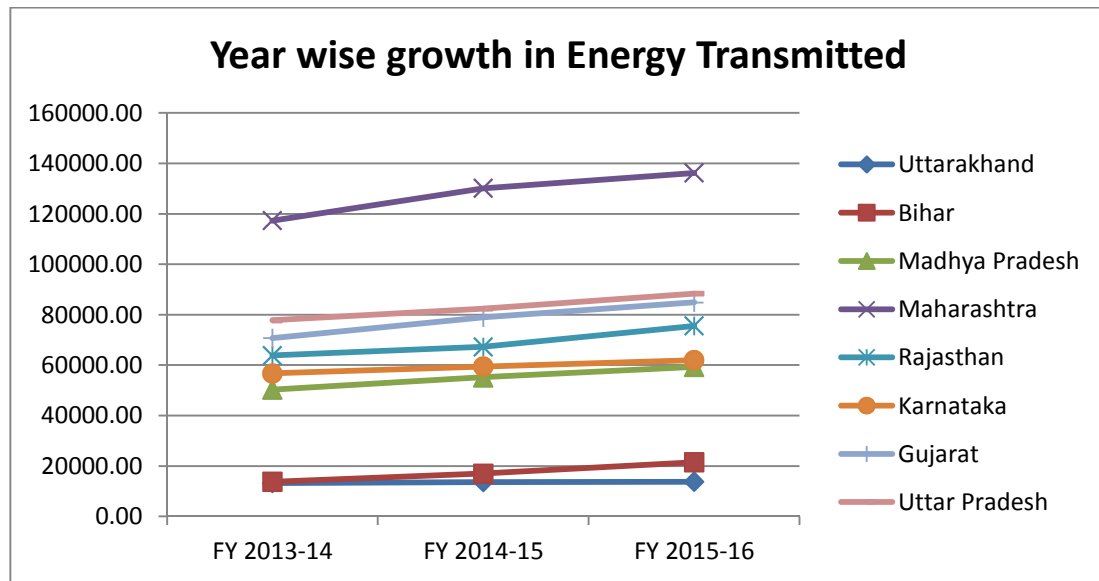
### C. Energy Transmitted

The details of the energy transmitted (MU) of UPPTCL and STUs of seven states chosen for the benchmarking study are given below:

**Table 12: Energy Transmitted (MU)**

S.No.	State	FY 2013-14	FY 2014-15	FY 2015-16
1	Uttarakhand	13227.00	13612.23	13734.00
2	Bihar	13786.16	16986.53	21485.35
3	Madhya Pradesh	50300.00	55206.00	59335.00

S.No.	State	FY 2013-14	FY 2014-15	FY 2015-16
4	Maharashtra	117289.13	130107.38	136215.34
5	Rajasthan	63851.02	67257.92	75567.74
6	Karnataka	56733.00	59420.35	61957.51
7	Gujarat	70712.07	78933.59	84889.83
8	Uttar Pradesh	77760.69	82413.86	88402.14



**Figure 14: Energy Transmitted (MU)**

It can be seen that the maximum energy was transmitted by Maharashtra followed by Uttar Pradesh.

#### D. Peak Demand

The details of the peak demand (MW) of Uttar Pradesh and seven states chosen for the benchmarking study are given below:

**Table 13: Peak Demand (MW)**

S.No.	State	FY 2013-14	FY 2014-15	FY 2015-16
1	Uttarakhand	1826.00	1930.00	2034.00
2	Bihar	2465.00	2994.00	3735.00
3	Madhya Pradesh	9716.00	9755.00	10902.00
4	Maharashtra	19276.00	20147.00	20973.00
5	Rajasthan	10047.00	10642.00	10961.00
6	Karnataka	9940.00	10001.00	10202.00
7	Gujarat	12201.00	13603.00	14495.00
8	Uttar Pradesh	13089.00	15670.00	16988.00

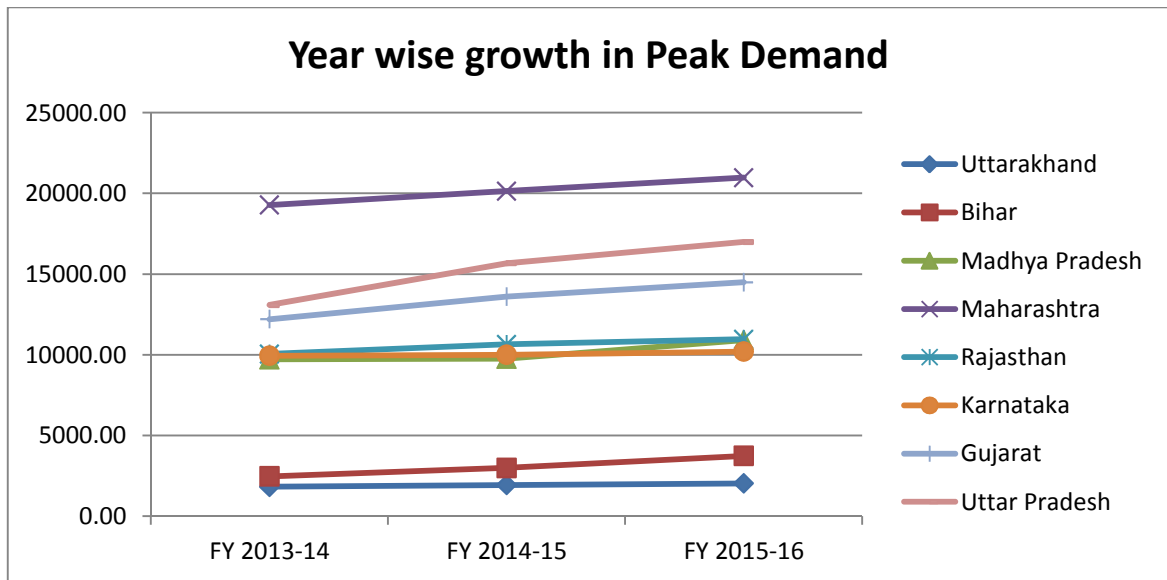


Figure 15: Peak Demand (MW)

It can be seen that the highest peak demand was met by Maharashtra followed by Uttar Pradesh.

## 4. Chapter4: Benchmarking of Financial Parameters

### 4.1 Operation & Maintenance (O&M) Expenses

O&M expenses means the expenditure incurred for the operation & maintenance of the project or part thereof, and includes the expenditure on manpower, repairs, maintenance spares, consumables, insurance and overheads but excludes fuel expenses and water charges.

Operation & Maintenance expenses shall include:

Employee Expenses including Salaries, wages, pension contribution and other employee costs;

Administrative and General expenses which shall also include expense related to raising of loans;

Repairs and Maintenance Expenses;

#### **Employee Cost:**

Employee Cost shall be computed as per the approved norm escalated by consumer price index (CPI) adjusted by provisions for expenses beyond the control of the Licensee and one time expected expenses, such as recovery /adjustment of terminal benefits, implications of pay commission, arrears, interim relief etc. governed by the following formula:

$$EMP_n = (EMP_b * CPI \text{ inflation}) + \text{Provision}$$

Where:

$EMP_n$  = Employee expense for the year n

$EMP_b$  = Employee expense as per the norm CPI inflation: is the average increase in the Consumer Price Index for immediately preceding three financial years.

Provision: Provision for expenses beyond control of the Transmission licensee and expected one-time expenses as specified above.

The Employee Expenses includes various types of allowances like:

Salary and Allowances

Dearness Allowance

Bonus/Ex-gratia

Other Allowances

Pension and Gratuity

Medical Expenses



Leave Travel Assistance  
 Earned Leave Encashment  
 Compensation  
 Contribution to Provident and other Funds  
 Expenditure on Trust  
 Staff Welfare Expenses  
 Common Expenditure (Charged by UPPCL)

### ***R&M Cost:***

Repair and maintenance expense shall be calculated as percentage (as per the norm defined) of Average Gross Fixed Assets for the year governed by the following formula:

$$R\&M_n = K_b * GFA_n$$

Where,

R&M<sub>n</sub>: Repair and Maintenance expense for n<sup>th</sup> year.

GFA<sub>n</sub>: Average Gross Fixed Assets for n<sup>th</sup> year.

K<sub>b</sub>: Percentage Point as per the norm

The R&M Expenses include the repair and maintenance of the following items:

Plant & Machinery  
 Buildings  
 Other Civil works  
 Lines Cables Networks etc.  
 Vehicles-Expenditure  
 Expenditure on Contractual Manpower  
 Furniture & Fixtures  
 Software's  
 Office Equipment

***A&G Expenses:*** It is related to day to day to day operation of the business. General and administrative expenses pertain to operation expenses rather that to expenses that can be directly related to the production of any goods or services, including rent, utilities, insurance and managerial salaries. In the company's income statement, these expenses generally appear under operating

expenses. A&G expenses shall be computed as per norm escalated by Wholesale Price Index (WPI) and adjusted by provisions for confirmed initiatives (IT etc. initiatives as proposed by the Transmission Licensee and validated by the Commission) or other expected one-time expenses and shall be governed by following formula:

$$A\&G_n : (A\&G_b * WPI \text{ Inflation}) + \text{Provision.}$$

Where:

A&G<sub>n</sub>: A&G expense for the year n

A&G<sub>b</sub>: A&G expense as per norm.

WPI inflation: is the average increase in the Wholesale Price Index (WPI) for immediately preceding three years.

Provision: Cost for initiatives or other one-time expenses as proposed by the Transmission Licensee and validated by the Commission.

It includes following items:

Payment to Auditor

Advertisement Expenses

Communication Charges

Consultancy Charges

Electricity Expenses

Entertainment

Expenditure on Trust

Corporate Social Responsibility Expenses

Insurance

Interest on GPF & CPF Balance

Legal Charges

Miscellaneous Expenses

Printing & Stationery

Rates & Taxes

Rent

Technical Fees & Professional Charges

Travelling & Conveyance

Water Charges

Common Expenditure (Charged by UPPCL)

## 4.2 Benchmarking of Employee Expenses

The benchmarking of the employee expenses has been carried out using the Partial Performance Indicator, Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Square Method.

### a. Partial Performance Indicator (PPI)

- **Employee Expense /Ckm**

The employee cost/Ckm of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 14: Employee Expense/Ckt Km for FY 2013-14**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Employee Expense/Ckt Km	Rank
1	Uttarakhand	50.61	2981.00	1.698	5
2	Bihar	86.68	8394.00	1.033	2
3	Madhya Pradesh	287.82	29009.77	0.992	1
4	Maharashtra	819.50	43019.81	1.905	6
5	Rajasthan	1004.25	31092.40	3.230	8
6	Karnataka	711.36	32471.00	2.191	7
7	Gujarat	596.71	50131.56	1.190	3
8	Uttar Pradesh	395.28	26876.00	1.471	4

The employee cost/Ckm of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 15: Employee Expense/ Ckt Km for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Employee Expense/Ckt Km	Rank
1	Uttarakhand	51.85	3017.00	1.719	5

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Employee Expense/Ckt Km	Rank
2	Bihar	93.35	8617.00	1.083	2
3	Madhya Pradesh	312.22	30194.99	1.034	1
4	Maharashtra	848.43	44207.00	1.919	6
5	Rajasthan	945.52	32514.17	2.908	8
6	Karnataka	804.73	33204.00	2.424	7
7	Gujarat	643.98	52531.56	1.226	3
8	Uttar Pradesh	396.88	28678.00	1.384	4

The employee cost/Ckm of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 16: Employee Expense/ Ckt Km for FY 2015-16**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Employee Expense/Ckm	Rank
1	Uttarakhand	57.55	3020.00	1.90555	5
2	Bihar	98.99	9573.90	1.03394	1
3	Madhya Pradesh	326.27	31364.08	1.04027	2
4	Maharashtra	927.76	46317.00	2.00307	6
5	Rajasthan	941.83	33959.92	2.77337	8
6	Karnataka	730.21	33794.00	2.16076	7
7	Gujarat	738.43	55456.56	1.33155	4
8	Uttar Pradesh	398.98	30151.00	1.32326	3

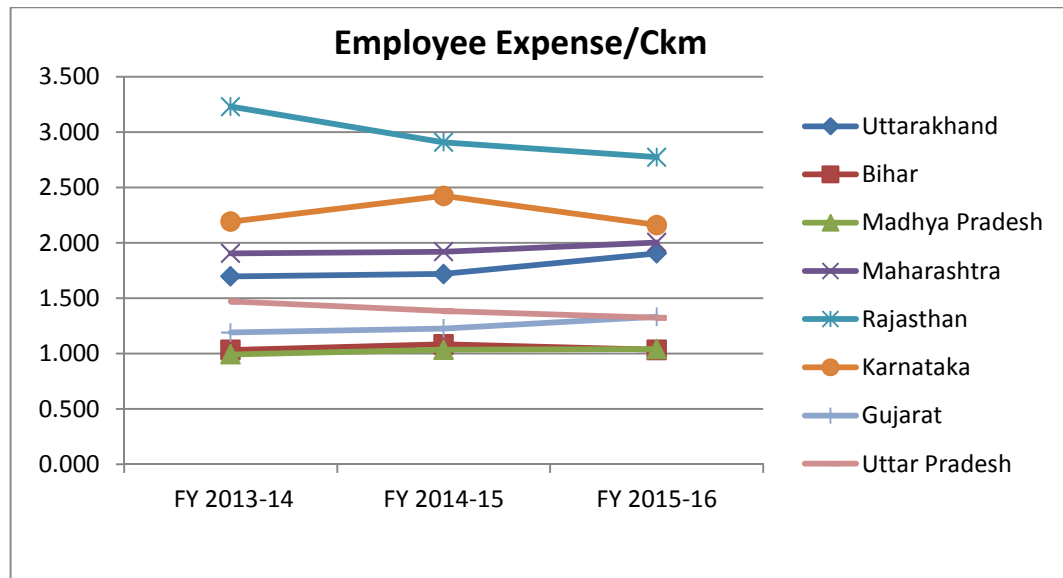


Figure 16: Employee Expense/Ckm

It can be seen that the employee expenses of UPPTCL are on a lower side however, the employee cost of Madhya Pradesh is the lowest and its ranked first during two out of three years.

- **Employee Expense /MVA**

The employee cost/MVA of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

Table 17: Employee Expense/ MVA for FY 2013-14

S.No.	State	Employee Expenses (Rs. Crore)	Transformation Capacity (MVA)	Employee Expense/MVA	Rank
1	Uttarakhand	50.61	6097.00	0.830	4
2	Bihar	86.68	9499.00	0.912	6
3	Madhya Pradesh	287.82	41163.00	0.699	2
4	Maharashtra	819.50	101547.00	0.807	3
5	Rajasthan	1004.25	53249.00	1.886	8
6	Karnataka	711.36	50221.85	1.416	7
7	Gujarat	596.71	68730.00	0.868	5
8	Uttar Pradesh	395.28	63791.00	0.620	1

The employee cost/MVA of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

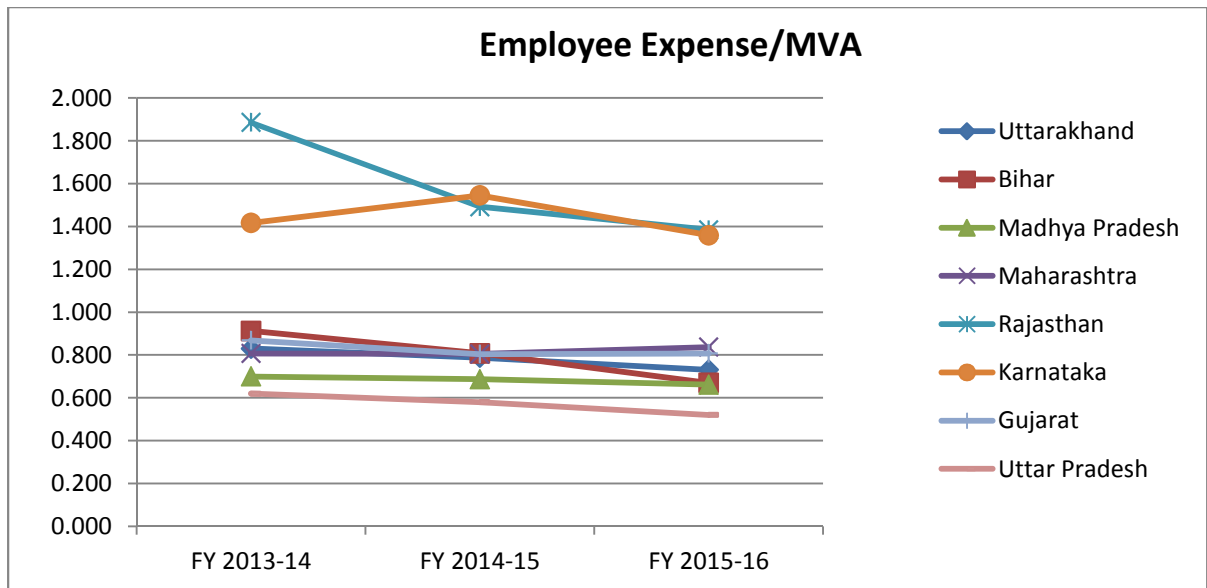
**Table 18: Employee Expense/ MVA for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore)	Transformation Capacity (MVA)	Employee Expense/MVA	Rank
1	Uttarakhand	51.85	6582.00	0.788	3
2	Bihar	93.35	11560.00	0.808	6
3	Madhya Pradesh	312.22	45457.00	0.687	2
4	Maharashtra	848.43	105434.00	0.805	5
5	Rajasthan	945.52	63378.50	1.492	7
6	Karnataka	804.73	52081.50	1.545	8
7	Gujarat	643.98	80113.00	0.804	4
8	Uttar Pradesh	396.88	68465.00	0.580	1

The employee cost/MVA of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 19: Employee Expense/ MVA for FY 2015-16**

S.No.	State	Employee Expenses (Rs. Crore)	Transformation Capacity (MVA)	Employee Expense/MVA	Rank
1	Uttarakhand	57.55	7872.00	0.731	4
2	Bihar	98.99	14779.90	0.670	3
3	Madhya Pradesh	326.27	49349.00	0.661	2
4	Maharashtra	927.76	110815.00	0.837	6
5	Rajasthan	941.83	68036.00	1.384	8
6	Karnataka	730.21	53734.90	1.359	7
7	Gujarat	738.43	91544.00	0.807	5
8	Uttar Pradesh	398.98	76725.00	0.520	1



**Figure 17: Employee Expense/MVA**

The employee expense/MVA of Uttar Pradesh is the least amongst all the utilities during all the three years considered. The same is due to the reason that the transformation capacity of UPPTCL is third among the eight utilities considered for the study.

- **Employee Expense /MU**

The employee cost/MU of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 20: Employee Expense/MU for FY 2013-14**

S.No.	State	Employee Expenses (Rs. Crore)	Energy Transmitted (MU)	Employee Expense/MU	Rank
1	Uttarakhand	50.61	13227.00	0.38261	1
2	Bihar	86.68	13786.16	0.62872	4
3	Madhya Pradesh	287.82	50300.00	0.57221	3
4	Maharashtra	819.50	117289.13	0.69870	5
5	Rajasthan	1004.25	63851.02	1.57280	8
6	Karnataka	711.36	56733.00	1.25388	7
7	Gujarat	596.71	70712.07	0.84386	6
8	Uttar Pradesh	395.28	77760.69	0.50832	2

The employee cost/MU of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 21: Employee Expense/MU for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore)	Energy Transmitted (MU)	Employee Expense/MU	Rank
1	Uttarakhand	51.85	13612.23	0.3809	1
2	Bihar	93.35	16986.53	0.5495	3
3	Madhya Pradesh	312.22	55206.00	0.5656	4
4	Maharashtra	848.43	130107.38	0.6521	5
5	Rajasthan	945.52	67257.92	1.4058	8
6	Karnataka	804.73	59420.35	1.3543	7
7	Gujarat	643.98	78933.59	0.8159	6
8	Uttar Pradesh	396.88	82413.86	0.4816	2

The employee cost/MU of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 22: Employee Expense/MU for FY 2015-16**

S.No.	State	Employee Expenses (Rs. Crore)	Energy Transmitted (MU)	Employee Expense/MU	Rank
1	Uttarakhand	57.55	13734.00	0.41901	1
2	Bihar	98.99	21485.35	0.46073	3
3	Madhya Pradesh	326.27	59335.00	0.54988	4
4	Maharashtra	927.76	136215.34	0.68110	5
5	Rajasthan	941.83	75567.74	1.24634	8
6	Karnataka	730.21	61957.51	1.17856	7
7	Gujarat	738.43	84889.83	0.86987	6
8	Uttar Pradesh	398.98	88402.14	0.45132	2



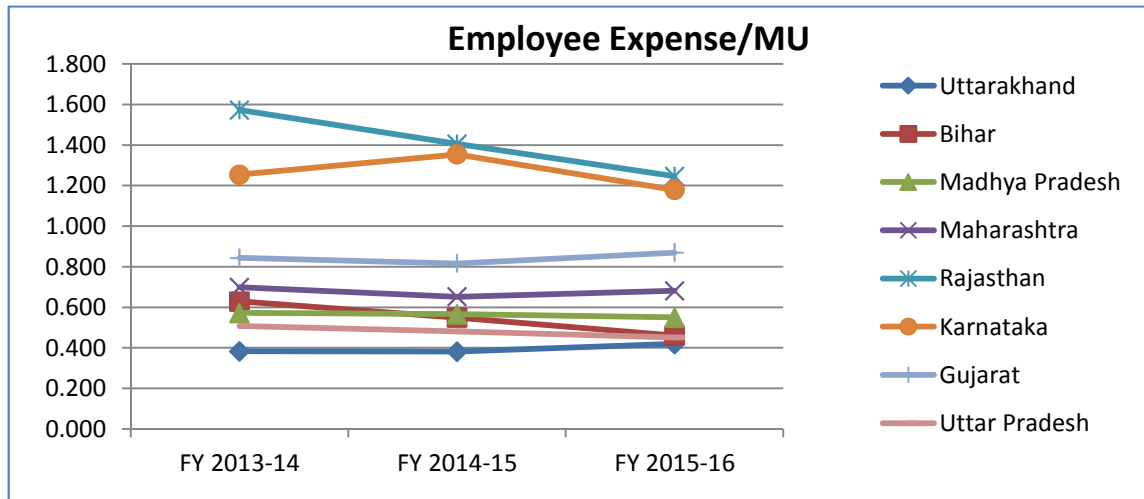


Figure 18: Employee Expense/MU

The UPPTCL is ranked second among all the utilities during all the three years in terms of employee expenses/MU as the energy transmitted by UPPTCL is the second highest among all the utilities considered for the study.

- **Employee Expense /MW**

The employee cost/MW of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

Table 23: Employee Expense/MW for FY 2013-14

S.No.	State	Employee Expenses (Rs. Crore)	Peak Demand (MW)	Employee Expense/MW	Rank
1	Uttarakhand	50.61	1826.00	2.7715	1
2	Bihar	86.68	2465.00	3.5163	4
3	Madhya Pradesh	287.82	9716.00	2.9623	2
4	Maharashtra	819.50	19276.00	4.2514	5
5	Rajasthan	1004.25	10047.00	9.9955	8
6	Karnataka	711.36	9940.00	7.1566	7
7	Gujarat	596.71	12201.00	4.8907	6
8	Uttar Pradesh	395.28	13089.00	3.0199	3

The employee cost/MW of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 24: Employee Expense/ MW for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore)	Peak Demand (MW)	Employee Expense/MW	Rank
1	Uttarakhand	51.85	1930.00	2.6865	2
2	Bihar	93.35	2994.00	3.1178	3
3	Madhya Pradesh	312.22	9755.00	3.2006	4
4	Maharashtra	848.43	20147.00	4.2112	5
5	Rajasthan	945.52	10642.00	8.8848	8
6	Karnataka	804.73	10001.00	8.0465	7
7	Gujarat	643.98	13603.00	4.7341	6
8	Uttar Pradesh	396.88	15670.00	2.5328	1

The employee cost/MW of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 25: Employee Expense/MW for FY 2015-16**

S.No.	State	Employee Expenses (Rs. Crore)	Peak Demand (MW)	Employee Expense/MW	Rank
1	Uttarakhand	57.55	2034.00	2.8293	3
2	Bihar	98.99	3735.00	2.6503	2
3	Madhya Pradesh	326.27	10902.00	2.9928	4
4	Maharashtra	927.76	20973.00	4.4236	5
5	Rajasthan	941.83	10961.00	8.5926	8
6	Karnataka	730.21	10202.00	7.1575	7
7	Gujarat	738.43	14495.00	5.0944	6
8	Uttar Pradesh	398.98	16988.00	2.3486	1

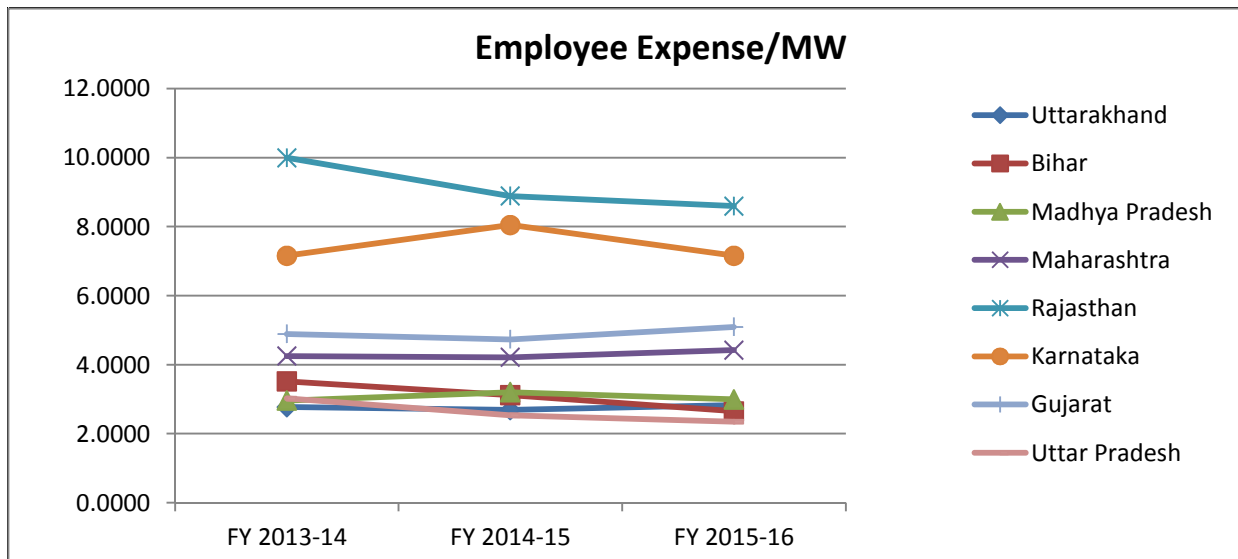


Figure 19: Employee Expense/MW

The UPPTCL is ranked second among all the utilities during the three years as the peak demand served by Uttar Pradesh is the second highest among all the utilities considered for the study.

## b. Econometric Method

- **The selection of variables**

Benchmarking of the employee expenses for FY 2013-14 has been carried out by considering the following variables as given in the table below:

**Table 26: Employee Expenses, Line Length & Transformation Capacity of different states**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	50.61	2981.00	6097.00
2	Bihar	86.68	8394.00	9499.00
3	Madhya Pradesh	287.82	29009.77	41163.00
4	Maharashtra	819.50	43019.81	101547.00
5	Rajasthan	1004.25	31092.40	53249.00
6	Karnataka	711.36	32471.00	50221.85
7	Gujarat	596.71	50131.56	68730.00
8	Uttar Pradesh	395.28	26876.00	63791.00

- **The selection of the type of cost function (the ‘functional form’);**

The Cobb - Douglas functional form has been chosen as the cost function as given below:

$$\ln \hat{C}(y_1, y_2, y_3, y_4) = a + b_1 \ln y_1 + b_2 \ln y_2 + c_1 \ln w_1 + c_2 \ln w_2$$

- **The selection of an estimation method that sets out a way to estimate the specified cost function that best fits the available data;**

The ordinary least squares (OLS) method has been chosen as the estimation method to estimate the specified cost function.

- **The compilation of data in relation to costs, outputs, prices, and environmental variables for a set of comparable businesses**

The details of seven states along with UPPTCL related to employee expenses, line length and transformation capacity has been considered to carry out the benchmarking study.

- **The estimation process and the interpretation of the residual (the difference between the estimated and actual costs) for each business as a measure of the inefficiency of that business.**

Doing the regression analysis on the values obtained after considering log of the values in table 26 we obtain the following values:

**Table 27: Regression Analysis of Employee Expenses**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	3.92	8.00	8.72	3.88
2	Bihar	4.46	9.04	9.16	4.57
3	Madhya Pradesh	5.66	10.28	10.63	6.03
4	Maharashtra	6.71	10.67	11.53	6.79
5	Rajasthan	6.91	10.34	10.88	6.23
6	Karnataka	6.57	10.39	10.82	6.21
7	Gujarat	6.39	10.82	11.14	6.59
8	Uttar Pradesh	5.98	10.20	11.06	6.30

Having obtained the regressed value the efficiency of the STUs have been obtained in the following table:

**Table 28: Rank Obtained (FY 2013-14)**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
-------	-------	---------------	--------	--------	---------------------------	-----	------

S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	3.92	8.00	8.72	3.88	1.01	6
2	Bihar	4.46	9.04	9.16	4.57	0.98	4
3	Madhya Pradesh	5.66	10.28	10.63	6.03	0.94	1
4	Maharashtra	6.71	10.67	11.53	6.79	0.99	5
5	Rajasthan	6.91	10.34	10.88	6.23	1.11	8
6	Karnataka	6.57	10.39	10.82	6.21	1.06	7
7	Gujarat	6.39	10.82	11.14	6.59	0.97	3
8	Uttar Pradesh	5.98	10.20	11.06	6.30	0.95	2

It can be seen from the table given above that the rank obtained by UPPTCL is no. 2.

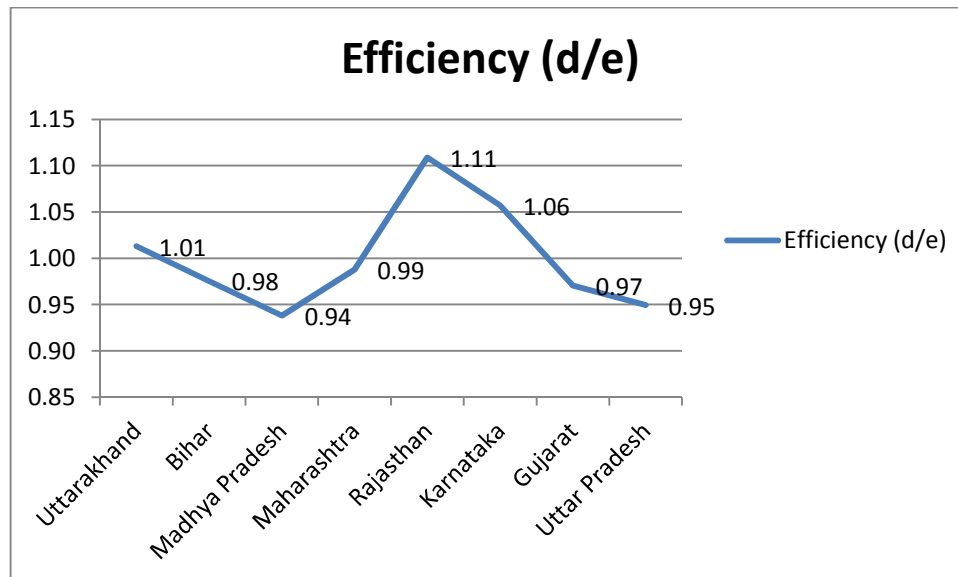


Figure 20: Efficiency (d/e) of states

### Analysis for FY 2014-15

Benchmarking of the employee expenses for FY 2014-15 has been carried out by considering the following variables as given in the table below:

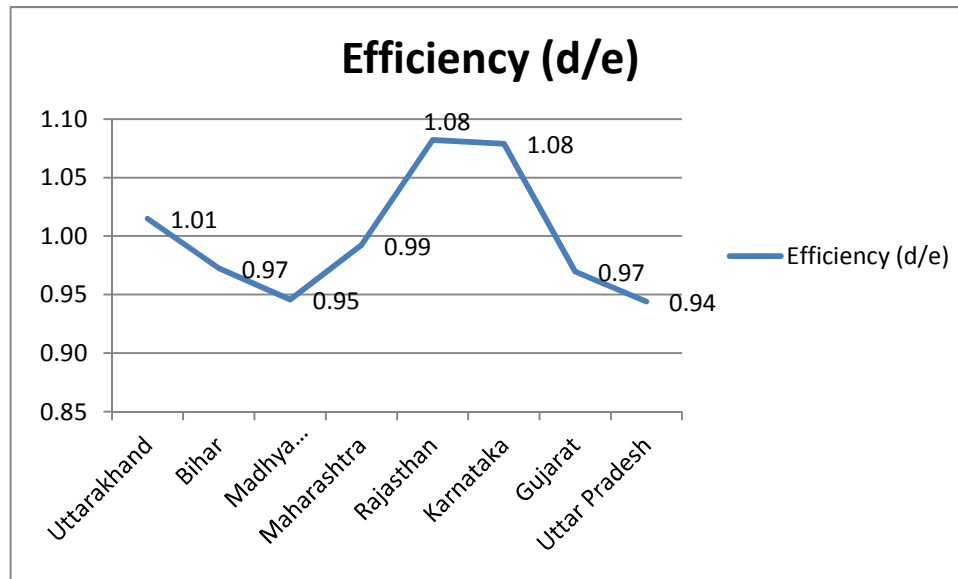
**Table 29: Employee Expenses, Line Length & Transformation Capacity of different states for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	51.85	3017.00	6582.00
2	Bihar	93.35	8617.00	11560.00
3	Madhya Pradesh	312.22	30194.99	45457.00
4	Maharashtra	848.43	44207.00	105434.00
5	Rajasthan	945.52	32514.17	63378.50
6	Karnataka	804.73	33204.00	52081.50
7	Gujarat	643.98	52531.56	80113.00
8	Uttar Pradesh	396.88	28678.00	68465.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

**Table 30: Rank Obtained for FY 2014-15**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	3.95	8.01	8.79	3.89	1.01	6
2	Bihar	4.54	9.06	9.36	4.66	0.97	4
3	Madhya Pradesh	5.74	10.32	10.72	6.07	0.95	2
4	Maharashtra	6.74	10.70	11.57	6.80	0.99	5
5	Rajasthan	6.85	10.39	11.06	6.33	1.08	8
6	Karnataka	6.69	10.41	10.86	6.20	1.08	7
7	Gujarat	6.47	10.87	11.29	6.67	0.97	3
8	Uttar Pradesh	5.98	10.26	11.13	6.34	0.94	1



**Figure 21: Efficiency (d/e) of states**

### Analysis for FY 2015-16

Benchmarking of the employee expenses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

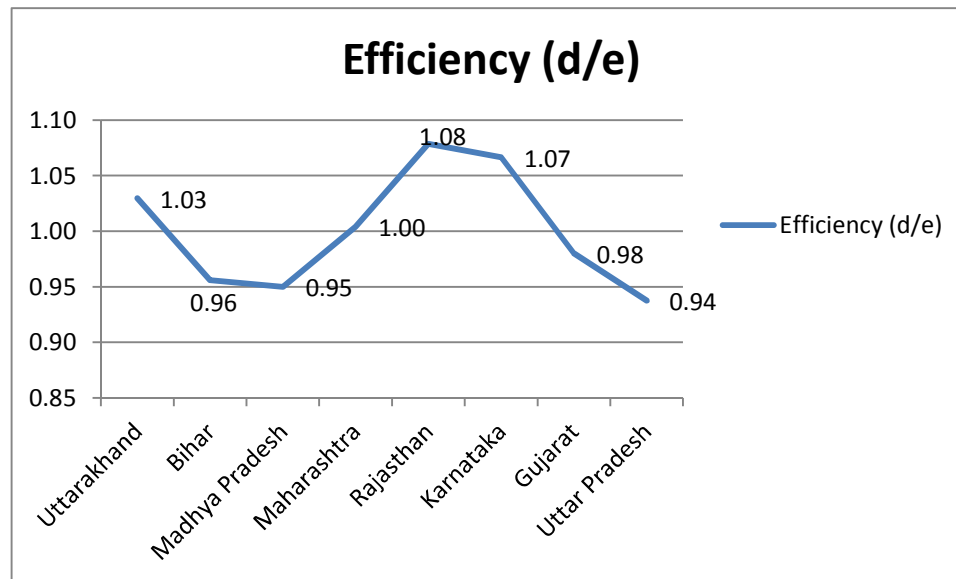
**Table 31: Employee Expenses, Line Length & Transformation Capacity of different states for FU 2015-16**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	57.55	3020.00	7872.00
2	Bihar	98.99	9573.90	14779.90
3	Madhya Pradesh	326.27	31364.08	49349.00
4	Maharashtra	927.76	46317.00	110815.00
5	Rajasthan	941.83	33959.92	68036.00
6	Karnataka	730.21	33794.00	53734.90
7	Gujarat	738.43	55456.56	91544.00
8	Uttar Pradesh	398.98	30151.00	76725.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for the FY 2015-16:

**Table 32: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.05	8.01	8.97	3.94	1.03	6
2	Bihar	4.60	9.17	9.60	4.81	0.96	3
3	Madhya Pradesh	5.79	10.35	10.81	6.09	0.95	2
4	Maharashtra	6.83	10.74	11.62	6.81	1.00	5
5	Rajasthan	6.85	10.43	11.13	6.35	1.08	8
6	Karnataka	6.59	10.43	10.89	6.18	1.07	7
7	Gujarat	6.60	10.92	11.42	6.74	0.98	4
8	Uttar Pradesh	5.99	10.31	11.25	6.39	0.94	1

**Figure 22: Efficiency (d/e) of states**

### ***c. Corrected Ordinary Least Square Method***

The Corrected Ordinary Least Square Method has been used along with regression analysis to arrive at the desired results. The following steps have been used to carry out the benchmarking study:

1. Establishment of Data Management Units (DMUs)
2. Carrying out the Regression Analysis
3. Ranking of the utilities after obtaining the corrected values

- **Establishment of Data Management Units (DMUs)**



The Data Management Units have been established by considering the employee cost along with the Circuit Kilometers (Ckt Km) and the Transformation Capacity (MVA). The employee cost is the input cost and the Circuit Kilometers (Ckt Km) and Transformation Capacity (MVA) are the output achieved. The following table gives the details of the eight states (DMUs) considered for the benchmarking study:

**Table 33: Employee Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	50.61	2981.00	6097.00
2	Bihar	86.68	8394.00	9499.00
3	Madhya Pradesh	287.82	29009.77	41163.00
4	Maharashtra	819.50	43019.81	101547.00
5	Rajasthan	1004.25	31092.40	53249.00
6	Karnataka	711.36	32471.00	50221.85
7	Gujarat	596.71	50131.56	68730.00
8	Uttar Pradesh	395.28	26876.00	63791.00

### • Regression Analysis

The employee expenses have been benchmarked with respect to line length (ckm) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the employee expenses as given in the table below:

**Table 34: Regression Analysis of Employee Expenses**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)	Regressed Value (Rs. Crore)
1	Uttarakhand	50.61	2981.00	6097.00	87.76
2	Bihar	86.68	8394.00	9499.00	148.86
3	Madhya Pradesh	287.82	29009.77	41163.00	465.93
4	Maharashtra	819.50	43019.81	101547.00	856.75
5	Rajasthan	1004.25	31092.40	53249.00	538.06
6	Karnataka	711.36	32471.00	50221.85	536.05
7	Gujarat	596.71	50131.56	68730.00	768.80
8	Uttar Pradesh	395.28	26876.00	63791.00	549.98

It can be seen from the table given above that the actual employee expenses for UPPTCL was Rs. 395.28 Crores for the FY 2013-14. However, after carrying out the regression analysis the employee expenses comes out to Rs. 549.98 Crores. This difference of Rs. 154.71 Crores indicates that the employee expenses of UPPTCL are on a lower side and the same can be increased by Rs. 154.71 Crores considering the employee expenses of other STUs. One key reason for lower employee expenses of

UPPTCL is the actual employee strength of the utility. As against the sanctioned strength of 11842 in the FY 2014-15, the actual no. of employees employed by UPPTCL was only 6778.

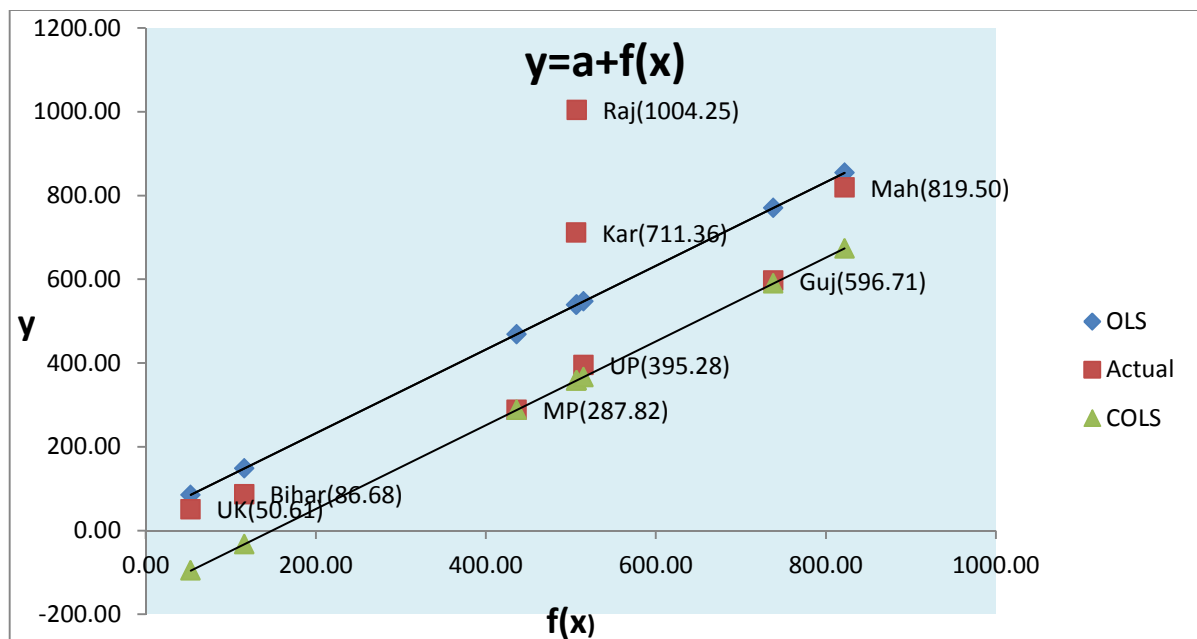
- **Ranking of the Utilities after obtaining the corrected values**

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of employee expenses. The utility with the maximum value of the ratio is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 35: Ranking of the utilities for FY 2013-14**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	50.61	2981.00	6097.00	87.76	-90.35	-1.79	8
2	Bihar	86.68	8394.00	9499.00	148.86	-29.26	-0.34	7
3	Madhya Pradesh	287.82	29009.77	41163.00	465.93	287.82	1.00	1
4	Maharashtra	819.50	43019.81	101547.00	856.75	678.64	0.83	4
5	Rajasthan	1004.25	31092.40	53249.00	538.06	359.95	0.36	6
6	Karnataka	711.36	32471.00	50221.85	536.05	357.94	0.50	5
7	Gujarat	596.71	50131.56	68730.00	768.80	590.69	0.99	2
8	Uttar Pradesh	395.28	26876.00	63791.00	549.98	371.87	0.94	3

The graphical representation of the COLS method is shown in the figure below:



**Figure 23: COLS for the Employee Cost for FY 2013-14****Analysis for FY 2014-15**

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

**Table 36: Employee Expenses, Line Length & Transformation Capacity of different states for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	51.85	3017.00	6582.00
2	Bihar	93.35	8617.00	11560.00
3	Madhya Pradesh	312.22	30194.99	45457.00
4	Maharashtra	848.43	44207.00	105434.00
5	Rajasthan	945.52	32514.17	63378.50
6	Karnataka	804.73	33204.00	52081.50
7	Gujarat	643.98	52531.56	80113.00
8	Uttar Pradesh	396.88	28678.00	68465.00

Following the steps carried out for FY 2013-14, the following ranks are obtained for the FY 2014-15:

**Table 37: Ranking of the utilities for FY 2014-15**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	51.85	3017.00	6582.00	86.17	-96.10	-1.8534	8
2	Bihar	93.35	8617.00	11560.00	151.93	-30.34	-0.3251	7
3	Madhya Pradesh	312.22	30194.99	45457.00	477.49	295.21	0.9455	3
4	Maharashtra	848.43	44207.00	105434.00	875.13	692.86	0.8166	4
5	Rajasthan	945.52	32514.17	63378.50	582.52	400.25	0.4233	6
6	Karnataka	804.73	33204.00	52081.50	532.19	349.92	0.4348	5
7	Gujarat	643.98	52531.56	80113.00	812.37	630.10	0.9784	2
8	Uttar Pradesh	396.88	28678.00	68465.00	579.16	396.88	1.0000	1

The graphical representation of the COLS method is shown in the figure below:

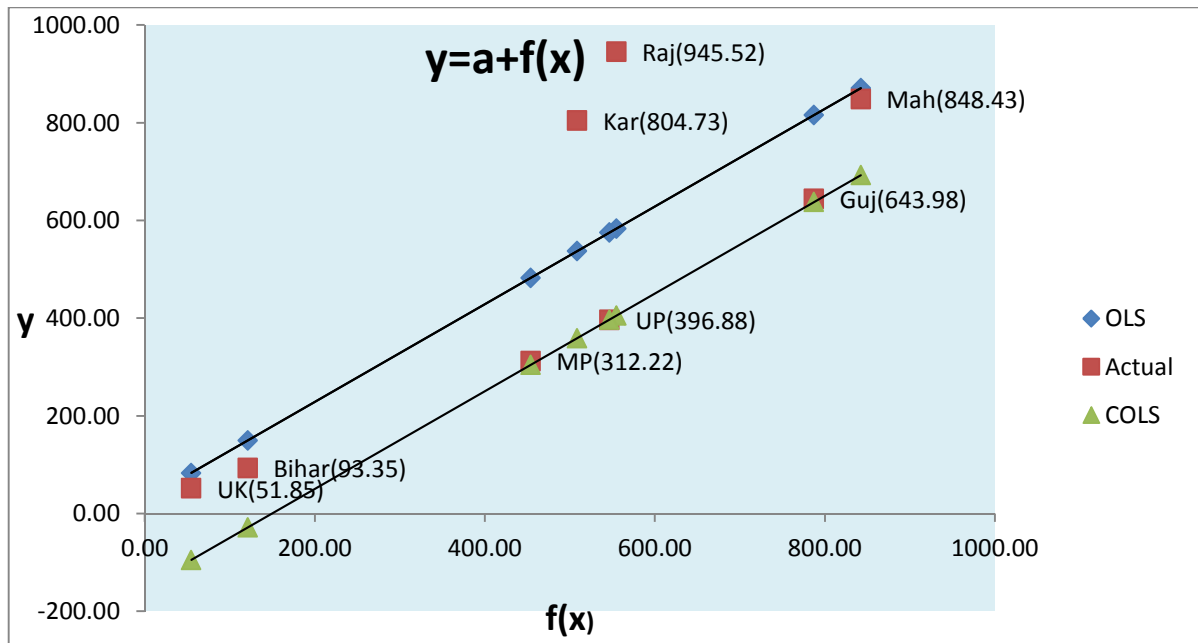


Figure 24: COLS for the Employee Cost for FY 2014-15

### Analysis for FY 2015-16

The following table gives the details of the eight states (DMUs) for the FY 2015-16:

Table 38: Employee Expenses, Line Length & Transformation Capacity of different states for FY 2015-16

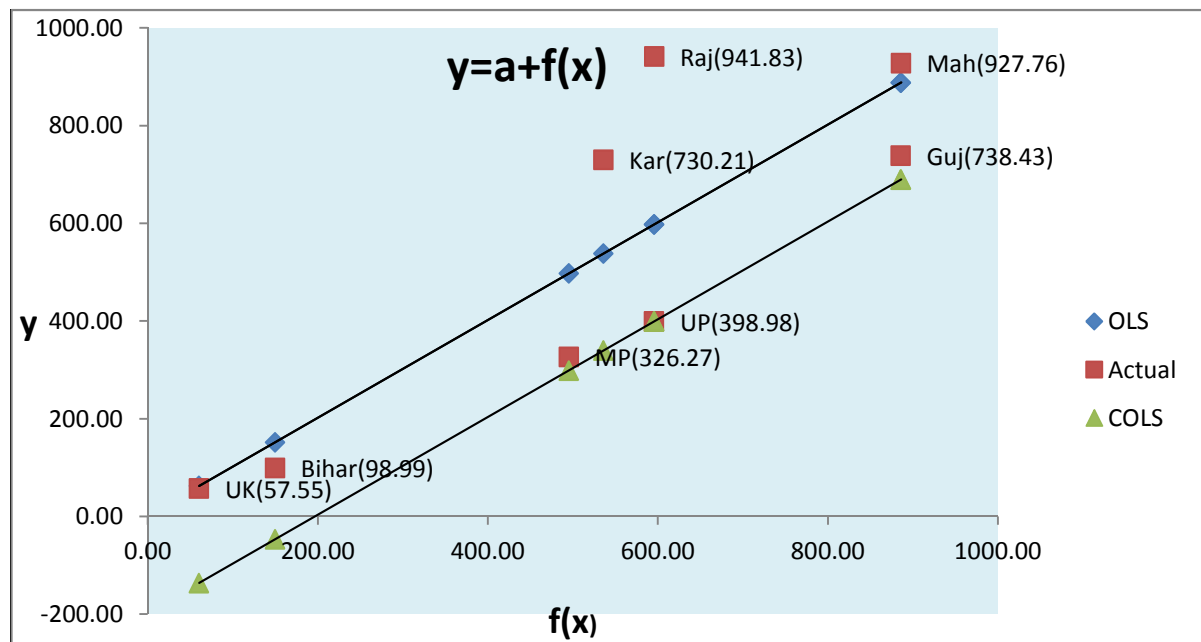
S.No.	State	Employee Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	57.55	3020.00	7872.00
2	Bihar	98.99	9573.90	14779.90
3	Madhya Pradesh	326.27	31364.08	49349.00
4	Maharashtra	927.76	46317.00	110815.00
5	Rajasthan	941.83	33959.92	68036.00
6	Karnataka	730.21	33794.00	53734.90
7	Gujarat	738.43	54665.00	91544.00
8	Uttar Pradesh	398.98	30151.00	76725.00

Following the steps carried out for FY 2013-14, the following the following ranks are obtained for the FY 2015-16:

**Table 39: Ranking of the Utilities for FY 2015-16**

S.No.	State	Employee Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	57.55	3020.00	7872.00	65.47	-136.75	-2.3763	8
2	Bihar	98.99	9573.90	14779.90	152.74	-49.48	-0.4998	7
3	Madhya Pradesh	326.27	31364.08	49349.00	493.17	290.95	0.8917	3
4	Maharashtra	927.76	46317.00	110815.00	890.35	688.13	0.7417	4
5	Rajasthan	941.83	33959.92	68036.00	596.86	394.64	0.4190	6
6	Karnataka	730.21	33794.00	53734.90	533.43	331.21	0.4536	5
7	Gujarat	738.43	55456.56	91544.00	886.79	684.57	0.9271	2
8	Uttar Pradesh	398.98	30151.00	76725.00	601.20	398.98	1.0000	1

The graphical representation of the COLS method is shown in the figure below:

**Figure 25: COLS for the Employee Cost for FY 2015-16**

### 4.3 Benchmarking of R&M Expenses

The benchmarking of the R&M Expenses has been carried out using the Partial Performance Indicator, Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Squares Method.

### a. Partial Performance Indicator

- **R&M Expense /Ckm**

The R&M expense/Ckm of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 40: R&M Expense/Ckt Km for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	R&M Expense/Ckt Km	Rank
1	Uttarakhand	18.67	2981.00	0.626	7
2	Bihar	59.01	8394.00	0.703	8
3	Madhya Pradesh	51.37	29009.77	0.177	1
4	Maharashtra	193.62	43019.81	0.450	5
5	Rajasthan	103.64	31092.40	0.333	3
6	Karnataka	99.91	32471.00	0.308	2
7	Gujarat	211.84	50131.56	0.423	4
8	Uttar Pradesh	162.70	26876.00	0.605	6

The R&M expense/Ckm of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 41: R&M Expenses (FY 2014-15)**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	R&M Expense/Ckm	Rank
1	Uttarakhand	16.57	3017.00	0.5492	7
2	Bihar	36.51	8617.00	0.4237	4
3	Madhya Pradesh	58.03	30194.99	0.1922	1
4	Maharashtra	214.05	44207.00	0.4842	6
5	Rajasthan	111.55	32514.17	0.3431	2
6	Karnataka	137.31	33204.00	0.4135	3
7	Gujarat	230.18	52531.56	0.4382	5
8	Uttar Pradesh	195.96	28678.00	0.6833	8

The R&M expense/Ckm of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 42: R&M Expense/Ckt km for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	R&M Expense/Ckt Km	Rank
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S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	R&M Expense/Ckt Km	Rank
1	Uttarakhand	25.43	3020.00	0.842	7
2	Bihar	36.17	9573.90	0.378	3
3	Madhya Pradesh	61.69	31364.08	0.197	1
4	Maharashtra	272.89	46317.00	0.589	6
5	Rajasthan	124.12	33959.92	0.365	2
6	Karnataka	153.21	33794.00	0.453	5
7	Gujarat	236.71	55456.56	0.427	4
8	Uttar Pradesh	289.69	30151.00	0.961	8

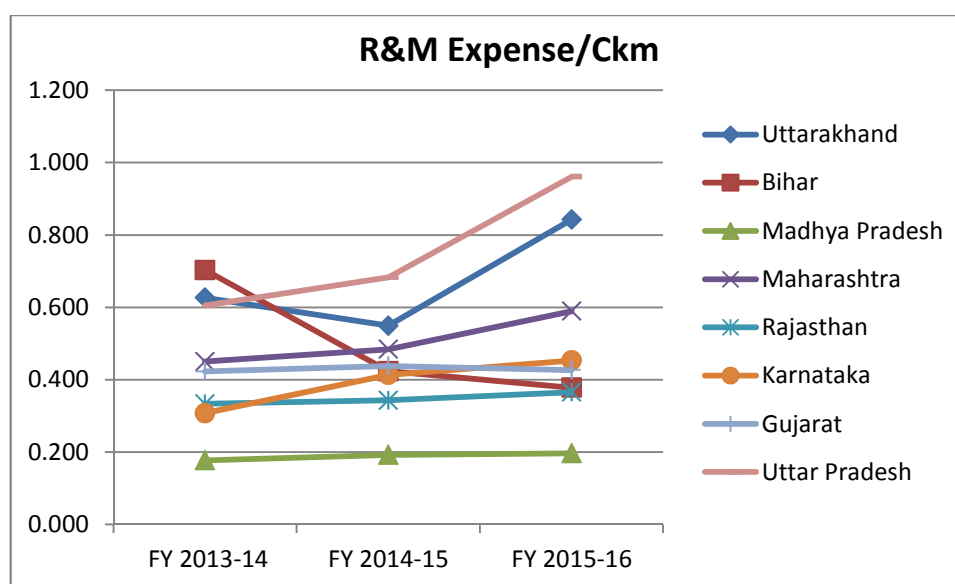


Figure 26: R&M Expense/Ckm

It can be seen that the R&M expenses of UPPTCL are on a higher side and the per Ckt km R&M expenses of UPPTCL was Rs. 0.961 lakh/Ckt km during the FY 2015-16. The rank of UPPTCL is 8 among the eight utilities considered with Madhya Pradesh getting the first rank.

- **R&M Expense /MVA**

The R&M expense/MVA of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

Table 43: R&M Expense/MVA for FY 2013-14

S.No.	State	R&M Expenses (Rs. Crore)	Transformation Capacity (MVA)	R&M Expense/MVA	Rank
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S.No.	State	R&M Expenses (Rs. Crore)	Transformation Capacity (MVA)	R&M Expense/MVA	Rank
1	Uttarakhand	18.67	6097.00	0.306	6
2	Bihar	59.01	9499.00	0.621	8
3	Madhya Pradesh	51.37	41163.00	0.125	1
4	Maharashtra	193.62	101547.00	0.191	2
5	Rajasthan	103.64	53249.00	0.195	3
6	Karnataka	99.91	50221.85	0.199	4
7	Gujarat	211.84	68730.00	0.308	7
8	Uttar Pradesh	162.70	63791.00	0.255	5

The R&M expense/MVA of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 44: R&M Expense/MVA for FY 2014-15**

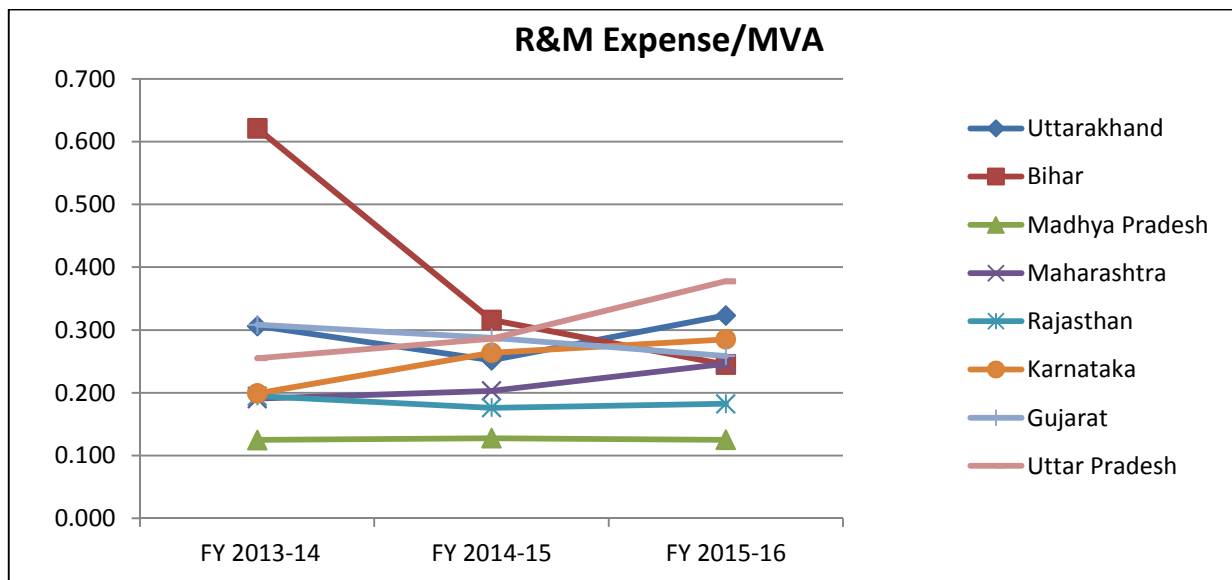
S.No.	State	R&M Expenses (Rs. Crore)	Transformation Capacity (MVA)	R&M Expense/MVA	Rank
1	Uttarakhand	16.57	6582.00	0.252	4
2	Bihar	36.51	11560.00	0.316	8
3	Madhya Pradesh	58.03	45457.00	0.128	1
4	Maharashtra	214.05	105434.00	0.203	3
5	Rajasthan	111.55	63378.50	0.176	2
6	Karnataka	137.31	52081.50	0.264	5
7	Gujarat	230.18	80113.00	0.287	7
8	Uttar Pradesh	195.96	68465.00	0.286	6

The R&M expense/MVA of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:



**Table 45: R&M Expense/MVA for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore)	Transformation Capacity (MVA)	R&M Expense/MVA	Rank
1	Uttarakhand	25.43	7872.00	0.323	7
2	Bihar	36.17	14779.90	0.245	3
3	Madhya Pradesh	61.69	49349.00	0.125	1
4	Maharashtra	272.89	110815.00	0.246	4
5	Rajasthan	124.12	68036.00	0.182	2
6	Karnataka	153.21	53734.90	0.285	6
7	Gujarat	236.71	91544.00	0.259	5
8	Uttar Pradesh	289.69	76725.00	0.378	8

**Figure 27: R&M Expense/MVA**

The R&M expenses of UPPTCL are on a higher side and during the FY 2015-16 UPPTCL registered the highest R&M cost among all the utilities. Hence, the R&M expenses/MVA of UPPTCL are highest during the FY 2015-16 among all the utilities.

- **R&M Expense /MU**

The R&M expense/MU of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 46: R&M Expense/MU for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore)	Energy Transmitted (MU)	R&M Expense/MU	Rank
1	Uttarakhand	18.67	13227.00	0.141	2
2	Bihar	59.01	13786.16	0.428	8
3	Madhya Pradesh	51.37	50300.00	0.102	1
4	Maharashtra	193.62	117289.13	0.165	4
5	Rajasthan	103.64	63851.02	0.162	3
6	Karnataka	99.91	56733.00	0.176	5
7	Gujarat	211.84	70712.07	0.300	7
8	Uttar Pradesh	162.70	77760.69	0.209	6

The R&M expense/MU of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

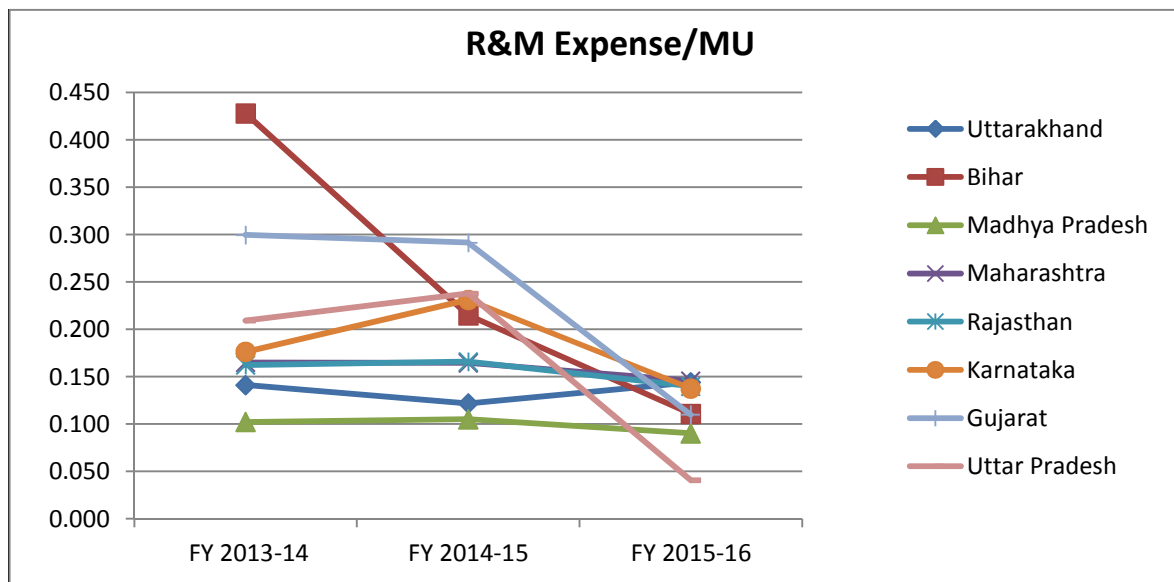
**Table 47: R&M Expense/MU for FY 2014-15**

S.No.	State	R&M Expenses (Rs. Crore)	Energy Transmitted (MU)	R&M Expense/MU	Rank
1	Uttarakhand	16.57	13612.23	0.1217	2
2	Bihar	36.51	16986.53	0.2149	5
3	Madhya Pradesh	58.03	55206.00	0.1051	1
4	Maharashtra	214.05	130107.38	0.1645	3
5	Rajasthan	111.55	67257.92	0.1659	4
6	Karnataka	137.31	59420.35	0.2311	6
7	Gujarat	230.18	78933.59	0.2916	8
8	Uttar Pradesh	195.96	82413.86	0.2378	7

The R&M expense/MU of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 48: R&M Expense/MU for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore)	Energy Transmitted (MU)	R&M Expense/MU	Rank
1	Uttarakhand	25.43	13734.00	0.144	7
2	Bihar	36.17	21485.35	0.111	4
3	Madhya Pradesh	61.69	59335.00	0.090	2
4	Maharashtra	272.89	136215.34	0.146	8
5	Rajasthan	124.12	75567.74	0.140	6
6	Karnataka	153.21	61957.51	0.137	5
7	Gujarat	236.71	84889.83	0.110	3
8	Uttar Pradesh	289.69	88402.14	0.041	1



**Figure 28: R&M Expense/MU**

The UPPTCL is ranked no. 1 during FY 2015-16 in terms of R&M Expense/MU due to the fact that the energy transmitted by it is second highest among all the utilities during FY 2015-16.

- **R&M Expense /MW**

The R&M expense/MW of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 49: R&M Expense/MW for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore)	Peak Demand (MW)	R&M Expense/MW	Rank
1	Uttarakhand	18.67	1826.00	1.022	4
2	Bihar	59.01	2465.00	2.394	8
3	Madhya Pradesh	51.37	9716.00	0.529	1
4	Maharashtra	193.62	19276.00	1.004	2
5	Rajasthan	103.64	10047.00	1.032	5
6	Karnataka	99.91	9940.00	1.005	3
7	Gujarat	211.84	12201.00	1.736	7
8	Uttar Pradesh	162.70	13089.00	1.243	6

The R&M expense/MW of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

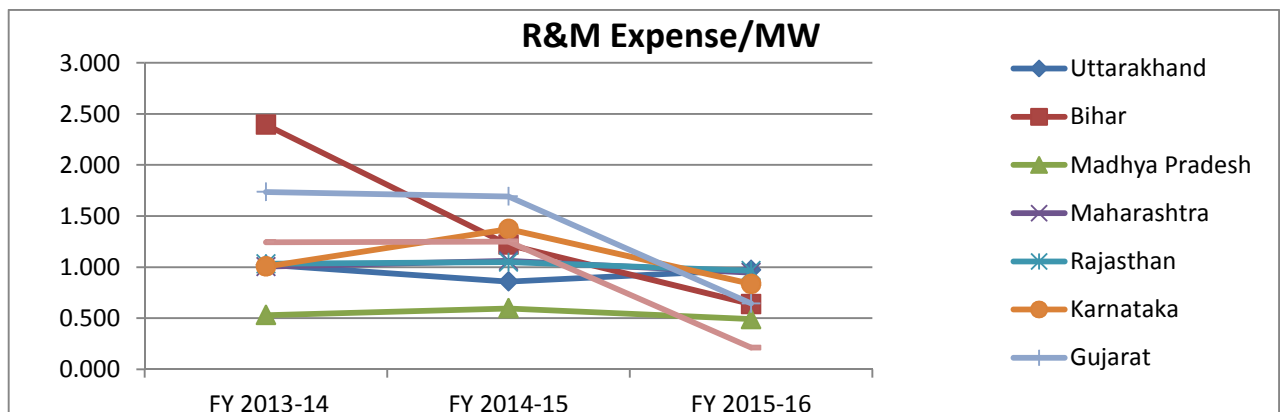
**Table 50: R&M Expense/MW for FY 2014-15**

S.No.	State	R&M Expenses (Rs. Crore)	Peak Demand (MW)	R&M Expense/MW	Rank
1	Uttarakhand	16.57	1930.00	0.8585	2
2	Bihar	36.51	2994.00	1.2194	5
3	Madhya Pradesh	58.03	9755.00	0.5949	1
4	Maharashtra	214.05	20147.00	1.0624	4
5	Rajasthan	111.55	10642.00	1.0482	3
6	Karnataka	137.31	10001.00	1.3730	7
7	Gujarat	230.18	13603.00	1.6921	8
8	Uttar Pradesh	195.96	15670.00	1.2505	6

The R&M expense/MW of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 51: R&M Expense/MW for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore)	Peak Demand (MW)	R&M Expense/MW	Rank
1	Uttarakhand	25.43	0.144	0.972	8
2	Bihar	36.17	0.111	0.637	3
3	Madhya Pradesh	61.69	0.090	0.490	2
4	Maharashtra	272.89	0.146	0.946	6
5	Rajasthan	124.12	0.140	0.965	7
6	Karnataka	153.21	0.137	0.835	5
7	Gujarat	236.71	0.110	0.644	4
8	Uttar Pradesh	289.69	0.041	0.212	1



**Figure 29: R&M Expense/ MW**

The UPPTCL is ranked no. 1 during FY 2015-16 in terms of R&M Expense/MW due to the fact that the peak demand met by it is second highest among all the utilities during FY 2015-16.

### ***b. Econometric Method***

- **The selection of variables**

Benchmarking of the R&M expenses has been carried out by considering the following variables as given in the table below:

**Table 52: R&M Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	18.67	2981.00	6097.00
2	Bihar	59.01	8394.00	9499.00
3	Madhya Pradesh	51.37	29009.77	41163.00
4	Maharashtra	193.62	43019.81	101547.00
5	Rajasthan	103.64	31092.40	53249.00
6	Karnataka	99.91	32471.00	50221.85
7	Gujarat	211.84	50131.56	68730.00
8	Uttar Pradesh	162.70	26876.00	63791.00

Doing the regression analysis on the values obtained after considering log of the values in table 52 we obtain the following values:

**Table 53: Regression Analysis of R&M Expenses**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	2.93	8.00	8.72	3.10
2	Bihar	4.08	9.04	9.16	3.63
3	Madhya Pradesh	3.94	10.28	10.63	4.65
4	Maharashtra	5.27	10.67	11.53	5.15
5	Rajasthan	4.64	10.34	10.88	4.78
6	Karnataka	4.60	10.39	10.82	4.77
7	Gujarat	5.36	10.82	11.14	5.04
8	Uttar Pradesh	5.09	10.20	11.06	4.80

Having obtained the regressed value the efficiency of the STUs have been obtained in the following table:

**Table 54: Rank Obtained (FY 2013-14)**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	2.93	8.00	8.72	3.10	0.95	2

S.No.	State	$\frac{LN (a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
2	Bihar	4.08	9.04	9.16	3.63	1.12	8
3	Madhya Pradesh	3.94	10.28	10.63	4.65	0.85	1
4	Maharashtra	5.27	10.67	11.53	5.15	1.02	5
5	Rajasthan	4.64	10.34	10.88	4.78	0.97	4
6	Karnataka	4.60	10.39	10.82	4.77	0.97	3
7	Gujarat	5.36	10.82	11.14	5.04	1.06	7
8	Uttar Pradesh	5.09	10.20	11.06	4.80	1.06	6

It can be seen from the table given above that the rank obtained by UPPTCL is no. 6.

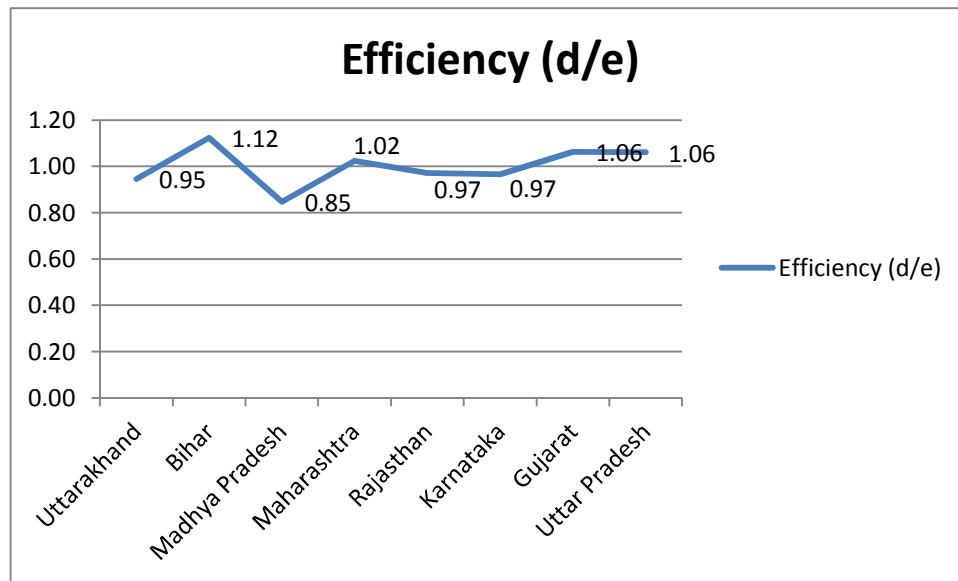


Figure 30: Efficiency (d/e) of states

### Analysis for FY 2014-15

Benchmarking of the R&M Expenses for FY 2014-15 has been carried out by considering the following variables as given in the table below:

Table 55: R&M Expenses, Line Length & Transformation Capacity of different states for FY 2014-15

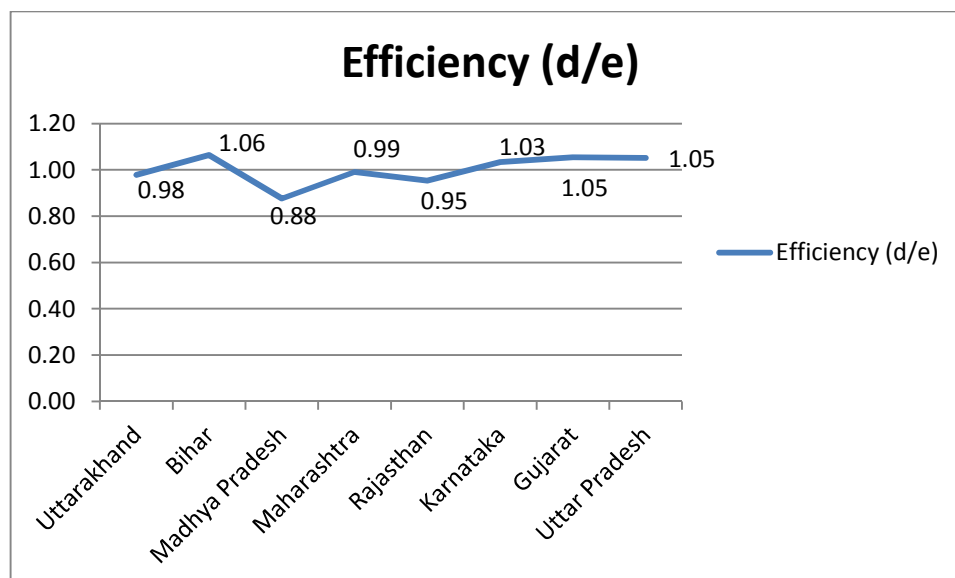
S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	16.57	3017.00	6582.00
2	Bihar	36.51	8617.00	11560.00

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
3	Madhya Pradesh	58.03	30194.99	45457.00
4	Maharashtra	214.05	44207.00	105434.00
5	Rajasthan	111.55	32514.17	63378.50
6	Karnataka	137.31	33204.00	52081.50
7	Gujarat	230.18	52531.56	80113.00
8	Uttar Pradesh	195.96	28678.00	68465.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

**Table 56: Rank Obtained for FY 2014-15**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	2.81	8.01	8.79	2.87	0.98	3
2	Bihar	3.60	9.06	9.36	3.38	1.06	8
3	Madhya Pradesh	4.06	10.32	10.72	4.64	0.88	1
4	Maharashtra	5.37	10.70	11.57	5.41	0.99	4
5	Rajasthan	4.71	10.39	11.06	4.94	0.95	2
6	Karnataka	4.92	10.41	10.86	4.76	1.03	5
7	Gujarat	5.44	10.87	11.29	5.16	1.05	7
8	Uttar Pradesh	5.28	10.26	11.13	5.02	1.05	6



**Figure 31: Efficiency (d/e) of states**



## Analysis for FY 2015-16

Benchmarking of the R&M Expenses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

**Table 57: R&M Expenses, Line Length & Transformation Capacity of different states for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	25.43	3020.00	7872.00
2	Bihar	36.17	9573.90	14779.90
3	Madhya Pradesh	61.69	31364.08	49349.00
4	Maharashtra	272.89	46317.00	110815.00
5	Rajasthan	124.12	33959.92	68036.00
6	Karnataka	153.21	33794.00	53734.90
7	Gujarat	236.71	55456.56	91544.00
8	Uttar Pradesh	289.69	30151.00	76725.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2015-16:

**Table 58: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	3.24	8.01	8.97	3.27	0.9896	4
2	Bihar	3.59	9.17	9.60	3.46	1.0379	5
3	Madhya Pradesh	4.12	10.35	10.81	4.62	0.8925	1
4	Maharashtra	5.61	10.74	11.62	5.72	0.9811	3
5	Rajasthan	4.82	10.43	11.13	5.11	0.9428	2
6	Karnataka	5.03	10.43	10.89	4.71	1.0688	8
7	Gujarat	5.47	10.92	11.42	5.24	1.0425	6
8	Uttar Pradesh	5.67	10.31	11.25	5.42	1.0467	7

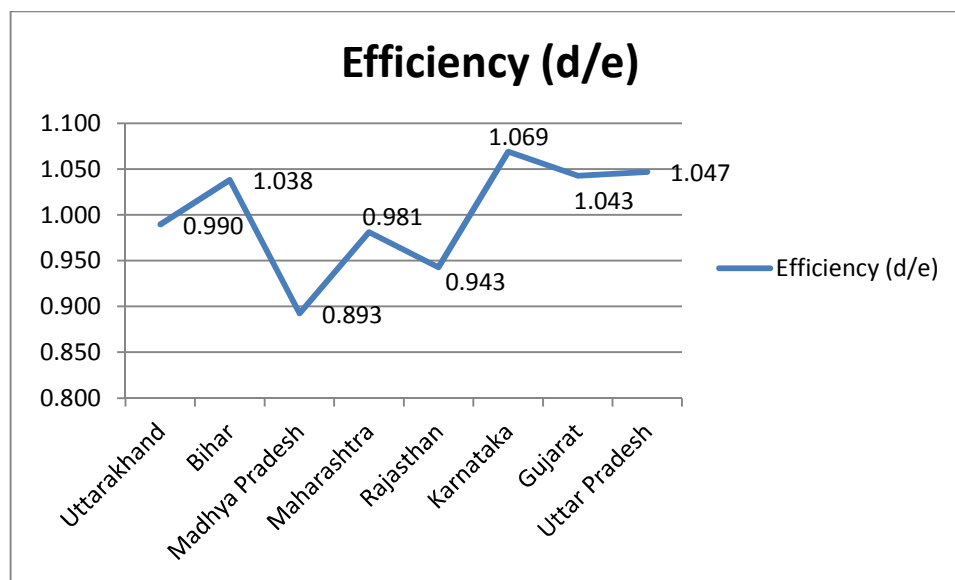


Figure 32: Efficiency (d/e) of states

### c. Corrected Ordinary Least Square Analysis

The Corrected Ordinary Least Square Method has been used along with regression analysis to arrive at the desired results.

- **Establishment of Data Management Units (DMUs)**

The Data Management Units have been established by considering the R&M cost along with the Circuit Kilometers (Ckt Km) and the Transformation Capacity (MVA). The R&M cost is the input cost and the Circuit Kilometers (Ckt Km) and Transformation Capacity (MVA) are the output achieved. The following table gives the details of the eight states (DMUs) considered for the benchmarking study:

**Table 59: R&M Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	18.67	2981.00	6097.00
2	Bihar	59.01	8394.00	9499.00
3	Madhya Pradesh	51.37	29009.77	41163.00
4	Maharashtra	193.62	43019.81	101547.00
5	Rajasthan	103.64	31092.40	53249.00
6	Karnataka	99.91	32471.00	50221.85
7	Gujarat	211.84	50131.56	68730.00
8	Uttar Pradesh	162.70	26876.00	63791.00

- **Regression Analysis**

The R&M expenses have been benchmarked with respect to line length (ckm) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the R&M expenses as given in the table below:

**Table 60: Regression Analysis of R&M Expenses**

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)	Regressed Value (Rs. Crore)
1	Uttarakhand	18.67	2981.00	6097.00	19.13
2	Bihar	59.01	8394.00	9499.00	31.45
3	Madhya Pradesh	51.37	29009.77	41163.00	103.25
4	Maharashtra	193.62	43019.81	101547.00	203.74
5	Rajasthan	103.64	31092.40	53249.00	122.32
6	Karnataka	99.91	32471.00	50221.85	120.28
7	Gujarat	211.84	50131.56	68730.00	170.33
8	Uttar Pradesh	162.70	26876.00	63791.00	130.27

It can be seen from the table given above that the actual R&M expenses for UPPTCL was Rs. 162.70 Crores for the FY 2013-14. However, after carrying out the regression analysis the employee expenses comes out to Rs. 130.27 Crores. This difference of Rs. 32.43 Crores indicates that the R&M expenses of UPPTCL are on a higher side and the same can be decreased by Rs. 32.43 Crores considering the R&M expenses of other STUs.

- **Ranking of the Utilities**

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of employee expenses. The utility with the maximum value of the ratio is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 61: Ranking of the utilities for FY 2013-14**

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	18.67	2981.00	6097.00	19.13	-32.75	-1.7543	8
2	Bihar	59.01	8394.00	9499.00	31.45	-20.43	-0.3463	7
3	Madhya Pradesh	51.37	29009.77	41163.00	103.25	51.37	1.0000	1
4	Maharashtra	193.62	43019.81	101547.00	203.74	151.86	0.7843	2
5	Rajasthan	103.64	31092.40	53249.00	122.32	70.44	0.6797	4
6	Karnataka	99.91	32471.00	50221.85	120.28	68.40	0.6846	3

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
7	Gujarat	211.84	50131.56	68730.00	170.33	118.45	0.5592	5
8	Uttar Pradesh	162.70	26876.00	63791.00	130.27	78.39	0.4818	6

It can be seen from the table given above that UPPTCL is obtaining the rank no. 6.

The graphical representation of the COLS method is shown in the figure below:

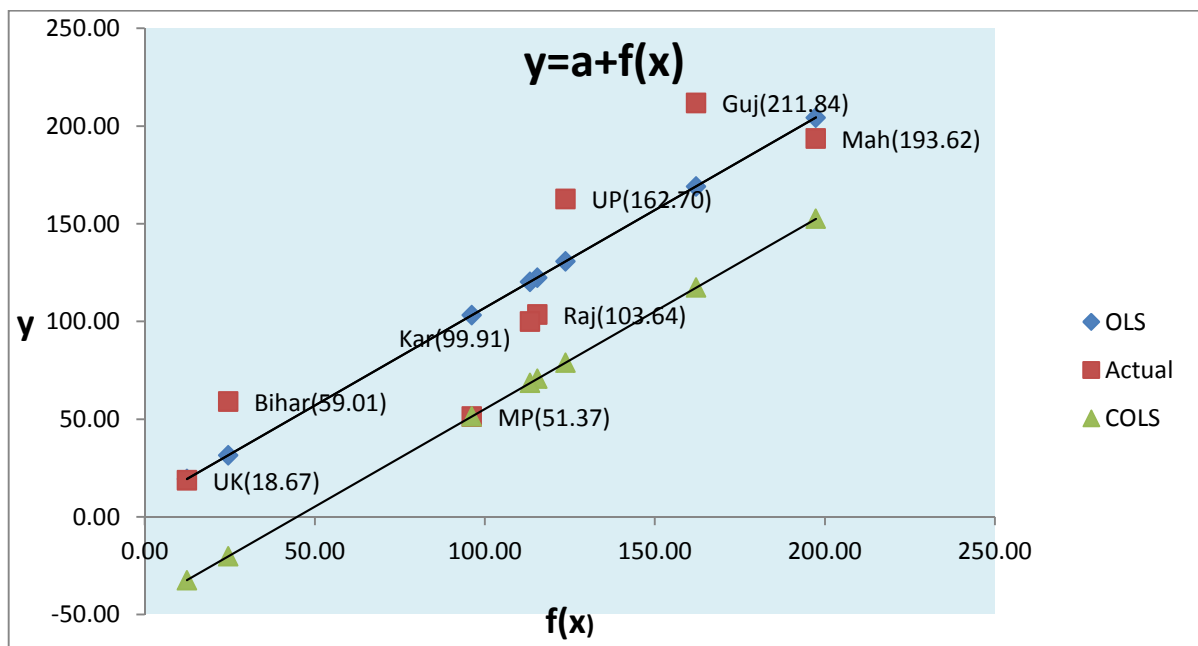


Figure 33: COLS for the R&M Expenses for the FY 2013-14

### Analysis for FY 2014-15

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

Table 62: R&M Expenses, Line Length & Transformation Capacity of different states for the FY 2014-15

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	16.57	3017.00	6582.00
2	Bihar	36.51	8617.00	11560.00
3	Madhya Pradesh	58.03	30194.99	45457.00

S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
4	Maharashtra	214.05	44207.00	105434.00
5	Rajasthan	111.55	32514.17	63378.50
6	Karnataka	137.31	33204.00	52081.50
7	Gujarat	230.18	52531.56	80113.00
8	Uttar Pradesh	195.96	28678.00	68465.00

Following the steps carried out for FY 2013-14, the following ranks are obtained for the FY 2014-15:

**Table 63: Ranking of Utilities for FY 2014-15**

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	16.57	3017.00	6582.00	11.42	-41.40	-2.4985	8
2	Bihar	36.51	8617.00	11560.00	26.53	-26.29	-0.7200	7
3	Madhya Pradesh	58.03	30194.99	45457.00	110.85	58.03	1.0000	1
4	Maharashtra	214.05	44207.00	105434.00	232.89	180.07	0.8412	2
5	Rajasthan	111.55	32514.17	63378.50	145.22	92.40	0.8283	3
6	Karnataka	137.31	33204.00	52081.50	125.97	73.15	0.5327	5
7	Gujarat	230.18	52531.56	80113.00	197.36	144.54	0.6280	4
8	Uttar Pradesh	195.96	28678.00	68465.00	149.92	97.10	0.4955	6

The graphical representation of the COLS method is shown in the figure below:

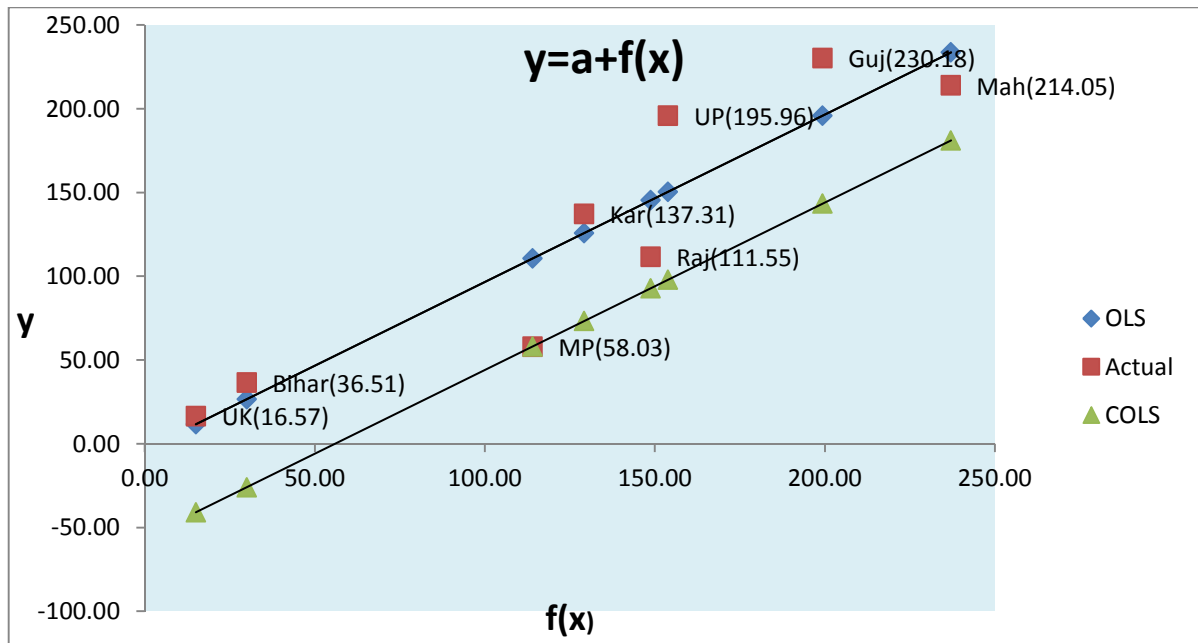


Figure 34: COLS for the R&M Expenses for the FY 2014-15

### Analysis for FY 2015-16

The following table gives the details of the eight states (DMUs) for the FY 2015-16:

Table 64: R&M Expenses, Line Length & Transformation Capacity of different states for the FY 2015-16

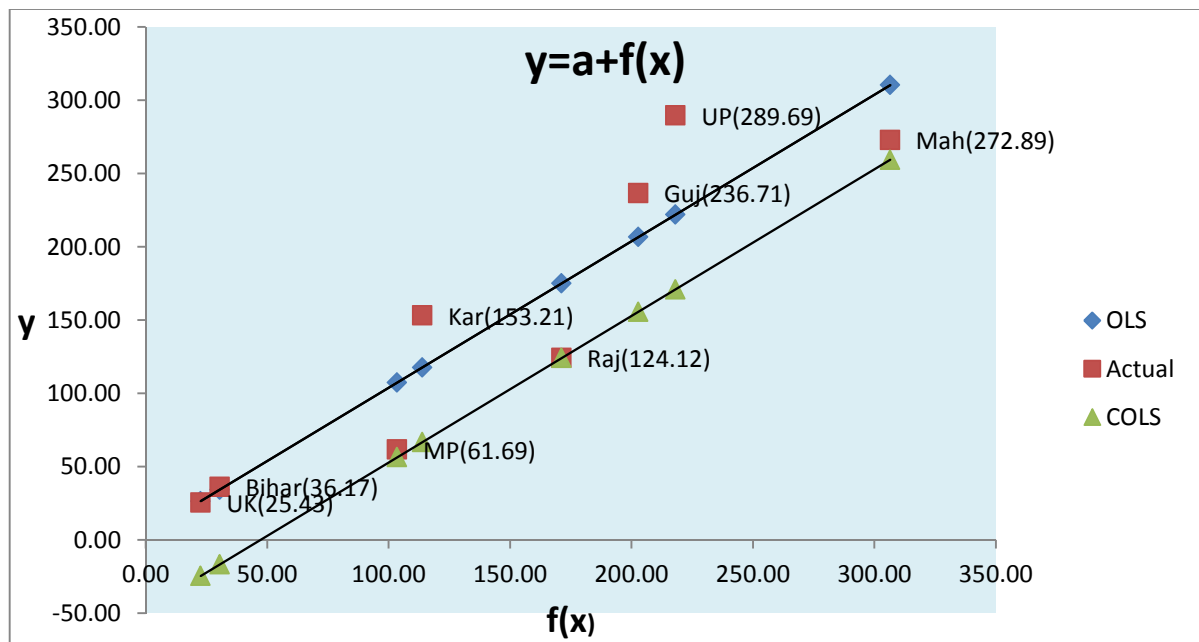
S.No.	State	R&M Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	25.43	3020.00	7872.00
2	Bihar	36.17	9573.90	14779.90
3	Madhya Pradesh	61.69	31364.08	49349.00
4	Maharashtra	272.89	46317.00	110815.00
5	Rajasthan	124.12	33959.92	68036.00
6	Karnataka	153.21	33794.00	53734.90
7	Gujarat	236.71	55456.56	91544.00
8	Uttar Pradesh	289.69	30151.00	76725.00

Following the steps carried out for FY 2013-14, the following ranks are obtained for the FY 2015-16:

**Table 65: Ranking of Utilities for FY 2015-16**

S.No.	State	R&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	25.43	3020.00	7872.00	25.61	-25.65	-1.0088	8
2	Bihar	36.17	9573.90	14779.90	34.06	-17.20	-0.4756	7
3	Madhya Pradesh	61.69	31364.08	49349.00	108.43	57.16	0.9266	3
4	Maharashtra	272.89	46317.00	110815.00	309.97	258.71	0.9480	2
5	Rajasthan	124.12	33959.92	68036.00	175.38	124.12	1.0000	1
6	Karnataka	153.21	33794.00	53734.90	118.84	67.57	0.4410	6
7	Gujarat	236.71	55456.56	91544.00	206.49	155.23	0.6558	4
8	Uttar Pradesh	289.69	30151.00	76725.00	221.13	169.87	0.5864	5

The graphical representation of the COLS method is shown in the figure below:

**Figure 35: COLS for the R&M Expenses for the FY 2015-16**

#### 4.4 Benchmarking of A&G Expenses

The benchmarking of the A&G Expenses has been carried out using the Partial Performance Indicator, Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Squares Method.

### a. Partial Performance Indicator

- A&G Expense /Ckm

The A&G expense/Ckm of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 66: A&G Expense/Ckm for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	A&G Expense/Ckt	Rank
1	Uttarakhand	12.96	2981.00	0.43475	7
2	Bihar	7.31	8394.00	0.08703	1
3	Madhya Pradesh	35.11	29009.77	0.12103	3
4	Maharashtra	189.76	43019.81	0.44110	8
5	Rajasthan <sup>1</sup>	102.64	31092.40	0.33013	6
6	Karnataka	54.26	32471.00	0.16710	4
7	Gujarat	86.13	50131.56	0.17181	5
8	Uttar Pradesh	29.03	26876.00	0.10801	2

The A&G expense/Ckm of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 67: A&G Expenses/Ckm for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	A&G Expense/Ckm	Rank
1	Uttarakhand	16.59	3017.00	0.5499	8
2	Bihar	11.66	8617.00	0.1353	2
3	Madhya Pradesh	41.64	30194.99	0.1379	3
4	Maharashtra	221.84	44207.00	0.5018	7
5	Rajasthan <sup>2</sup>	77.28	32514.17	0.2377	6
6	Karnataka	70.59	33204.00	0.2126	5
7	Gujarat	88.43	52531.56	0.1683	4
8	Uttar Pradesh	34.07	28678.00	0.1188	1

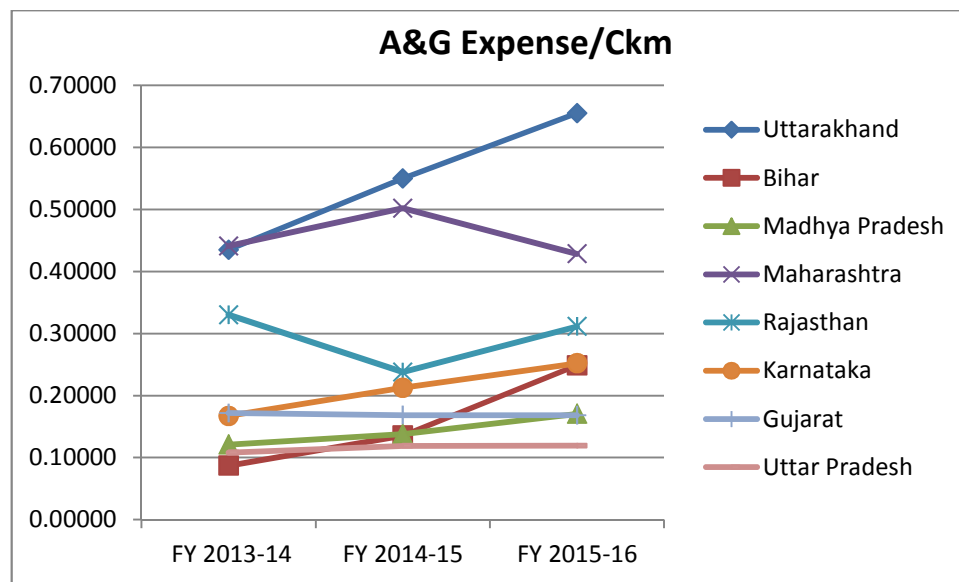
The A&G expense/Ckm of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

<sup>2</sup>As per the audited accounts of RVPN for the FY 2014-15, the total A&G expenses were Rs. 287.90 Crore. However, these include Rs. 210.63 Crore of bad and doubtful written off. The same have not been included in the benchmarking study as the A&G expenses of other STUs considered for the study do not include the bad and doubtful written off.



**Table 68: A&G Expense/Ckm for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	A&G Expense/Ckt	Rank
1	Uttarakhand	19.78	3020.00	0.6550	8
2	Bihar	23.79	9573.90	0.2485	4
3	Madhya Pradesh	53.47	31364.08	0.1705	3
4	Maharashtra	198.44	46317.00	0.4284	7
5	Rajasthan	105.73	33959.92	0.3114	6
6	Karnataka	85.18	33794.00	0.2520	5
7	Gujarat	93.32	55456.56	0.1683	2
8	Uttar Pradesh	35.96	30151.00	0.1193	1

**Figure 36: A&G Expense/Ckm**

It can be seen that the A&G expenses of UPPTCL are one of the lowest and the per Ckm A&G expenses of UPPTCL is Rs. 0.1193 lakh/Ckm during the FY 2015-16 which is the lowest among all the utilities. The rank of UPPTCL is 1 among the eight utilities considered for the study.

- **A&G Expense /MVA**

The A&G expense/MVA of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 69: A&G Expense/MVA for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore)	Transformation Capacity (MVA)	A&G Expense/MVA	Rank
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S.No.	State	A&G Expenses (Rs. Crore)	Transformation Capacity (MVA)	A&G Expense/MVA	Rank
1	Uttarakhand	12.96	6097.00	0.2126	8
2	Bihar	7.31	9499.00	0.0769	2
3	Madhya Pradesh	35.11	41163.00	0.0853	3
4	Maharashtra	189.76	101547.00	0.1869	6
5	Rajasthan	102.64	53249.00	0.1928	7
6	Karnataka	54.26	50221.85	0.1080	4
7	Gujarat	86.13	68730.00	0.1253	5
8	Uttar Pradesh	29.03	63791.00	0.0455	1

The A&G expense/MVA of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

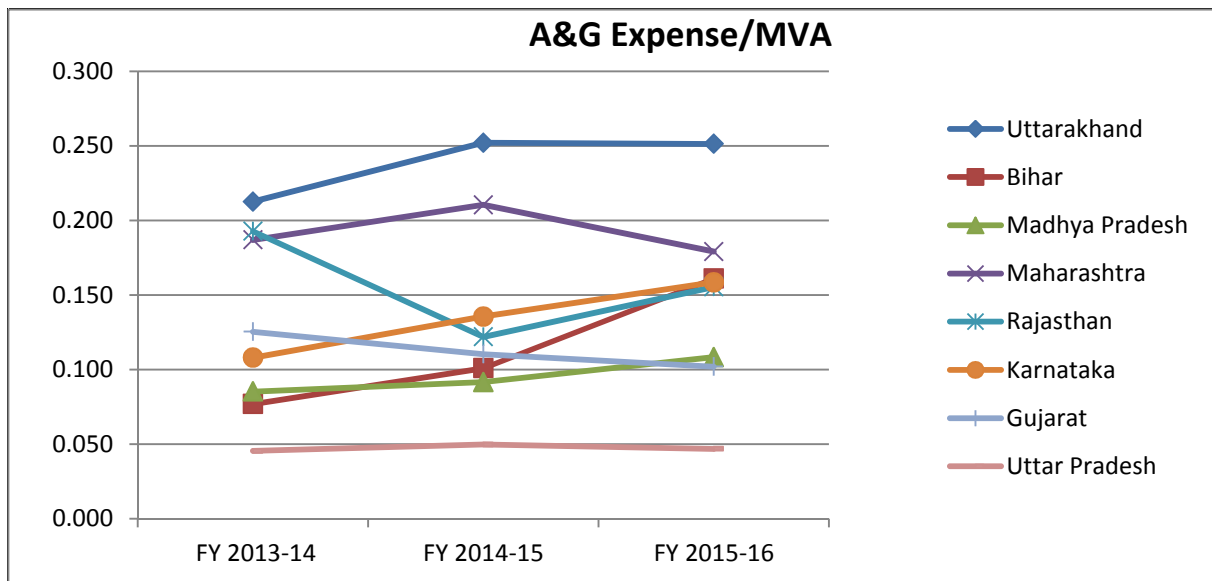
**Table 70: A&G Expense/MVA for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore)	Transformation Capacity (MVA)	A&G Expense/MVA	Rank
1	Uttarakhand	16.59	6582.00	0.25205	8
2	Bihar	11.66	11560.00	0.10086	3
3	Madhya Pradesh	41.64	45457.00	0.09160	2
4	Maharashtra	221.84	105434.00	0.21041	7
5	Rajasthan	77.28	63378.50	0.12193	5
6	Karnataka	70.59	52081.50	0.13554	6
7	Gujarat	88.43	80113.00	0.11038	4
8	Uttar Pradesh	34.07	68465.00	0.04976	1

The A&G expense/MVA of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 71: A&G Expense/MVA for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore)	Transformation Capacity (MVA)	A&G Expense/MVA	Rank
1	Uttarakhand	19.78	7872.00	0.2513	8
2	Bihar	23.79	14779.90	0.1610	6
3	Madhya Pradesh	53.47	49349.00	0.1083	3
4	Maharashtra	198.44	110815.00	0.1791	7
5	Rajasthan	105.73	68036.00	0.1554	4
6	Karnataka	85.18	53734.90	0.1585	5
7	Gujarat	93.32	91544.00	0.1019	2
8	Uttar Pradesh	35.96	76725.00	0.0469	1

**Figure 37: A&G Expense/MVA**

The A&G Expenses of UPPTCL is the lowest among all the utilities and the MVA capacity is the third highest, hence, the per MVA A&G Expense is the lowest among all the utilities during all the three years.

- **A&G Expense /MU**

The A&G expense/MU of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 72: A&G Expense/MU for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore)	Energy Transmitted (MU)	A&G Expense/MU	Rank
1	Uttarakhand	12.96	13227.00	0.09798	5
2	Bihar	7.31	13786.16	0.05299	2
3	Madhya Pradesh	35.11	50300.00	0.06980	3
4	Maharashtra	189.76	117289.13	0.16179	8
5	Rajasthan	102.64	63851.02	0.16076	7
6	Karnataka	54.26	56733.00	0.09564	4
7	Gujarat	86.13	70712.07	0.12180	6
8	Uttar Pradesh	29.03	77760.69	0.03733	1

The A&G expense/MU of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

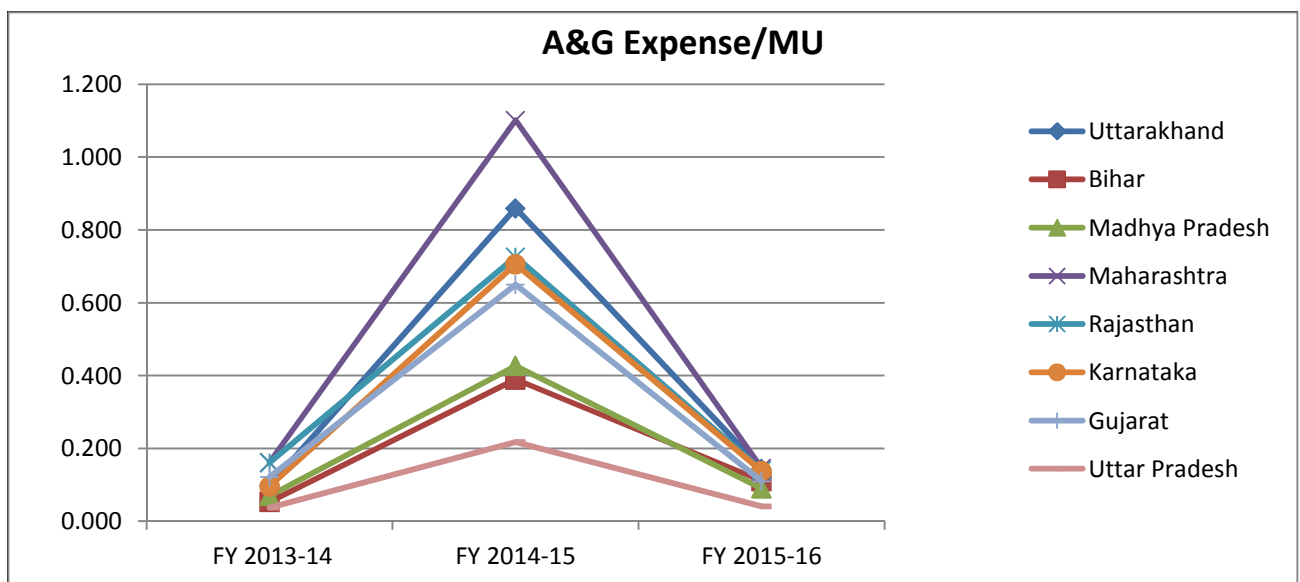
**Table 73: A&G Expense/MU for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore)	Energy Transmitted (MU)	A&G Expense/MU	Rank
1	Uttarakhand	16.59	13612.23	0.8596	7
2	Bihar	11.66	16986.53	0.3894	2
3	Madhya Pradesh	41.64	55206.00	0.4269	3
4	Maharashtra	221.84	130107.38	1.1011	8
5	Rajasthan	77.28	67257.92	0.7261	6
6	Karnataka	70.59	59420.35	0.7058	5
7	Gujarat	88.43	78933.59	0.6501	4
8	Uttar Pradesh	34.07	82413.86	0.2174	1

The A&G expense/MU of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 74: A&G Expense/MU for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore)	Energy Transmitted (MU)	A&G Expense/MU	Rank
1	Uttarakhand	19.78	13734.00	0.14402	7
2	Bihar	23.79	21485.35	0.11073	4
3	Madhya Pradesh	53.47	59335.00	0.09011	2
4	Maharashtra	198.44	136215.34	0.14568	8
5	Rajasthan	105.73	75567.74	0.13992	6
6	Karnataka	85.18	61957.51	0.13747	5
7	Gujarat	93.32	84889.83	0.10993	3
8	Uttar Pradesh	35.96	88402.14	0.04068	1

**Figure 38: A&G Expense/MU**

The A&G Expenses of UPPTCL is the lowest among all the utilities and the energy transmitted is the second highest, hence, the per MU A&G Expense is the lowest among all the utilities during all the three years.

- A&G Expense /MW**

The A&G expense/MW of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 75: A&G Expense/MW for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore)	Peak Demand (MW)	A&G Expense/MW	Rank
1	Uttarakhand	12.96	1826.00	0.7097	6
2	Bihar	7.31	2465.00	0.2964	2
3	Madhya Pradesh	35.11	9716.00	0.3614	3
4	Maharashtra	189.76	19276.00	0.9844	7
5	Rajasthan	102.64	10047.00	1.0216	8
6	Karnataka	54.26	9940.00	0.5459	4
7	Gujarat	86.13	12201.00	0.7059	5
8	Uttar Pradesh	29.03	13089.00	0.2218	1

The A&G expense/MW of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

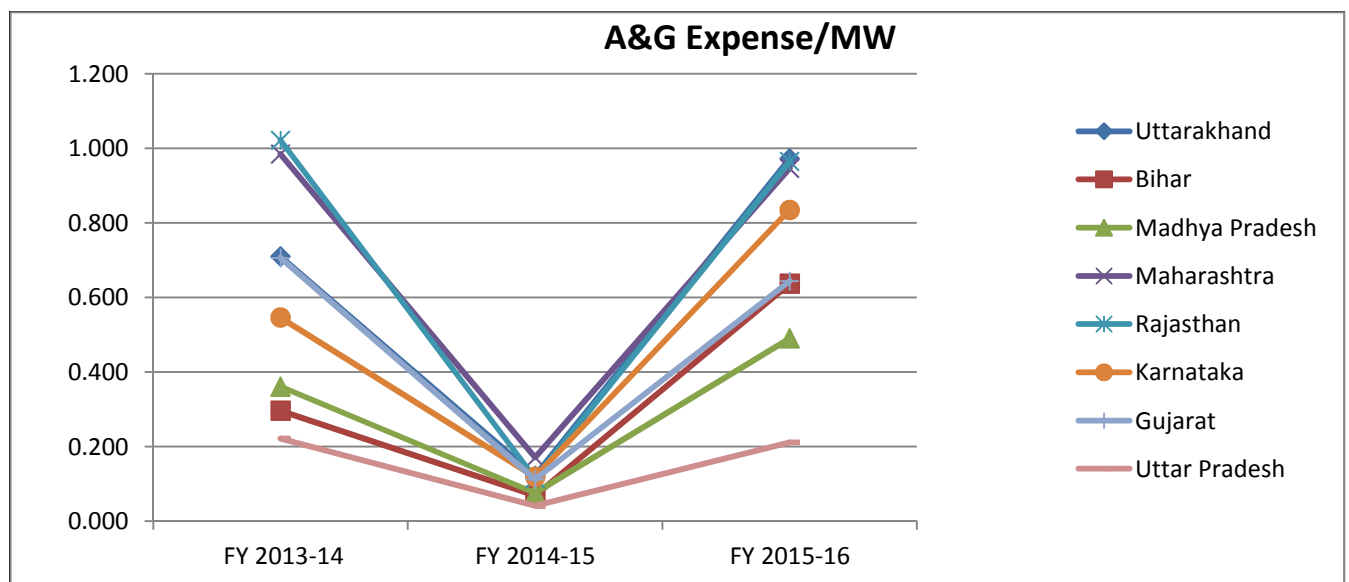
**Table 76: A&G Expense/MW for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore)	Peak Demand (MW)	A&G Expense/MW	Rank
1	Uttarakhand	16.59	1930.00	0.1219	7
2	Bihar	11.66	2994.00	0.0686	2
3	Madhya Pradesh	41.64	9755.00	0.0754	3
4	Maharashtra	221.84	20147.00	0.1705	8
5	Rajasthan	77.28	10642.00	0.1149	5
6	Karnataka	70.59	10001.00	0.1188	6
7	Gujarat	88.43	13603.00	0.1120	4
8	Uttar Pradesh	34.07	15670.00	0.0413	1

The A&G expense/MW of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 77: A&G Expense/MW for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore)	Peak Demand (MW)	A&G Expense/MW	Rank
1	Uttarakhand	19.78	2034.00	0.9725	8
2	Bihar	23.79	3735.00	0.6370	3
3	Madhya Pradesh	53.47	10902.00	0.4904	2
4	Maharashtra	198.44	20973.00	0.9462	6
5	Rajasthan	105.73	10961.00	0.9646	7
6	Karnataka	85.18	10202.00	0.8349	5
7	Gujarat	93.32	14495.00	0.6438	4
8	Uttar Pradesh	35.96	16988.00	0.2117	1

**Figure 39: A&G Expense/MW**

The A&G Expenses of UPPTCL is the lowest among all the utilities and the peak demand met is the second highest, hence, the per MW A&G Expense is the lowest among all the utilities during all the three years.

### ***b. Econometric Method***

- **The selection of variables**

Benchmarking of the A&G expenses has been carried out by considering the following variables as given in the table below:

**Table 78: A&G Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	12.96	2981.00	6097.00
2	Bihar	7.31	8394.00	9499.00
3	Madhya Pradesh	35.11	29009.77	41163.00
4	Maharashtra	189.76	43019.81	101547.00
5	Rajasthan	102.64	31092.40	53249.00
6	Karnataka	54.26	32471.00	50221.85
7	Gujarat	86.13	50131.56	68730.00
8	Uttar Pradesh	29.03	26876.00	63791.00

Doing the regression analysis on the values obtained after considering log of the values in table 78 we obtain the following values:

**Table 79: Regression Analysis of A&G Expenses**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	2.56	8.00	8.72	2.19
2	Bihar	1.99	9.04	9.16	2.34
3	Madhya Pradesh	3.56	10.28	10.63	3.77
4	Maharashtra	5.25	10.67	11.53	4.82
5	Rajasthan	4.63	10.34	10.88	4.09
6	Karnataka	3.99	10.39	10.82	3.99
7	Gujarat	4.46	10.82	11.14	4.22
8	Uttar Pradesh	3.37	10.20	11.06	4.39

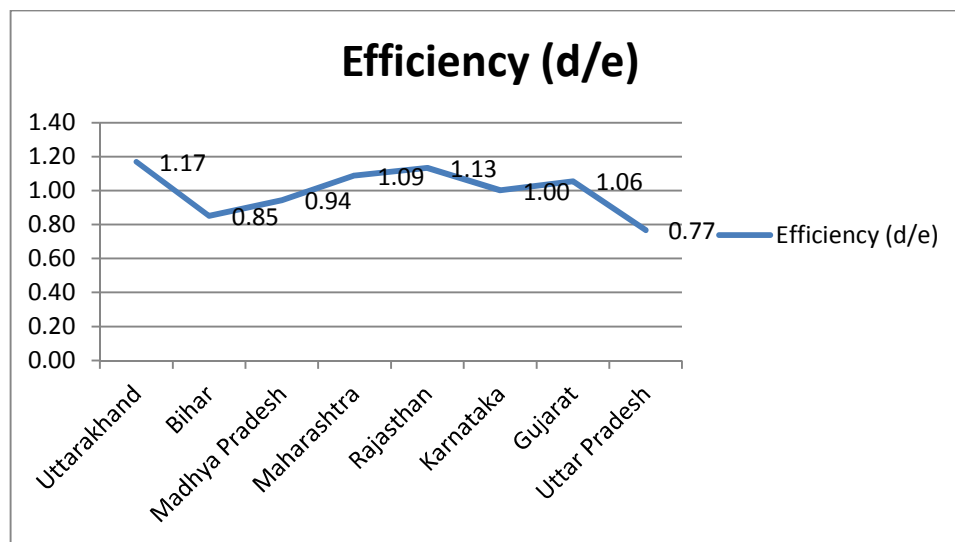
Having obtained the regressed value the efficiency of the STUs has been obtained in the following table:



**Table 80: Rank Obtained (FY 2013-14)**

S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	2.56	8.00	8.72	2.19	1.17	8
2	Bihar	1.99	9.04	9.16	2.34	0.85	2
3	Madhya Pradesh	3.56	10.28	10.63	3.77	0.94	3
4	Maharashtra	5.25	10.67	11.53	4.82	1.09	6
5	Rajasthan	4.63	10.34	10.88	4.09	1.13	7
6	Karnataka	3.99	10.39	10.82	3.99	1.00	4
7	Gujarat	4.46	10.82	11.14	4.22	1.06	5
8	Uttar Pradesh	3.37	10.20	11.06	4.39	0.77	1

It can be seen from the table given above that the rank obtained by UPPTCL is no. 1.

**Figure 40: Efficiency (d/e) of states**

### Analysis for FY 2014-15

Benchmarking of the A&G Expenses for FY 2014-15 has been carried out by considering the following variables as given in the table below:

**Table 81: A&G Expenses, Line Length & Transformation Capacity of different states for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	16.59	3017.00	6582.00
2	Bihar	11.66	8617.00	11560.00

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
3	Madhya Pradesh	41.64	30194.99	45457.00
4	Maharashtra	221.84	44207.00	105434.00
5	Rajasthan	77.28	32514.17	63378.50
6	Karnataka	70.59	33204.00	52081.50
7	Gujarat	88.43	52531.56	80113.00
8	Uttar Pradesh	34.07	28678.00	68465.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

**Table 82: Rank Obtained for FY 2014-15**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	2.81	8.01	8.79	2.51	1.12	7
2	Bihar	2.46	9.06	9.36	2.70	0.91	2
3	Madhya Pradesh	3.73	10.32	10.72	3.87	0.96	3
4	Maharashtra	5.40	10.70	11.57	4.82	1.12	8
5	Rajasthan	4.35	10.39	11.06	4.29	1.01	4
6	Karnataka	4.26	10.41	10.86	4.01	1.06	6
7	Gujarat	4.48	10.87	11.29	4.34	1.03	5
8	Uttar Pradesh	3.53	10.26	11.13	4.47	0.79	1

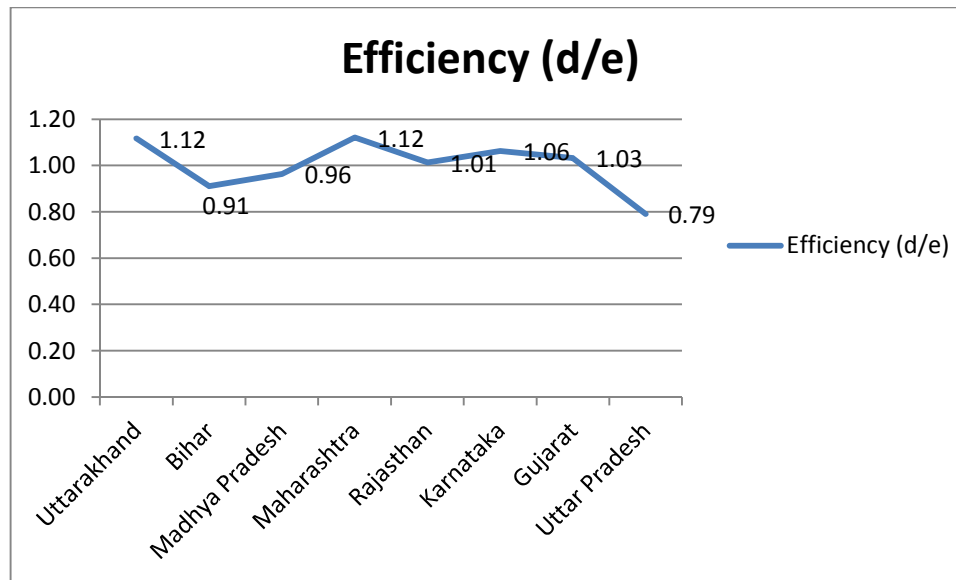


Figure 41: Efficiency (d/e) of states

### Analysis for FY 2015-16

Benchmarking of the A&G Expenses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

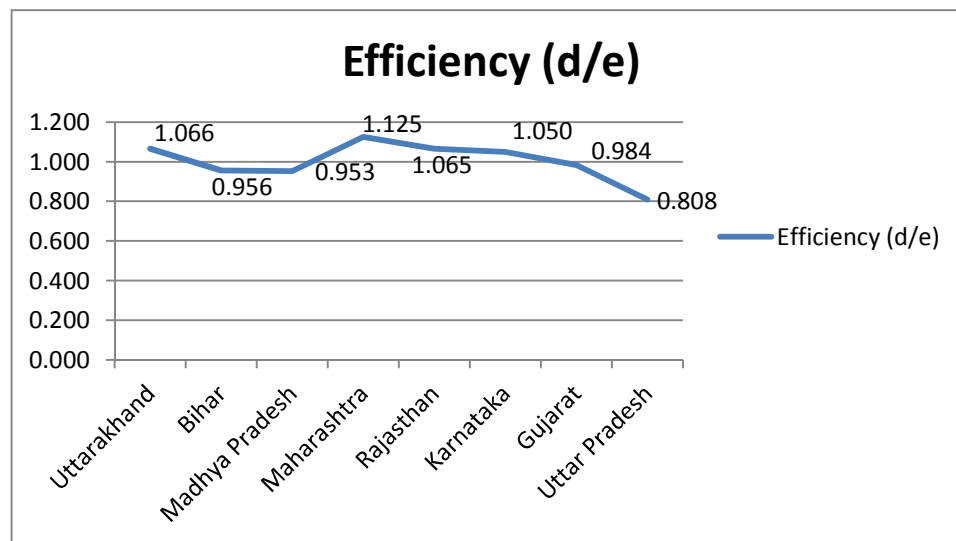
**Table 83: A&G Expenses, Line Length & Transformation Capacity of different states for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	19.78	3020.00	7872.00
2	Bihar	23.79	9573.90	14779.90
3	Madhya Pradesh	53.47	31364.08	49349.00
4	Maharashtra	198.44	46317.00	110815.00
5	Rajasthan	105.73	33959.92	68036.00
6	Karnataka	85.18	33794.00	53734.90
7	Gujarat	93.32	55456.56	91544.00
8	Uttar Pradesh	35.96	30151.00	76725.00

Following the steps carried out for FY 2014-15, the efficiency of the STUs have been obtained in the following table for FY 2015-16:

**Table 84: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	2.98	8.01	8.97	2.80	1.0656	7
2	Bihar	3.17	9.17	9.60	3.31	0.9563	3
3	Madhya Pradesh	3.98	10.35	10.81	4.17	0.9532	2
4	Maharashtra	5.29	10.74	11.62	4.70	1.1248	8
5	Rajasthan	4.66	10.43	11.13	4.38	1.0652	6
6	Karnataka	4.44	10.43	10.89	4.23	1.0497	5
7	Gujarat	4.54	10.92	11.42	4.61	0.9837	4
8	Uttar Pradesh	3.58	10.31	11.25	4.43	0.8081	1

**Figure 42: Efficiency (d/e) of states**

### ***c. Corrected Ordinary Least Squares Method***

The Corrected Ordinary Least Squares Method has been used along with regression analysis to arrive at the desired results.

- **Establishment of Data Management Units (DMUs)**

The Data Management Units have been established by considering the A&G cost along with the Circuit Kilometers (Ckm) and the Transformation Capacity (MVA). The A&G cost is the input cost and the Circuit Kilometers (Ckm) and Transformation Capacity (MVA) are the output achieved. The following table gives the details of the eight states (DMUs) considered for the benchmarking study:

**Table 85: A&G Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	12.96	2981.00	6097.00
2	Bihar	7.31	8394.00	9499.00
3	Madhya Pradesh	35.11	29009.77	41163.00
4	Maharashtra	189.76	43019.81	101547.00
5	Rajasthan	102.64	31092.40	53249.00
6	Karnataka	54.26	32471.00	50221.85
7	Gujarat	86.13	50131.56	68730.00
8	Uttar Pradesh	29.03	26876.00	63791.00

### • Regression Analysis

The A&G expenses have been benchmarked with respect to line length (Ckm) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the A&G expenses as given in the table below:

**Table 86: Regression Analysis of A&G Expenses**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	12.96	2981.00	6097.00	-3.52
2	Bihar	7.31	8394.00	9499.00	-0.15
3	Madhya Pradesh	35.11	29009.77	41163.00	48.51
4	Maharashtra	189.76	43019.81	101547.00	155.97
5	Rajasthan	102.64	31092.40	53249.00	70.44
6	Karnataka	54.26	32471.00	50221.85	63.85
7	Gujarat	86.13	50131.56	68730.00	89.04
8	Uttar Pradesh	29.03	26876.00	63791.00	93.06

It can be seen from the table given above that the actual A&G expenses for UPPTCL was Rs. 29.03 Crores for the FY 2013-14. However, after carrying out the regression analysis the A&G expenses comes out to Rs. 93.06 Crores. This difference of Rs. 64.03 Crores indicates that the A&G expenses of UPPTCL are on a much lower side as compared to other STUs and the same can be increased by Rs. 64.03 Crores considering the A&G expenses of other STUs.

### • Ranking of the Utilities

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of employee expenses. The utility with the maximum value of the ratio

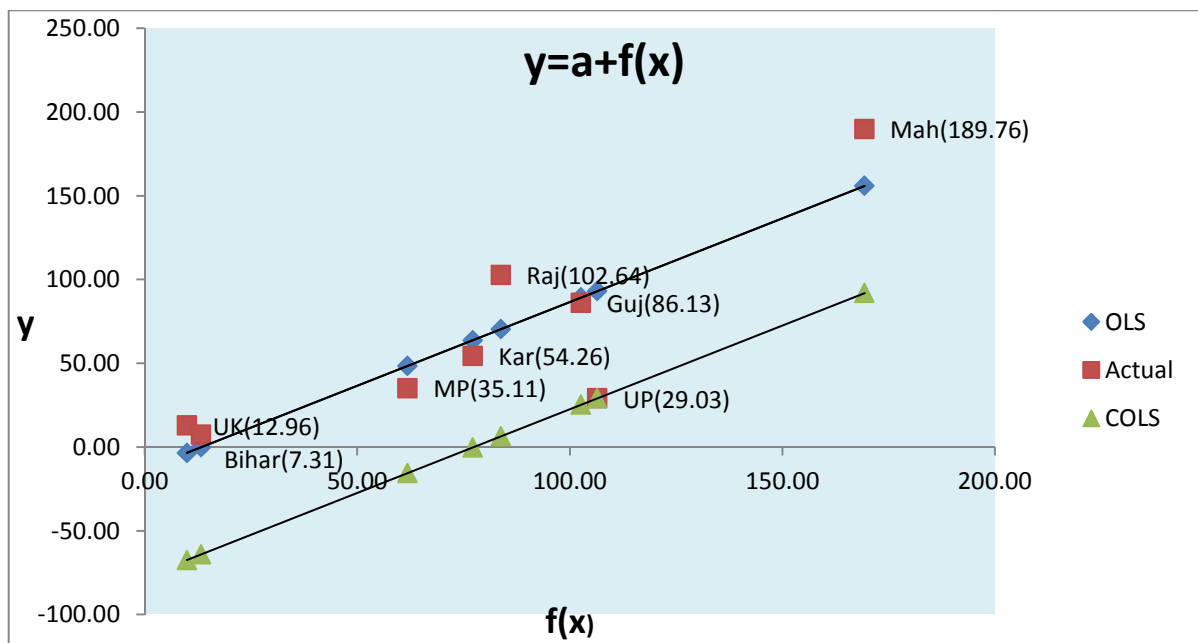
is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 87: Ranking of the Utilities for FY 2013-14**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Values (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	12.96	2981.00	6097.00	-3.52	-67.55	-5.2122	7
2	Bihar	7.31	8394.00	9499.00	-0.15	-64.18	-8.7850	8
3	Madhya Pradesh	35.11	29009.77	41163.00	48.51	-15.52	-0.4420	6
4	Maharashtra	189.76	43019.81	101547.00	155.97	91.94	0.4845	2
5	Rajasthan	102.64	31092.40	53249.00	70.44	6.41	0.0624	4
6	Karnataka	54.26	32471.00	50221.85	63.85	-0.18	-0.0034	5
7	Gujarat	86.13	50131.56	68730.00	89.04	25.01	0.2903	3
8	Uttar Pradesh	29.03	26876.00	63791.00	93.06	29.03	1.0000	1

It can be seen from the table given above that UPPTCL is obtaining the rank no. 1.

The graphical representation of the COLS method is shown in the figure below:



**Figure 43: COLS for the A&G Expenses for FY 2013-14**

## Analysis for FY 2014-15

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

**Table 88: A&G Expenses, Line Length & Transformation Capacity of different states for the FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	16.59	3017.00	6582.00
2	Bihar	11.66	8617.00	11560.00
3	Madhya Pradesh	41.64	30194.99	45457.00
4	Maharashtra	221.84	44207.00	105434.00
5	Rajasthan	77.28	32514.17	63378.50
6	Karnataka	70.59	33204.00	52081.50
7	Gujarat	88.43	52531.56	80113.00
8	Uttar Pradesh	34.07	28678.00	68465.00

Following the steps carried out for FY 2013-14, the following ranks are obtained for the utilities for FY 2014-15:

**Table 89: Ranking of Utilities for FY 2014-15**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	16.59	3017.00	6582.00	-1.61	-74.67	-4.50	7
2	Bihar	11.66	8617.00	11560.00	0.67	-72.39	-6.21	8
3	Madhya Pradesh	41.64	30194.99	45457.00	46.46	-26.60	-0.64	6
4	Maharashtra	221.84	44207.00	105434.00	171.73	98.67	0.44	2
5	Rajasthan	77.28	32514.17	63378.50	87.31	14.25	0.18	4
6	Karnataka	70.59	33204.00	52081.50	57.62	-15.44	-0.22	5
7	Gujarat	88.43	52531.56	80113.00	92.78	19.71	0.22	3
8	Uttar Pradesh	34.07	28678.00	68465.00	107.13	34.07	1.00	1

The graphical representation of the COLS method is shown in the figure below:

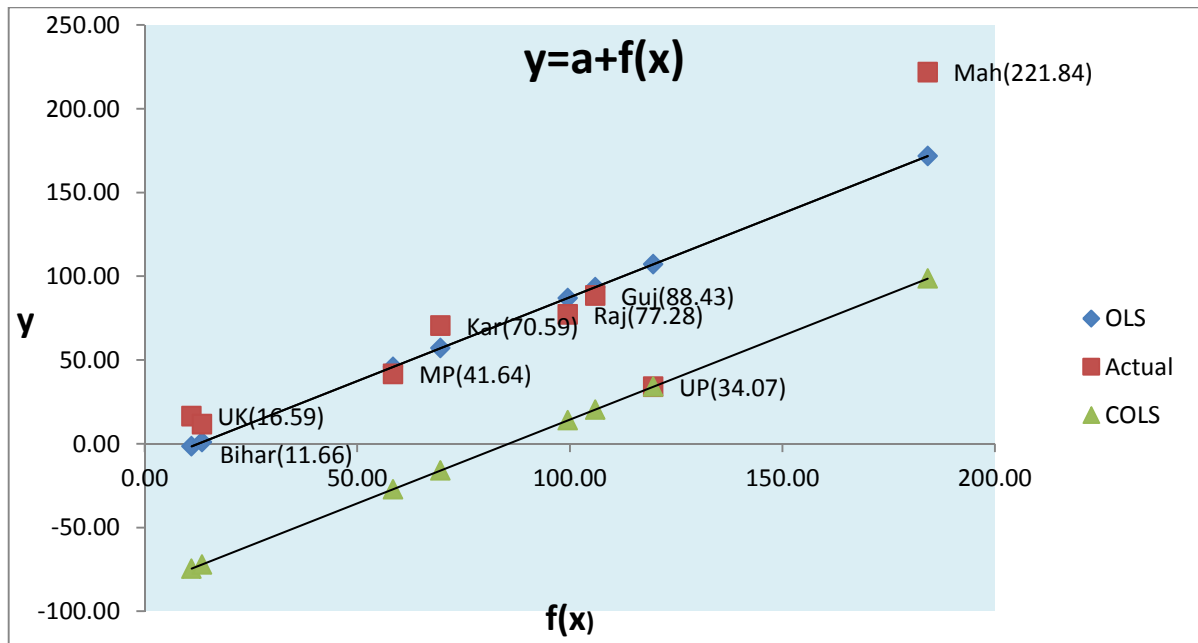


Figure 44: COLS for the A&G Expenses for FY 2014-15

### Analysis for FY 2015-16

The following table gives the details of the eight states (DMUs) for the FY 2015-16:

Table 90: A&G Expenses, Line Length & Transformation Capacity of different states for the FY 2015-16

S.No.	State	A&G Expenses (Rs. Crore)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	19.78	3020.00	7872.00
2	Bihar	23.79	9573.90	14779.90
3	Madhya Pradesh	53.47	31364.08	49349.00
4	Maharashtra	198.44	46317.00	110815.00
5	Rajasthan	105.73	33959.92	68036.00
6	Karnataka	85.18	33794.00	53734.90
7	Gujarat	93.32	55456.56	91544.00
8	Uttar Pradesh	35.96	30151.00	76725.00

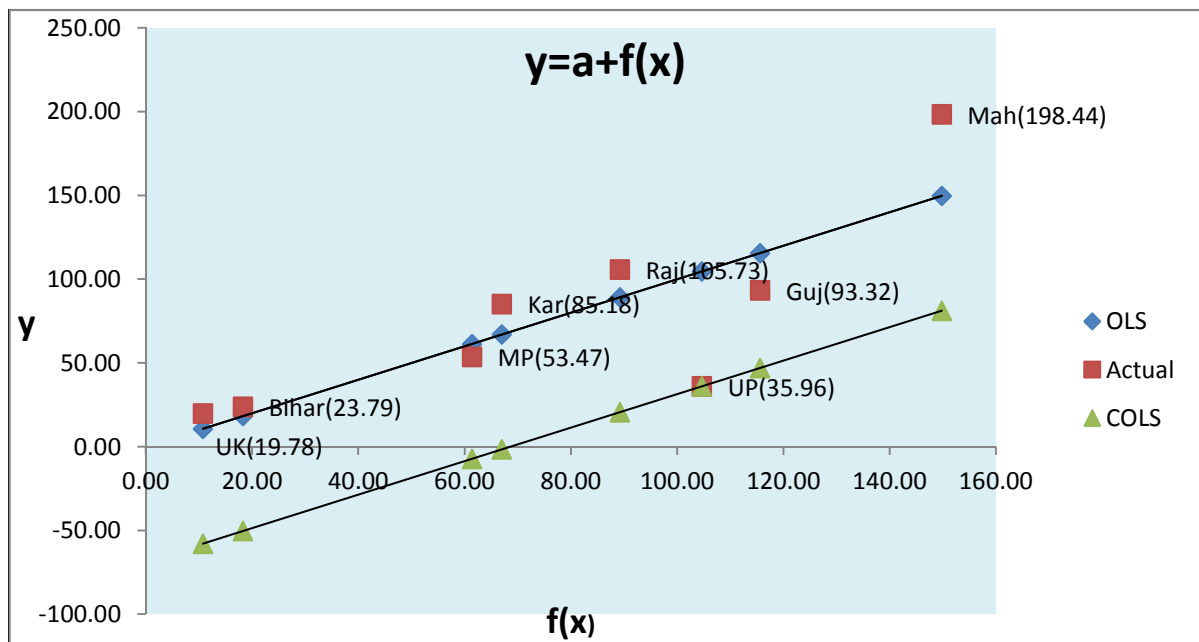
Following the steps carried out for FY 2013-14, the following ranks are obtained for the utilities for the FY 2015-16:



**Table 91: Ranking of Utilities for FY 2015-16**

S.No.	State	A&G Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Values (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	19.78	3020.00	7872.00	10.78	-58.22	-2.9431	8
2	Bihar	23.79	9573.90	14779.90	18.16	-50.83	-2.1364	7
3	Madhya Pradesh	53.47	31364.08	49349.00	61.06	-7.93	-0.1484	6
4	Maharashtra	198.44	46317.00	110815.00	150.11	81.12	0.4088	3
5	Rajasthan	105.73	33959.92	68036.00	89.18	20.19	0.1909	4
6	Karnataka	85.18	33794.00	53734.90	66.68	-2.31	-0.0271	5
7	Gujarat	93.32	55456.56	91544.00	114.76	45.77	0.4904	2
8	Uttar Pradesh	35.96	30151.00	76725.00	104.95	35.96	1.0000	1

The graphical representation of the COLS method is shown in the figure below:



**Figure 45: COLS for the A&G Expenses for FY 2015-16**

## 4.5 Benchmarking of O&M Expenses

The benchmarking of the O&M Expenses (Employee Expense, R&M Expense and A&G Expense) has been carried out using the Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Squares Method.

### a. Econometric Method

- **The selection of variables**

Benchmarking of the O&M expenses for FY 2013-14 has been carried out by considering the following variables as given in the table below:

**Table 92: O&M Expenses, Line Length & Transformation Capacity of different states**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	82.24	2981.00	6097.00
2	Bihar	152.99	8394.00	9499.00
3	Madhya Pradesh	374.30	29009.77	41163.00
4	Maharashtra	1202.88	43019.81	101547.00
5	Rajasthan	1210.53	31092.40	53249.00
6	Karnataka	865.53	32471.00	50221.85
7	Gujarat	894.68	50131.56	68730.00
8	Uttar Pradesh	587.00	26876.00	63791.00

Doing the regression analysis on the values obtained after considering log of the values in table 92 we obtain the following values:

**Table 93: Regression Analysis of O&M Expenses**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	4.41	8.00	8.72	4.40
2	Bihar	5.03	9.04	9.16	5.02
3	Madhya Pradesh	5.93	10.28	10.63	6.37
4	Maharashtra	7.09	10.67	11.53	7.08
5	Rajasthan	7.10	10.34	10.88	6.56
6	Karnataka	6.76	10.39	10.82	6.54

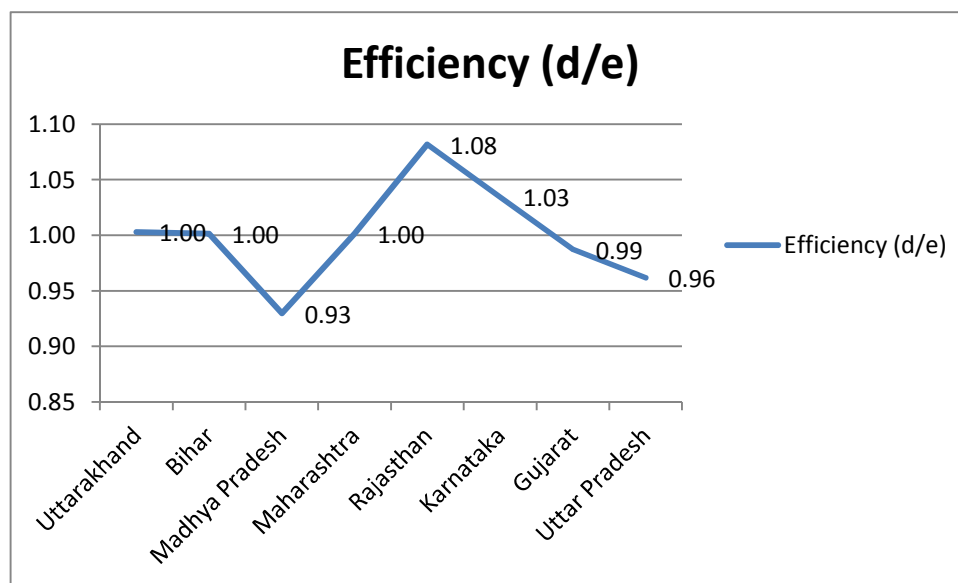
S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)
7	Gujarat	6.80	10.82	11.14	6.88
8	Uttar Pradesh	6.38	10.20	11.06	6.63

Having obtained the regressed value the efficiency of the STUs have been obtained in the following table:

**Table 94: Rank Obtained (FY 2013-14)**

S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.41	8.00	8.72	4.40	1.00	6
2	Bihar	5.03	9.04	9.16	5.02	1.00	5
3	Madhya Pradesh	5.93	10.28	10.63	6.37	0.93	1
4	Maharashtra	7.09	10.67	11.53	7.08	1.00	4
5	Rajasthan	7.10	10.34	10.88	6.56	1.08	8
6	Karnataka	6.76	10.39	10.82	6.54	1.03	7
7	Gujarat	6.80	10.82	11.14	6.88	0.99	3
8	Uttar Pradesh	6.38	10.20	11.06	6.63	0.96	2

It can be seen from the table given above that the rank obtained by UPPTCL is no. 2.



**Figure 46: Efficiency (d/e) of states**

### Analysis for FY 2014-15

Benchmarking of the O&M expenses for FY 2014-15 has been carried out by considering the following variables as given in the table below:

**Table 95: O&M Expenses, Line Length & Transformation Capacity of different states for FY 2014-15**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	85.01	3017.00	6582.00
2	Bihar	141.52	8617.00	11560.00
3	Madhya Pradesh	411.89	30194.99	45457.00
4	Maharashtra	1284.32	44207.00	105434.00
5	Rajasthan	1134.34	32514.17	63378.50
6	Karnataka	1012.63	33204.00	52081.50
7	Gujarat	962.59	52531.56	80113.00
8	Uttar Pradesh	626.91	28678.00	68465.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

**Table 96: Rank Obtained for FY 2014-15**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.44	8.01	8.79	4.39	1.01	6
2	Bihar	4.95	9.06	9.36	5.03	0.99	3
3	Madhya Pradesh	6.02	10.32	10.72	6.38	0.94	1
4	Maharashtra	7.16	10.70	11.57	7.16	1.00	5
5	Rajasthan	7.03	10.39	11.06	6.68	1.05	7
6	Karnataka	6.92	10.41	10.86	6.52	1.06	8
7	Gujarat	6.87	10.87	11.29	6.95	0.99	4
8	Uttar Pradesh	6.44	10.26	11.13	6.73	0.96	2

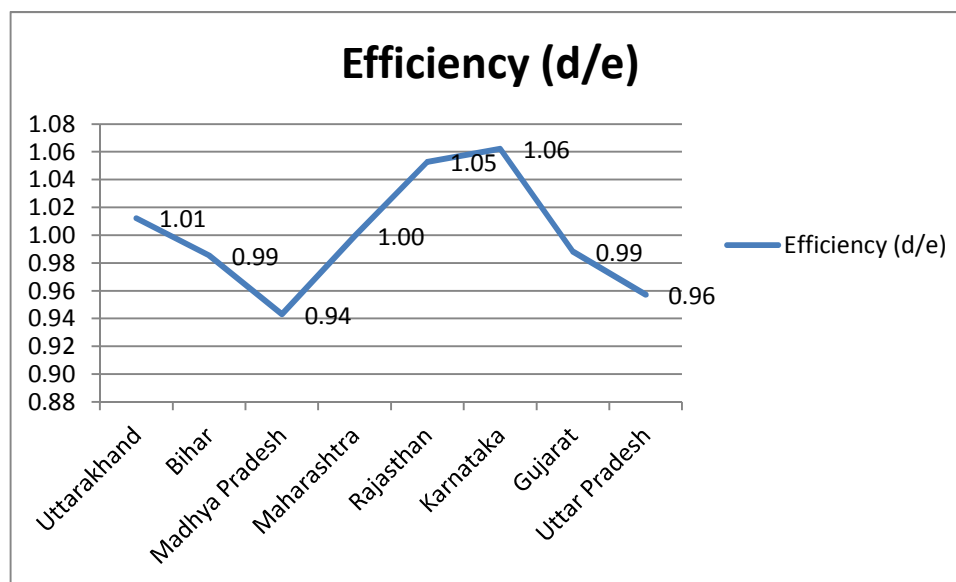


Figure 47: Efficiency (d/e) of states

### Analysis for FY 2015-16

Benchmarking of the O&M expenses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

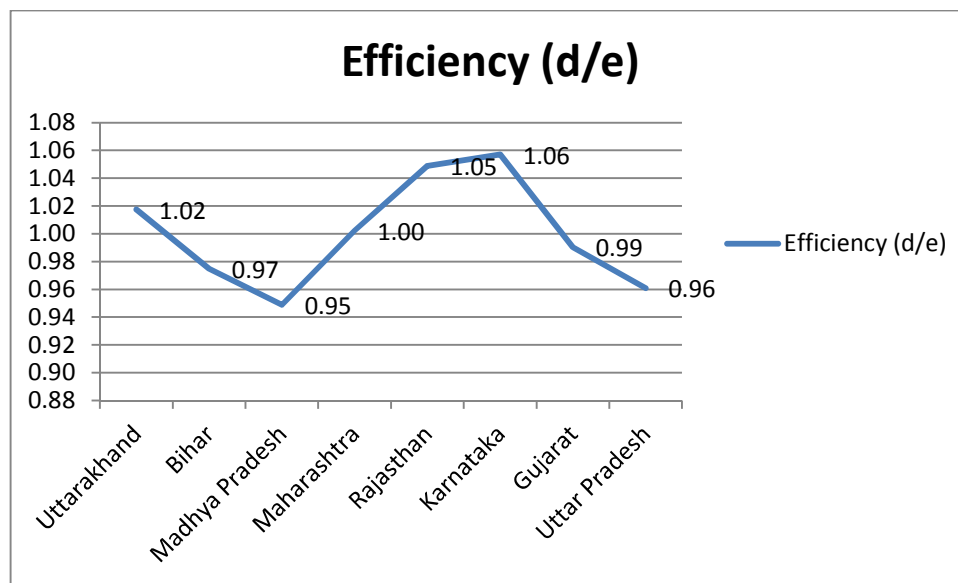
Table 97: O&M Expenses, Line Length & Transformation Capacity of different states for FY 2015-16

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	102.76	3020.00	7872.00
2	Bihar	158.95	9573.90	14779.90
3	Madhya Pradesh	441.43	31364.08	49349.00
4	Maharashtra	1399.09	46317.00	110815.00
5	Rajasthan	1171.69	33959.92	68036.00
6	Karnataka	968.59	33794.00	53734.90
7	Gujarat	1068.46	55456.56	91544.00
8	Uttar Pradesh	724.62	30151.00	76725.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for the FY 2015-16:

**Table 98: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.63	8.01	8.97	4.55	1.02	6
2	Bihar	5.07	9.17	9.60	5.20	0.97	3
3	Madhya Pradesh	6.09	10.35	10.81	6.42	0.95	1
4	Maharashtra	7.24	10.74	11.62	7.23	1.00	5
5	Rajasthan	7.07	10.43	11.13	6.74	1.05	7
6	Karnataka	6.88	10.43	10.89	6.50	1.06	8
7	Gujarat	6.97	10.92	11.42	7.04	0.99	4
8	Uttar Pradesh	6.59	10.31	11.25	6.85	0.96	2

**Figure 48: Efficiency (d/e) of states**

### ***b. Corrected Ordinary Least Square Method***

The Corrected Ordinary Least Square Method has been used along with regression analysis to arrive at the desired results.

- **Establishment of Data Management Units (DMUs)**

The Data Management Units have been established by considering the O&M cost along with the Circuit Kilometers (Ckt Km) and the Transformation Capacity (MVA). The O&M cost is the input cost and the Circuit Kilometers (Ckt Km) and Transformation Capacity (MVA) are the output achieved. The following table gives the details of the eight states (DMUs) considered for the benchmarking study:

**Table 99: O&M Expenses, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	82.24	2981.00	6097.00
2	Bihar	152.99	8394.00	9499.00
3	Madhya Pradesh	374.30	29009.77	41163.00
4	Maharashtra	1202.88	43019.81	101547.00
5	Rajasthan	1210.53	31092.40	53249.00
6	Karnataka	865.53	32471.00	50221.85
7	Gujarat	894.68	50131.56	68730.00
8	Uttar Pradesh	587.00	26876.00	63791.00

- **Regression Analysis**

The O&M expenses have been benchmarked with respect to line length (ckm) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the O&M expenses as given in the table below:

**Table 100: Regression Analysis of O&M Expenses**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)
1	Uttarakhand	82.24	2981.00	6097.00	103.37
2	Bihar	152.99	8394.00	9499.00	180.16
3	Madhya Pradesh	374.30	29009.77	41163.00	617.69
4	Maharashtra	1202.88	43019.81	101547.00	1216.46
5	Rajasthan	1210.53	31092.40	53249.00	730.82
6	Karnataka	865.53	32471.00	50221.85	720.18
7	Gujarat	894.68	50131.56	68730.00	1028.17
8	Uttar Pradesh	587.00	26876.00	63791.00	773.32

It can be seen from the table given above that the actual O&M expenses for UPPTCL was Rs. 587.00 Crores for the FY 2013-14. However, after carrying out the regression analysis the O&M expenses comes out to Rs. 773.32 Crores. This difference of Rs. 186.31 Crores indicates that the O&M expenses of UPPTCL are on a lower side and the same can be increased by Rs. 186.31 Crores considering the O&M expenses of other STUs.

- **Ranking of the Utilities after obtaining the corrected values**

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of O&M expenses. The utility with the maximum value of the ratio is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 101: Ranking of the utilities for FY 2013-14**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	82.24	2981.00	6097.00	103.37	-140.03	-1.70	8
2	Bihar	152.99	8394.00	9499.00	180.16	-63.24	-0.41	7
3	Madhya Pradesh	374.30	29009.77	41163.00	617.69	374.30	1.00	1
4	Maharashtra	1202.88	43019.81	101547.00	1216.46	973.06	0.81	4
5	Rajasthan	1210.53	31092.40	53249.00	730.82	487.43	0.40	6
6	Karnataka	865.53	32471.00	50221.85	720.18	476.79	0.55	5
7	Gujarat	894.68	50131.56	68730.00	1028.17	784.77	0.88	3
8	Uttar Pradesh	587.00	26876.00	63791.00	773.32	529.92	0.90	2

The graphical representation of the COLS method is shown in the figure below:



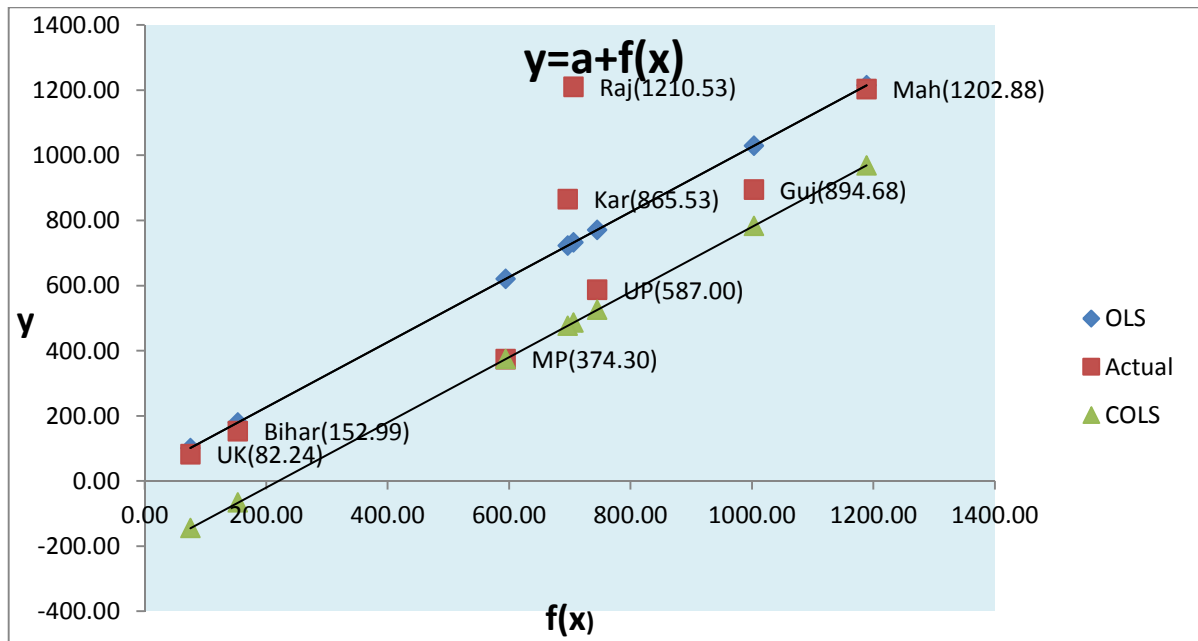


Figure 49: COLS for the O&M Cost for FY 2013-14

### Analysis for FY 2014-15

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

Table 102: O&M Expenses, Line Length & Transformation Capacity of different states for FY 2014-15

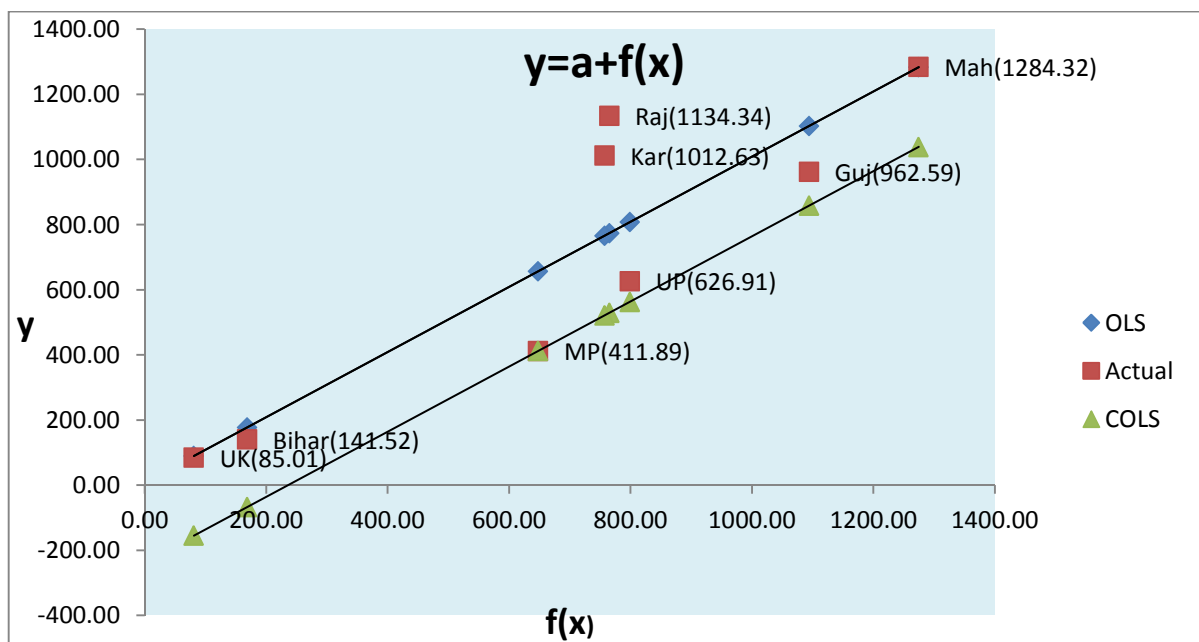
S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	85.01	3017.00	6582.00
2	Bihar	141.52	8617.00	11560.00
3	Madhya Pradesh	411.89	30194.99	45457.00
4	Maharashtra	1284.32	44207.00	105434.00
5	Rajasthan	1134.34	32514.17	63378.50
6	Karnataka	1012.63	33204.00	52081.50
7	Gujarat	962.59	52531.56	80113.00
8	Uttar Pradesh	626.91	28678.00	68465.00

Following the steps carried out for FY 2013-14, the following ranks are obtained for the FY 2014-15:

**Table 103: Ranking of the utilities for FY 2014-15**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	85.01	3017.00	6582.00	95.99	-126.92	-1.49	8
2	Bihar	141.52	8617.00	11560.00	179.13	-43.78	-0.31	7
3	Madhya Pradesh	411.89	30194.99	45457.00	634.80	411.89	1.00	1
4	Maharashtra	1284.32	44207.00	105434.00	1279.75	1056.84	0.82	4
5	Rajasthan	1134.34	32514.17	63378.50	815.05	592.14	0.52	5
6	Karnataka	1012.63	33204.00	52081.50	715.79	492.88	0.49	6
7	Gujarat	962.59	52531.56	80113.00	1102.50	879.60	0.91	3
8	Uttar Pradesh	626.91	28678.00	68465.00	836.21	613.30	0.98	2

The graphical representation of the COLS method is shown in the figure below:



**Figure 50: COLS for the O&M Cost for FY 2014-15**

**Analysis for FY 2015-16**

The following table gives the details of the eight states (DMUs) for the FY 2015-16:

**Table 104: O&M Expenses, Line Length & Transformation Capacity of different states for FY 2015-16**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	102.76	3020.00	7872.00
2	Bihar	158.95	9573.90	14779.90
3	Madhya Pradesh	441.43	31364.08	49349.00
4	Maharashtra	1399.09	46317.00	110815.00
5	Rajasthan	1171.69	33959.92	68036.00
6	Karnataka	968.59	33794.00	53734.90
7	Gujarat	1068.46	55456.56	91544.00
8	Uttar Pradesh	724.62	30151.00	76725.00

Following the steps carried out for FY 2013-14, the following the following ranks are obtained for the FY 2015-16:

**Table 105: Ranking of the Utilities for FY 2015-16**

S.No.	State	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	102.76	3020.00	7872.00	101.86	-119.36	-1.16	8
2	Bihar	158.95	9573.90	14779.90	204.97	-16.25	-0.10	7
3	Madhya Pradesh	441.43	31364.08	49349.00	662.65	441.43	1.00	1
4	Maharashtra	1399.09	46317.00	110815.00	1350.43	1129.21	0.81	4
5	Rajasthan	1171.69	33959.92	68036.00	861.42	640.20	0.55	5
6	Karnataka	968.59	33794.00	53734.90	718.95	497.73	0.51	6
7	Gujarat	1068.46	55456.56	91544.00	1208.04	986.82	0.92	3
8	Uttar Pradesh	724.62	30151.00	76725.00	927.28	706.06	0.97	2

The graphical representation of the COLS method is shown in the figure below:

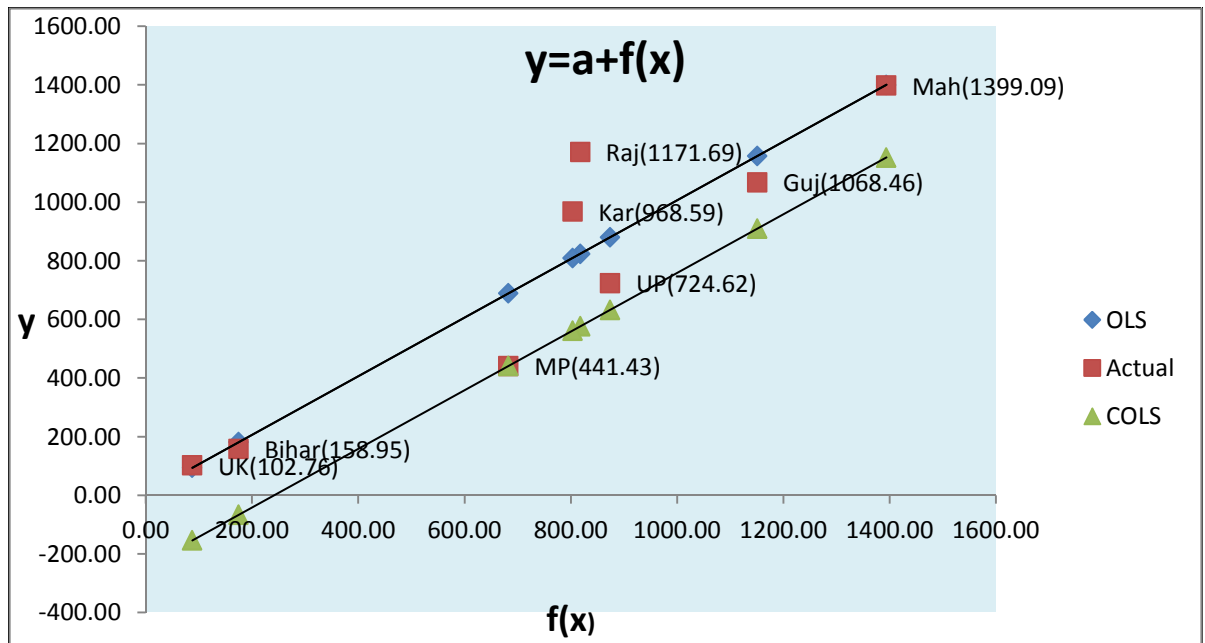


Figure 51: COLS for the O&M Cost for FY 2015-16

## 4.6 Voltage wise Benchmarking of O&M Expenses

Due to the non-availability of actual voltage wise O&M expenses from any of the STUs considered for the benchmarking study, the UPPTCL has attempted to compute the same with the help of norms approved by CERC and the voltage wise actual per unit cost being incurred by the utility in the maintenance of lines and substations. The actual voltage wise O&M Expenses obtained for the various utilities is given as follows:

### 1. Uttar Pradesh

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.40	0.96	32.08%
Substation	0.75	0.69	0.60	2.04	67.92%
Total				3.00	

### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	413.56	1.50	620.34	4%
400 KV	4798.58	1.00	4798.58	34%
220 KV	9238.35	0.50	4619.18	33%
132 KV	15699.83	0.25	3924.96	28%
66 KV	0.00	0.18	0.00	0%
Total	30150.322		13963.06	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	2000.00	0.12	233.33	2%
400 KV	11955.00	0.16	1897.62	12%
220 KV	28190.00	0.19	5285.63	35%
132 KV	34580.50	0.23	7780.61	51%
66 KV	0.00	0.30	0.00	0%
Total	76725.50		15197.19	

**FY 2015-16**

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	32.08% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>724.62</b>	<b>232.48</b>			
765 KV	413.56	4%			10.33	2.50	2.50
400 KV	4798.583	34%			79.90	1.66	2.15
220 KV	9238.35	33%			76.91	0.83	1.06
132 KV	15699.829	28%			65.35	0.42	0.51
66 KV	0	0%			0.00	-	-
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor			Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				<b>492.14</b>			
765 KV	2000.00	2%			7.56	0.38	0.47
400 KV	11955.00	12%			61.45	0.51	0.71
220 KV	28190.00	35%			171.17	0.61	0.83
132 KV	34580.50	51%			251.96	0.73	0.97
66 KV	0.00	0%			0.00	-	-

## 2. Bihar

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.27	0.83	27.75%
Substation	0.75	0.69	0.73	2.17	72.25%
Total				3.00	

### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	0	1.50	0.00	0%
400 KV	0.00	1.00	0.00	0%
220 KV	2125.64	0.50	1062.82	36%
132 KV	7448.26	0.25	1862.07	64%
66 KV	0.00	0.18	0.00	0%
Total	9573.9		2924.89	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	0.00	0.12	0.00	0%
400 KV	0.00	0.16	0.00	0%
220 KV	5750.00	0.19	1078.13	35%
132 KV	9029.90	0.23	2031.73	65%
66 KV	0.00	0.30	0.00	0%
Total	14779.90		3109.85	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	27.75% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>158.95</b>	<b>44.11</b>			
765 KV	0	0%			0.00	-	-
400 KV	0	0%			0.00	-	-
220 KV	2125.64	36%			16.03	0.75	1.09
132 KV	7448.26	64%			28.08	0.38	0.53
66 KV	0	0%			0.00	-	-
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor		72.25% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				<b>114.84</b>			
765 KV	0.00	0%			0.00	-	-
400 KV	0.00	0%			0.00	-	-
220 KV	5750.00	35%			39.81	0.69	0.78
132 KV	9029.90	65%			75.03	0.83	0.99
66 KV	0.00	0%			0.00	-	-



### 3. Rajasthan

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.45	1.01	33.75%
Substation	0.75	0.69	0.55	1.99	66.25%
Total				3.00	

#### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	425.50	1.50	638.25	4%
400 KV	3628.65	1.00	3628.65	24%
220 KV	13724.68	0.50	6862.34	45%
132 KV	16181.09	0.25	4045.27	27%
66 KV	0.00	0.18	0.00	0%
Total	33959.92		15174.51	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	6000.00	0.12	700.00	5%
400 KV	8410.00	0.16	1334.92	10%
220 KV	33046.00	0.19	6196.13	48%
132 KV	20580.00	0.23	4630.50	36%
66 KV	0.00	0.30	0.00	0%
Total	68036.00		12861.55	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	33.75% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>1171.69</b>	<b>395.44</b>			
765 KV	425.50	4%			16.63	3.91	3.91
400 KV	3628.65	24%			94.56	2.61	2.26
220 KV	13724.68	45%			178.83	1.30	1.03
132 KV	16181.09	27%			105.42	0.65	0.51
66 KV	0.00	0%			0.00	-	
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor			Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
					776.24		
765 KV	6000.00	5%			42.25	0.70	0.69
400 KV	8410.00	10%			80.57	0.96	0.73
220 KV	33046.00	48%			373.96	1.13	0.84
132 KV	20580.00	36%			279.47	1.36	0.98
66 KV	0.00	0%			0.00	-	-

#### 4. Gujarat

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.38	0.94	31.42%
Substation	0.75	0.69	0.62	2.06	68.58%
Total				3.00	

#### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	0	1.50	0.00	0%
400 KV	4300.80	1.00	4300.80	22%
220 KV	17846.73	0.50	8923.37	46%
132 KV	5332.36	0.25	1333.09	7%
66 KV	27976.67	0.18	5035.80	26%
Total	55456.56		19593.06	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	0.00	0.12	0.00	0%
400 KV	13505.00	0.16	2143.65	10%
220 KV	28690.00	0.19	5379.38	25%
132 KV	8275.00	0.23	1861.88	9%
66 KV	41074.00	0.30	12322.20	57%
Total	91544.00		21707.10	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	31.42% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>1068.46</b>	<b>335.67</b>			
765 KV	0	0%			0.00	-	-
400 KV	4300.8	22%			73.68	1.71	2.20
220 KV	17846.73	46%			152.88	0.86	1.01
132 KV	5332.36	7%			22.84	0.43	0.54
66 KV	27976.67	26%			86.27	0.31	0.33
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor		68.58% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				732.79			
765 KV	0.00	0%			0.00	-	-
400 KV	13505.00	10%			72.37	0.54	0.70
220 KV	28690.00	25%			181.60	0.63	0.83
132 KV	8275.00	9%			62.85	0.76	0.99
66 KV	41074.00	57%			415.97	1.01	1.11

## 5. Maharashtra

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.40	0.96	32.08%
Substation	0.75	0.69	0.60	2.04	67.92%
Total				3.00	

### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	0	1.50	0.00	0%
400 KV	9729.00	1.00	9729.00	43%
220 KV	16326.00	0.50	8163.00	36%
132 KV	16992.00	0.25	4248.00	19%
66 KV	3270.00	0.18	588.60	3%
Total	46317		22728.60	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	1500.00	0.12	175.00	1%
400 KV	26977.00	0.16	4282.06	20%
220 KV	49748.00	0.19	9327.75	44%
132 KV	31737.00	0.23	7140.83	34%
66 KV	853.00	0.30	255.90	1%
Total	110815.00		21181.54	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	32.08% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>1399.09</b>	<b>448.87</b>			
765 KV	0	0%			0.00	-	-
400 KV	9729	43%			192.14	1.97	1.70
220 KV	16326	36%			161.21	0.99	1.02
132 KV	16992	19%			83.90	0.49	0.51
66 KV	3270	3%			11.62	0.36	0.41
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor		67.92% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				<b>950.22</b>			
765 KV	1500.00	1%			7.85	0.52	0.44
400 KV	26977.00	20%			192.10	0.71	0.63
220 KV	49748.00	44%			418.45	0.84	0.87
132 KV	31737.00	34%			320.34	1.01	0.97
66 KV	853.00	1%			11.48	1.35	1.51

## 6. Karnataka

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.40	0.96	32.08%
Substation	0.75	0.69	0.60	2.04	67.92%
Total				3.00	

### Voltage wise Factor Considered for O&M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	0	1.50	0.00	0%
400 KV	2683.00	1.00	2683.00	22%
220 KV	10498.00	0.50	5249.00	42%
132 KV	10171.00	0.25	2542.75	21%
66 KV	10442.00	0.18	1879.56	15%
Total	33794		12354.31	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	0.00	0.12	0.00	0%
400 KV	4575.00	0.16	726.19	6%
220 KV	21327.50	0.19	3998.91	33%
132 KV	12396.00	0.23	2789.10	23%
66 KV	15436.40	0.30	4630.92	38%
Total	53734.90		12145.12	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	32.08% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>968.59</b>	<b>310.76</b>			
765 KV	0	0%			0.00	-	-
400 KV	2683	22%			67.49	2.52	2.35
220 KV	10498	42%			132.03	1.26	1.05
132 KV	10171	21%			63.96	0.63	0.53
66 KV	10442	15%			47.28	0.45	0.38
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor		67.92% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				<b>657.84</b>			
765 KV	0.00	0%			0.00	-	-
400 KV	4575.00	6%			39.33	0.86	0.75
220 KV	21327.50	33%			216.60	1.02	0.82
132 KV	12396.00	23%			151.07	1.22	0.99
66 KV	15436.40	38%			250.83	1.62	1.36



## 7. Uttarakhand

Factor Considered for O&M Expense					
	Employee Expense (As per MYT Norms)	A&G Expense (As per MYT Norms)	R&M Expense (on the basis of GFA for FY 2015-16)	Total	Factor for O&M Expense
line	0.25	0.31	0.44	1.00	33.42%
Substation	0.75	0.69	0.56	2.00	66.58%
Total				3.00	

## Voltage wise Factor Considered for O&amp;M Expense

Voltage Level	Network Configuration	Indicative Per CKM cost	Indicative Capex	Voltage wise Factor
Line	In CKM			
765 KV	0	1.50	0.00	0%
400 KV	388.00	1.00	388.00	31%
220 KV	807.00	0.50	403.50	32%
132 KV	1825.00	0.25	456.25	37%
66 KV	0.00	0.18	0.00	0%
Total	3020		1247.75	
Voltage Level	Network Configuration	Indicative Per MVA cost	Indicative Capex	Voltage wise Factor
Substation	Capacity in MVA			
765 KV	0.00	0.12	0.00	0%
400 KV	1815.00	0.16	288.10	19%
220 KV	2840.00	0.19	532.50	34%
132 KV	3217.00	0.23	723.83	47%
66 KV	0.00	0.30	0.00	0%
Total	7872.00		1544.42	

## FY 2015-16

Line Length	Actual Line Length in CKM	Voltage wise Factor	Actual O&M Expense (Rs. Crore)	33.42% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per CKM)	Benchmarked Value (Rs. Lakh per CKM)
			<b>102.76</b>	<b>34.34</b>			
765 KV	0	0%			0.00	-	-
400 KV	388	31%			10.68	2.75	2.56
220 KV	807	32%			11.10	1.38	1.10
132 KV	1825	37%			12.56	0.69	0.55
66 KV	0	0%			0.00	-	-
Substation	Actual Transformation Capacity in MVA	Voltage wise Factor		66.58% of O&M Expense	Derived Voltage wise O&M Expense (Rs. Crore)	Actual O&M Expense (Rs. Lakh per MVA)	Benchmarked Value (Rs. Lakh per MVA)
				<b>68.42</b>			
765 KV	0.00	0%			0.00	-	-
400 KV	1815.00	19%			12.76	0.70	0.76
220 KV	2840.00	34%			23.59	0.83	0.78
132 KV	3217.00	47%			32.07	1.00	1.00
66 KV	0.00	0%			0.00	-	-

The actual voltage wise expenses obtained above for all the STUs considered for the study have been used to obtain the voltage wise benchmark values for the lines and substations. The benchmarked values of the voltage wise O&M expenses along with the rank obtained by the STUs are given as follows:

### 765 kV Line

S.No.	State	Actual O&M Expense (Rs. Lakh per CKM) (a)	Line Length (Ckt Km) (b)	Regressed Value (Rs. Lakh per CKM) (c)	COLS Value (Rs. Lakh per CKM) (d)	(d/a)	Ranking
1	Rajasthan	3.91	425.50	3.91	3.91	1.00	-
2	Uttar Pradesh	2.50	413.56	2.50	2.50	1.00	-

### 400 kV Line

S.No.	State	Actual O&M Expense (Rs. Lakh per CKM) (a)	Line Length (Ckt Km) (b)	Regressed Value (Rs. Lakh per CKM) (c)	COLS Value (Rs. Lakh per CKM) (d)	(d/a)	Ranking
1	Uttarakhand	2.75	388.00	2.56	2.07	0.75	3
2	Maharashtra	1.97	9729.00	1.70	1.21	0.61	6
3	Rajasthan	2.61	3628.65	2.26	1.77	0.68	5
4	Karnataka	2.52	2683.00	2.35	1.86	0.74	4
5	Gujarat	1.71	4300.80	2.20	1.71	1.00	2
6	Uttar Pradesh	1.66	4798.58	2.15	1.66	1.00	1

### 220 kV Line

S.No.	State	Actual O&M Expense (Rs. Lakh per CKM) (a)	Line Length (Ckt Km) (b)	Regressed Value (Rs. Lakh per CKM) (c)	COLS Value (Rs. Lakh per CKM) (d)	(d/a)	Ranking
1	Uttarakhand	1.38	807.00	1.10	0.76	0.55	6
2	Bihar	0.75	2125.64	1.09	0.75	1.00	1
3	Maharashtra	0.99	16326.00	1.02	0.68	0.69	4
4	Rajasthan	1.30	13724.68	1.03	0.69	0.53	7
5	Karnataka	1.26	10498.00	1.05	0.71	0.56	5
6	Gujarat	0.86	17846.73	1.01	0.67	0.78	3
7	Uttar Pradesh	0.83	9238.35	1.06	0.72	0.86	2

**132 kV Line**

S.No.	State	Actual O&M Expense (Rs. Lakh per CKM) (a)	Line Length (Ckt Km) (b)	Regressed Value (Rs. Lakh per CKM) (c)	COLS Value (Rs. Lakh per CKM) (d)	(d/a)	Ranking
1	Uttarakhand	0.69	1825.00	0.55	0.39	0.57	6
2	Bihar	0.38	7448.26	0.53	0.38	1.00	1
3	Maharashtra	0.49	16992.00	0.51	0.35	0.71	4
4	Rajasthan	0.65	16181.09	0.51	0.35	0.54	7
5	Karnataka	0.63	10171.00	0.53	0.37	0.59	5
6	Gujarat	0.43	5332.36	0.54	0.38	0.89	2
7	Uttar Pradesh	0.42	15699.83	0.51	0.36	0.85	3

**66 kV Line**

S.No.	State	Actual O&M Expense (Rs. Lakh per CKM) (a)	Line Length (Ckt Km) (b)	Regressed Value (Rs. Lakh per CKM) (c)	COLS Value (Rs. Lakh per CKM) (d)	(d/a)	Ranking
1	Karnataka	0.45	10442.00	0.38	0.33	0.74	3
2	Gujarat	0.31	27976.67	0.33	0.28	0.90	2
3	Maharashtra	0.36	3270	0.41	0.36	1.00	1

**765 kV Transformation Capacity**

S.No.	State	Actual O&M Expense (Rs. Lakh per MVA) (a)	Transformation Capacity (MVA) (b)	Regressed Value (Rs. Lakh per MVA) (c)	COLS Value (Rs. Lakh per MVA) (d)	(d/a)	Ranking
1	Maharashtra	0.52	1500.00	0.44	0.35	0.67	3
2	Rajasthan	0.70	6000.00	0.69	0.60	0.85	2
3	Uttar Pradesh	0.38	2000.00	0.47	0.38	1.00	1

**400 kV Transformation Capacity**

S.No.	State	Actual O&M Expense (Rs. Lakh per MVA) (a)	Transformation Capacity (MVA) (b)	Regressed Value (Rs. Lakh per MVA) (c)	COLS Value (Rs. Lakh per MVA) (d)	(d/a)	Ranking
1	Uttarakhand	0.70	1815.00	0.76	0.57	0.81	3
2	Maharashtra	0.71	26977.00	0.63	0.43	0.61	5
3	Rajasthan	0.96	8410.00	0.73	0.53	0.56	6
4	Karnataka	0.86	4575.00	0.75	0.55	0.64	4
5	Gujarat	0.54	13505.00	0.70	0.51	0.94	2
6	Uttar Pradesh	0.51	11955.00	0.71	0.51	1.00	1

**220 kV Transformation Capacity**

S.No.	State	Actual O&M Expense (Rs. Lakh per MVA) (a)	Transformation Capacity (MVA) (b)	Regressed Value (Rs. Lakh per MVA) (c)	COLS Value (Rs. Lakh per MVA) (d)	(d/a)	Ranking
1	Uttarakhand	0.83	2840.00	0.78	0.556	0.67	5
2	Bihar	0.69	5750.00	0.78	0.562	0.81	3
3	Maharashtra	0.84	49748.00	0.87	0.651	0.77	4
4	Rajasthan	1.13	33046.00	0.84	0.617	0.55	7
5	Karnataka	1.02	21327.50	0.82	0.593	0.58	6
6	Gujarat	0.63	28690.00	0.83	0.608	0.96	2
7	Uttar Pradesh	0.61	28190.00	0.83	0.607	1.00	1

**132 kV Transformation Capacity**

S.No.	State	Actual O&M Expense (Rs. Lakh per MVA) (a)	Transformation Capacity (MVA) (b)	Regressed Value (Rs. Lakh per MVA) (c)	COLS Value (Rs. Lakh per MVA) (d)	(d/a)	Ranking
1	Uttarakhand	1.00	3217.00	1.00	0.76	0.76	4
2	Bihar	0.83	9029.90	0.99	0.75	0.91	3
3	Maharashtra	1.01	31737.00	0.97	0.73	0.72	5
4	Rajasthan	1.36	20580.00	0.98	0.74	0.55	7
5	Karnataka	1.22	12396.00	0.99	0.75	0.62	6
6	Gujarat	0.76	8275.00	0.99	0.75	0.99	2
7	Uttar Pradesh	0.73	34580.50	0.97	0.73	1.00	1

**66 kV Transformation Capacity**

S.No.	State	Actual O&M Expense (Rs. Lakh per MVA) (a)	Transformation Capacity (MVA) (b)	Regressed Value (Rs. Lakh per MVA) (c)	COLS Value (Rs. Lakh per MVA) (d)	(d/a)	Ranking
1	Karnataka	1.62	15436.40	1.36	1.20	0.74	3
2	Gujarat	1.01	41074.00	1.11	0.94	0.93	2
3	Maharashtra	1.35	853.00	1.51	1.35	1.00	1

## 5. Chapter5: Benchmarking of Capital Expenditure

### 5.1 Benchmarking of Capital Expenditure

The benchmarking of capital expenditure at various voltage levels was to be carried out as per the scope of work of the study. However, instead of capital expenditure the benchmarking of capitalization has been carried out with respect to Line Length and Transformation Capacity as the actual details of line length and transformation capacity added to the existing network against amount capitalized in during FY 2014-15 was available.

The benchmarking of the Capitalization has been carried out using the Partial Performance Indicator, Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Squares Method.

#### a. Partial Performance Indicator

##### a. Capitalization /Ckm

The Capitalization/Ckm of the five STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 106: Capitalization/Ckm for FY 2013-14**

S.No.	State	Capitalization (Rs. Crore)	Line Length (Ckt Km)	Capitalization/Ckm	Rank
1	Uttarakhand	144.33	21.00	687.29	6
2	Madhya Pradesh	679.83	1184.77	57.38	1
3	Maharashtra	1578.00	1187.73	132.86	4
4	Karnataka	865.97	982.00	88.18	3
5	Gujarat	1686.79	2159.00	78.13	2
6	Uttar Pradesh	1317.89	955.00	138.00	5

The Capitalization/Ckm of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 107: Capitalization/Ckm for FY 2014-15**

S.No.	State	Capitalization (Rs. Crore)	Addition in Line Length (Ckt Km)	Capitalization/Ckm	Rank
1	Uttarakhand	91.27	36.00	253.53	8
2	Bihar	375.52	223.00	168.39	7
3	Madhya Pradesh	591.31	1185.22	49.89	1
4	Maharashtra	1401.17	1187.20	118.02	5
5	Rajasthan	1100.88	1421.77	77.43	3
6	Karnataka	1098.99	733.00	149.93	6
7	Gujarat	2662.95	2400.00	110.96	4
8	Uttar Pradesh	1284.68	1802.00	71.29	2

The Capitalization/Ckm of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 108: Capitalization/Ckm for FY 2015-16**

S.No.	State	Capitalization (Rs. Crore)	Line Length (Ckm)	Capitalization/Ckm	Rank
1	Uttarakhand	69.77	3.00	2325.67	8
2	Bihar	79.36	956.90	8.29	1
3	Madhya Pradesh	1349.49	1169.09	115.43	5
4	Maharashtra	2150.70	2110.00	101.93	3
5	Rajasthan	1528.13	1445.75	105.70	4
6	Karnataka	1042.03	590.00	176.61	7
7	Gujarat	2525.45	2925.00	86.34	2
8	Uttar Pradesh	1900.31	1473.00	129.01	6



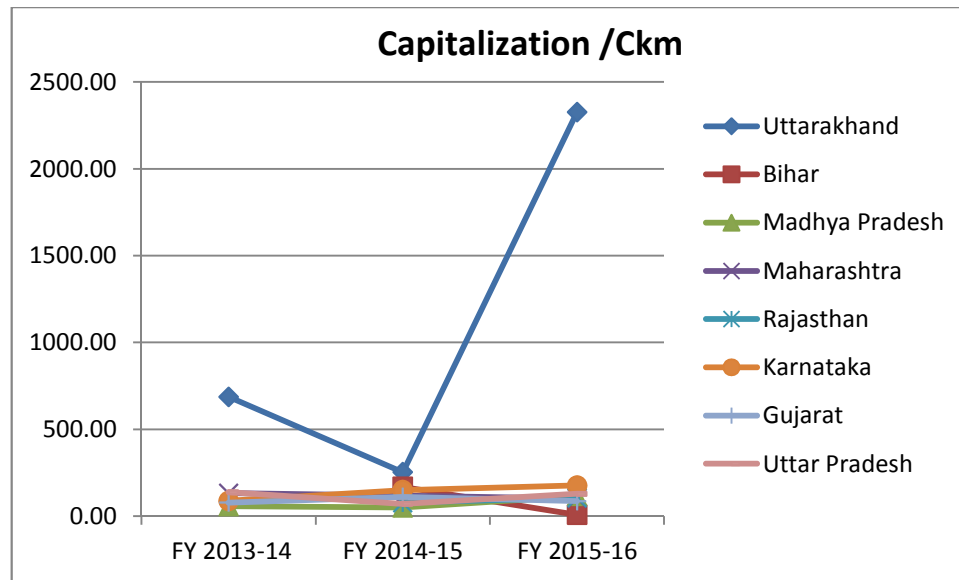


Figure 52: Capitalization/Ckm

It can be seen that the per Ckm Capitalization of Bihar is the lowest among all the utilities at Rs. 8.294 lakh/Ckm. The rank of UPPTCL is 6<sup>th</sup> among the eight utilities considered for the study with its per Ckm capitalization at Rs. 129.010 lakh/Ckm.

### b. Capitalization /MVA

The Capitalization/MVA of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

Table 109: Capitalization/MVA for FY 2013-14

S.No.	State	Capitalization (Rs. Crore)	Addition in Transformation Capacity (MVA)	Capitalization/MVA	Rank
1	Uttarakhand	144.33	255.00	56.600	6
2	Madhya Pradesh	679.83	3413.00	19.919	1
3	Maharashtra	1578.00	4671.00	33.783	4
4	Karnataka	865.97	1859.65	46.566	5
5	Gujarat	1686.79	6161.50	27.376	3
6	Uttar Pradesh	1317.89	4941.00	26.673	2

The Capitalization/MVA of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

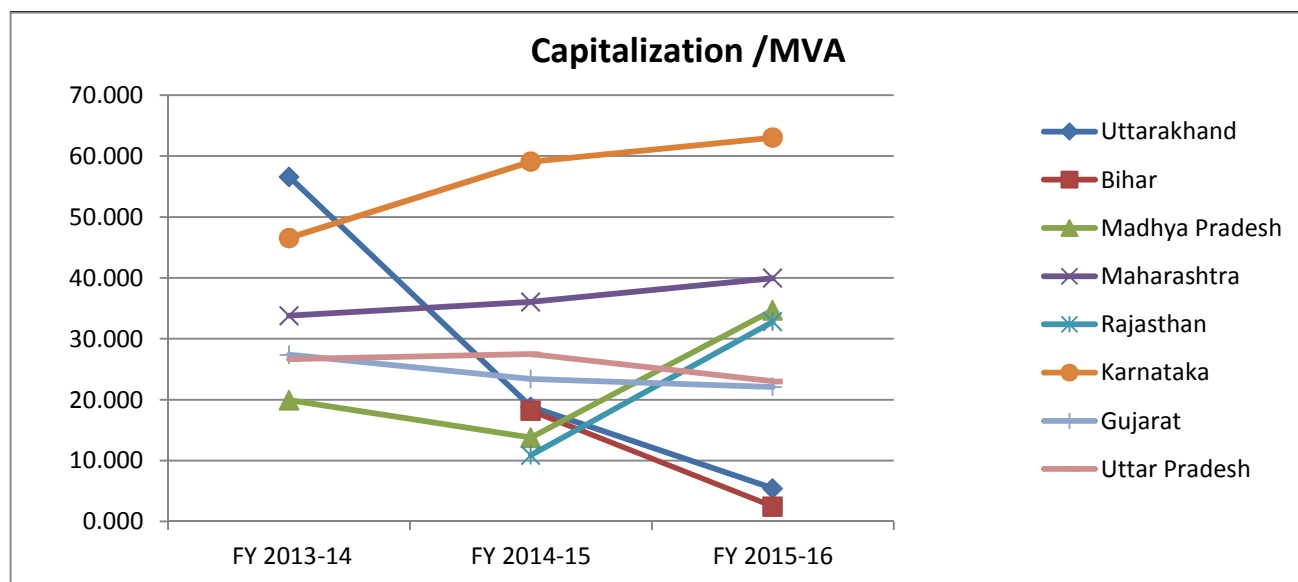
**Table 110: Capitalization/MVA for FY 2014-15**

S.No.	State	Capitalization (Rs. Crore)	Transformation Capacity(MVA)	Capitalization/MVA	Rank
1	Uttarakhand	91.27	485.00	18.82	4
2	Bihar	375.52	2061.00	18.22	3
3	Madhya Pradesh	591.31	4294.00	13.77	2
4	Maharashtra	1401.17	3887.00	36.05	7
5	Rajasthan	1100.88	10129.50	10.87	1
6	Karnataka	1098.99	1859.65	59.10	8
7	Gujarat	2662.95	11383.00	23.39	5
8	Uttar Pradesh	1284.68	4674.00	27.49	6

The Capitalization/MVA of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 111: Capitalization/MVA for FY 2015-16**

S.No.	State	Capitalization (Rs. Crore)	Transformation Capacity (MVA)	Capitalization/MVA	Rank
1	Uttarakhand	69.77	1290.00	5.409	2
2	Bihar	79.36	3219.90	2.465	1
3	Madhya Pradesh	1349.49	3892.00	34.673	6
4	Maharashtra	2150.70	5381.00	39.968	7
5	Rajasthan	1528.13	4657.50	32.810	5
6	Karnataka	1042.03	1653.40	63.023	8
7	Gujarat	2525.45	11431.00	22.093	3
8	Uttar Pradesh	1900.31	8260.00	23.006	4



**Figure 53: Capitalization/MVA**

The rank of Bihar is no. 1 followed by Uttarakhand during the FY 2015-16. UPPTCL is ranked 4<sup>th</sup> among all the utilities considered for the study.

### c. Average GFA /MU

The Average GFA/MU of the seven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 112: Average GFA/MU for FY 2013-14**

S.No.	State	Average GFA (Rs. Crore)	Energy Transmitted (MU)	Average GFA/MU	Rank
1	Uttarakhand	906.99	13227.00	0.069	1
2	Bihar	3548.20	13786.16	0.257	8
3	Madhya Pradesh	5884.12	50300.00	0.117	2
4	Maharashtra	18960.86	117289.13	0.162	4
5	Rajasthan	11568.17	63851.02	0.181	6
6	Karnataka	11794.90	56733.00	0.208	7
7	Gujarat	12014.23	70712.07	0.170	5
8	Uttar Pradesh	9252.64	77760.69	0.119	3

The Average GFA /MU of the seven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 113: Average GFA/MU for FY 2014-15**

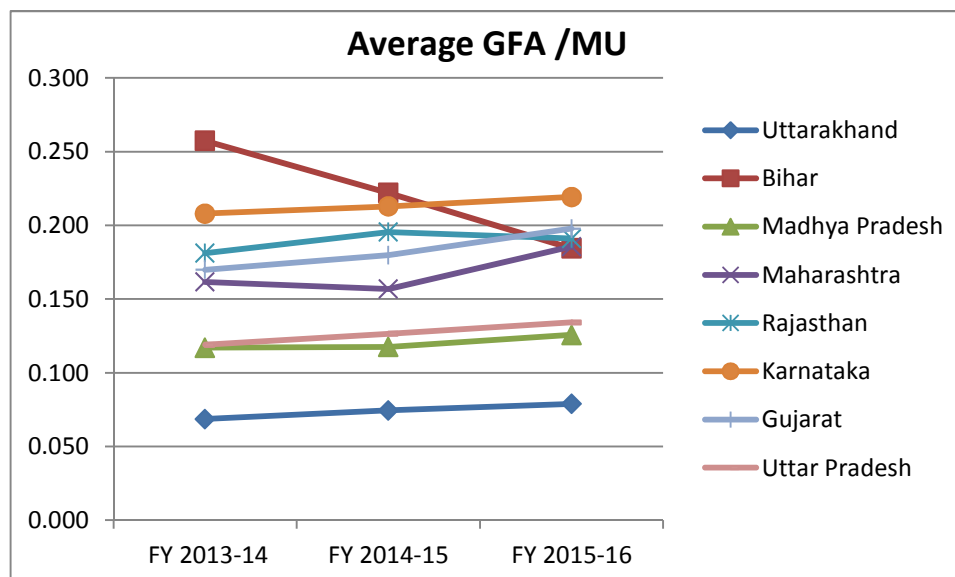
S.No.	State	Average GFA (Rs. Crore)	Energy Transmitted (MU)	Average GFA/MU	Rank
1	Uttarakhand	1013.95	13612.23	0.074	1

S.No.	State	Average GFA (Rs. Crore)	Energy Transmitted (MU)	Average GFA/MU	Rank
2	Bihar	3771.07	16986.53	0.222	8
3	Madhya Pradesh	6488.89	55206.00	0.118	2
4	Maharashtra	20409.70	130107.38	0.157	4
5	Rajasthan	13145.98	67257.92	0.195	6
6	Karnataka	12647.01	59420.35	0.213	7
7	Gujarat	14189.10	78933.59	0.180	5
8	Uttar Pradesh	10417.87	82413.86	0.126	3

The Average GFA/MU of the seven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 114: Average GFA/MU for FY 2015-16**

S.No.	State	Average GFA (Rs. Crore)	Energy Transmitted (MU)	Average GFA/MU	Rank
1	Uttarakhand	1083.64	13734.00	0.079	1
2	Bihar	3961.57	21485.35	0.184	4
3	Madhya Pradesh	7459.29	59335.00	0.126	2
4	Maharashtra	25282.48	136215.34	0.186	5
5	Rajasthan	14437.46	75567.74	0.191	6
6	Karnataka	13585.32	61957.51	0.219	8
7	Gujarat	16783.30	84889.83	0.198	7
8	Uttar Pradesh	11860.63	88402.14	0.134	3



**Figure 54: Average GFA/MU**

The rank of Uttarakhand is no. 1 followed by Madhya Pradesh during the FY 2015-16. UPPTCL is ranked 3<sup>rd</sup> among all the utilities considered for the study.

**d. Average GFA /MW****Table 115: Average GFA/MW for the FY 2013-14**

S.No.	State	Average GFA (Rs. Crore)	Peak Demand (MW)	Average GFA/MW	Rank
1	Uttarakhand	906.99	1826.00	0.497	1
2	Bihar	3548.20	2465.00	1.439	8
3	Madhya Pradesh	5884.12	9716.00	0.606	2
4	Maharashtra	18960.86	19276.00	0.984	4
5	Rajasthan	11568.17	10047.00	1.151	6
6	Karnataka	11794.90	9940.00	1.187	7
7	Gujarat	12014.23	12201.00	0.985	5
8	Uttar Pradesh	9252.64	13089.00	0.707	3

**Table 116: Average GFA/MW for the FY 2014-15**

S.No.	State	Average GFA (Rs. Crore)	Peak Demand (MW)	Average GFA/MW	Rank
1	Uttarakhand	1013.95	1930.00	0.5254	1
2	Bihar	3771.07	2994.00	1.2595	7
3	Madhya Pradesh	6488.89	9755.00	0.6652	3
4	Maharashtra	20409.70	20147.00	1.0130	4
5	Rajasthan	13145.98	10642.00	1.2353	6
6	Karnataka	12647.01	10001.00	1.2646	8
7	Gujarat	14189.10	13603.00	1.0431	5
8	Uttar Pradesh	10417.87	15670.00	0.6648	2

**Table 117: Average GFA/ MW for the FY 2015-16**

S.No.	State	Average GFA (Rs. Crore)	Peak Demand (MW)	Average GFA/MW	Rank
1	Uttarakhand	1083.64	2034.00	0.533	1
2	Bihar	3961.57	3735.00	1.061	4
3	Madhya Pradesh	7459.29	10902.00	0.684	2

S.No.	State	Average GFA (Rs. Crore)	Peak Demand (MW)	Average GFA/MW	Rank
4	Maharashtra	25282.48	20973.00	1.205	6
5	Rajasthan	14437.46	10961.00	1.317	7
6	Karnataka	13585.32	10202.00	1.332	8
7	Gujarat	16783.30	14495.00	1.158	5
8	Uttar Pradesh	11860.63	16988.00	0.698	3

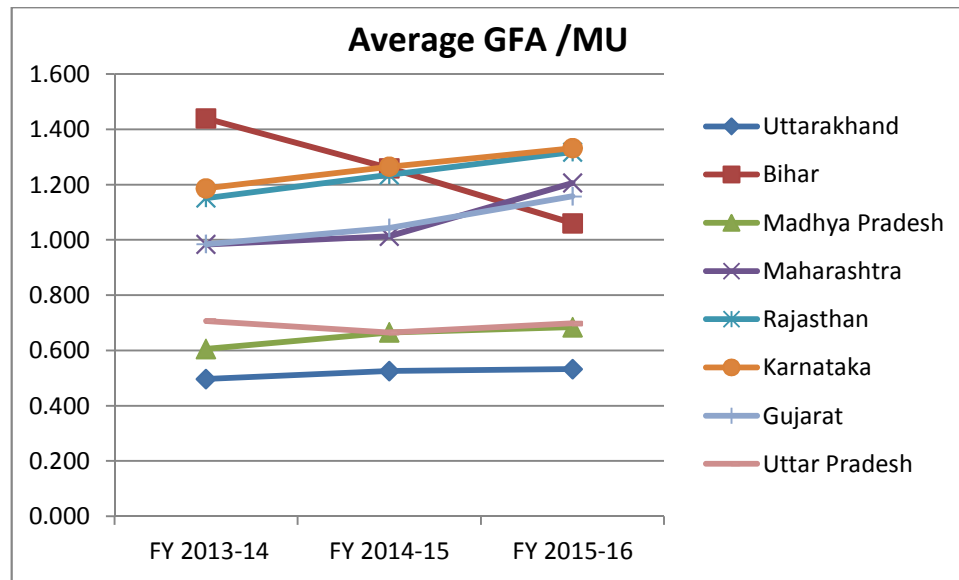


Figure 55: Average GFA/MW

The rank of Uttarakhand is no. 1 followed by Madhya Pradesh during the FY 2015-16. UPPTCL is ranked 3<sup>rd</sup> among all the utilities considered for the study.

### b. Econometric Method

- The selection of variables

Benchmarking of the Capitalization has been carried out by considering the following variables as given in the table below:

Table 118: Capitalization, Line Length & Transformation Capacity of different states for FY 2013-14

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)
1	Uttarakhand	144.33	21.00	255.00
2	Madhya Pradesh	679.83	1184.77	3413.00

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)
3	Maharashtra	1578.00	1187.73	4671.00
4	Karnataka	865.97	982.00	1859.65
5	Gujarat	1686.79	2159.00	6161.50
6	Uttar Pradesh	1317.89	955.00	4941.00

Doing the regression analysis on the values obtained after considering log of the values in table 118 we obtain the following values:

**Table 119: Regression Analysis of Capitalization**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	4.97	3.04	5.54	4.97
2	Madhya Pradesh	6.52	7.08	8.14	6.97
3	Maharashtra	7.36	7.08	8.45	7.15
4	Karnataka	6.76	6.89	7.53	6.59
5	Gujarat	7.43	7.68	8.73	7.39
6	Uttar Pradesh	7.18	6.86	8.51	7.16

Having obtained the regressed value the efficiency of the STUs have been obtained in the following table:

**Table 120: Rank Obtained**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.97	3.04	5.54	4.97	1.00	2
2	Madhya Pradesh	6.52	7.08	8.14	6.97	0.94	1
3	Maharashtra	7.36	7.08	8.45	7.15	1.03	6
4	Karnataka	6.76	6.89	7.53	6.59	1.03	5
5	Gujarat	7.43	7.68	8.73	7.39	1.01	4
6	Uttar Pradesh	7.18	6.86	8.51	7.16	1.00	3

It can be seen from the table given above that the rank obtained by UPPTCL is no. 3.

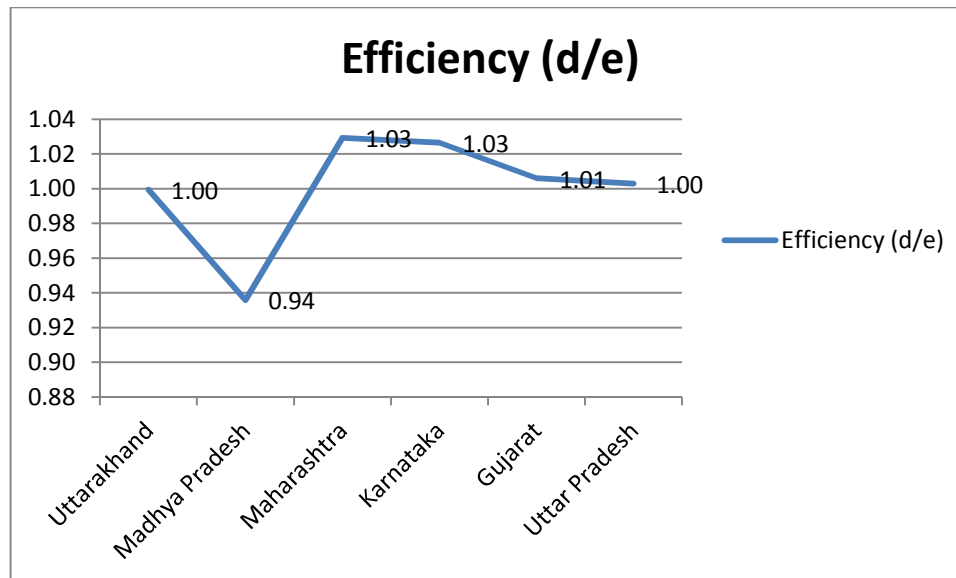


Figure 56: Efficiency (d/e)

### Analysis for FY 2014-15

Benchmarking of the Capitalization for FY 2014-15 has been carried out by considering the following variables as given in the table below:

**Table 121: Capitalization, Line Length & Transformation Capacity of different states for FY 2014-15**

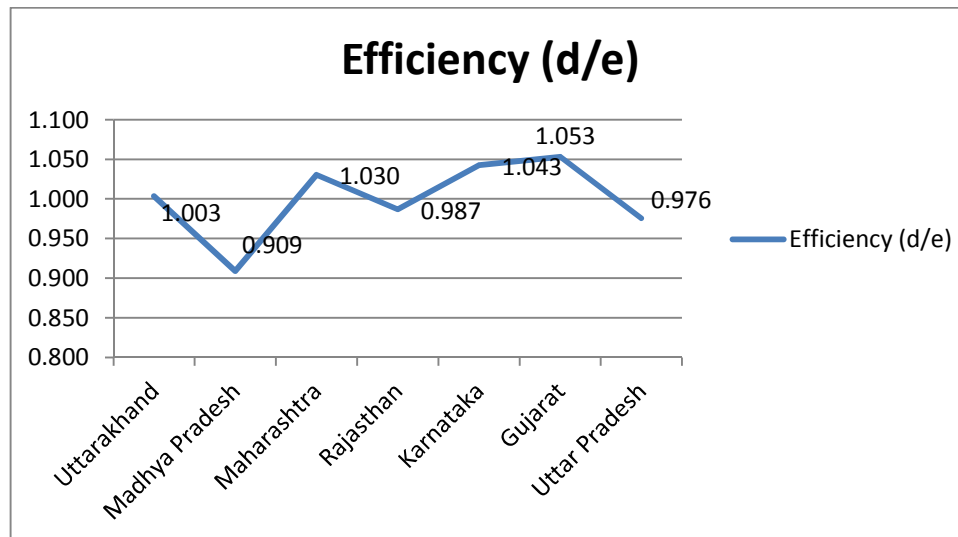
S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)
1	Uttarakhand	91.27	36.00	485.00
2	Madhya Pradesh	591.31	1185.22	4294.00
3	Maharashtra	1401.17	1187.20	3887.00
4	Rajasthan	1100.88	1421.77	10129.50
5	Karnataka	1098.99	733.00	1859.65
6	Gujarat	2662.95	2400.00	11383.00
7	Uttar Pradesh	1284.68	1802.00	4674.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:



**Table 122: Rank Obtained for FY 2014-15**

S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.51	3.58	6.18	4.50	1.0032	4
2	Madhya Pradesh	6.38	7.08	8.36	7.02	0.9089	1
3	Maharashtra	7.25	7.08	8.27	7.03	1.0305	5
4	Rajasthan	7.00	7.26	9.22	7.10	0.9870	3
5	Karnataka	7.00	6.60	7.53	6.72	1.0426	6
6	Gujarat	7.89	7.78	9.34	7.49	1.0530	7
7	Uttar Pradesh	7.16	7.50	8.45	7.34	0.9755	2

**Figure 57: Efficiency (d/e)****Analysis for FY 2015-16**

Benchmarking of the Capitalization for FY 2015-16 has been carried out by considering the following variables as given in the table below:

**Table 123: Capitalization, Line Length & Transformation Capacity of different states for FY 2015-16**

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)
1	Uttarakhand	69.77	3.00	1290.00
2	Madhya Pradesh	1349.49	1169.09	3892.00
3	Maharashtra	2150.70	2110.00	5381.00
4	Rajasthan	1528.13	1445.75	4657.50
5	Karnataka	1042.03	590.00	1653.40
6	Gujarat	2525.45	2925.00	11431.00
7	Uttar Pradesh	1900.31	1473.00	8260.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs has been obtained in the following table for FY 2015-16:

**Table 124: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.25	1.10	7.16	4.25	0.9993	4
2	Madhya Pradesh	7.21	7.06	8.27	7.30	0.9875	1
3	Maharashtra	7.67	7.65	8.59	7.62	1.0072	5
4	Rajasthan	7.33	7.28	8.45	7.42	0.9883	2
5	Karnataka	6.95	6.38	7.41	6.89	1.0088	6
6	Gujarat	7.83	7.98	9.34	7.84	0.9989	3
7	Uttar Pradesh	7.55	7.30	9.02	7.48	1.0099	7

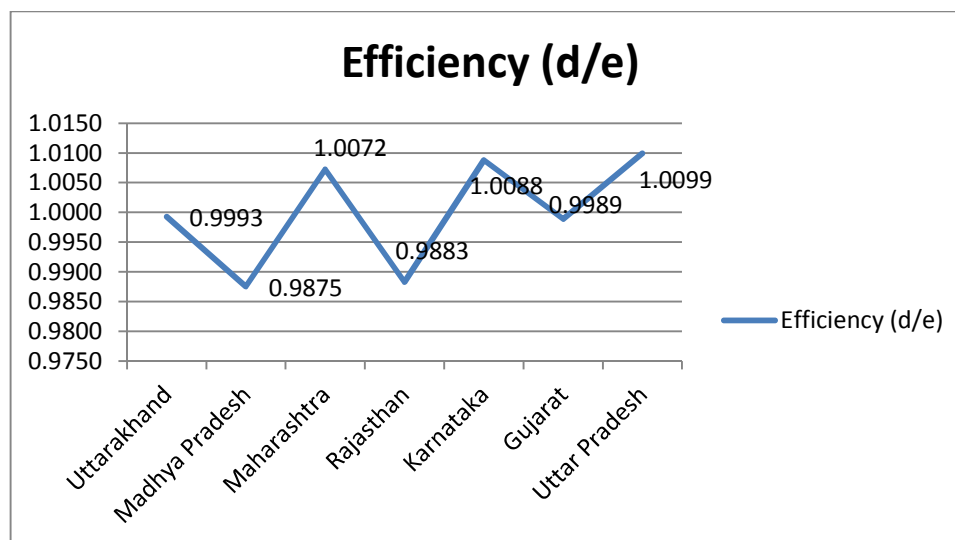


Figure 58: Efficiency (d/e)

### c. Corrected Ordinary Least Squares Method

The Corrected Ordinary Least Squares Method has been used along with regression analysis to arrive at the desired results.

- Establishment of Data Management Units (DMUs)**

The Data Management Units have been established by considering the Capitalization along with the Circuit Kilometers (Ckm) and the Transformation Capacity (MVA). The Capitalization is the input cost and the Circuit Kilometers (Ckm) and Transformation Capacity (MVA) are the output achieved. The following table gives the details of the six states (DMUs) considered for the benchmarking study:

**Table 125: Capitalization, Line Length & Transformation Capacity of different states for FY 2013-14**

S.No.	State	Capitalization (Rs. Crore)	Addition in Line Length (Ckt Km)	Addition in Transformation Capacity (MVA)
1	Uttarakhand	144.33	21.00	255.00
2	Madhya Pradesh	679.83	1184.77	3413.00
3	Maharashtra	1578.00	1187.73	4671.00
4	Karnataka	865.97	982.00	1859.65
5	Gujarat	1686.79	2159.00	6161.50
6	Uttar Pradesh	1317.89	955.00	4941.00

- Regression Analysis**

The Capitalization has been benchmarked with respect to line length (Ckm) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the Capitalization as given in the table below:

**Table 126: Regression Analysis of Capitalization**

S.No.	State	Capitalization (Rs. Crore)	Addition in Line Length (Ckt Km)	Addition in Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	144.33	21.00	255.00	205.87
2	Madhya Pradesh	679.83	1184.77	3413.00	1019.63
3	Maharashtra	1578.00	1187.73	4671.00	1315.29
4	Karnataka	865.97	982.00	1859.65	642.23
5	Gujarat	1686.79	2159.00	6161.50	1725.48
6	Uttar Pradesh	1317.89	955.00	4941.00	1364.31

It can be seen from the table given above that the actual Capitalization for UPPTCL was Rs. 1317.89 Crores for the FY 2013-14. However, after carrying out the regression analysis the Capitalization comes out to Rs. 1364.31 Crores. This difference of Rs. 46.42 Crores indicates that the Capitalization of UPPTCL are on a lower side as compared to other STUs and the same can be increased by Rs. 46.42 Crores considering the Capitalization of other STUs.

### • Ranking of the Utilities

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of employee expenses. The utility with the maximum value of the ratio is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 127: Ranking of the Utilities for FY 2013-14**

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)	Regressed Values (d)	COLS Value (Rs. Crore) (e)	$\frac{(e/a)}{}$	Ranking
1	Uttarakhand	144.33	21.00	255.00	205.87	-133.93	-	6
2	Madhya Pradesh	679.83	1184.77	3413.00	1019.63	679.83	1.0000	1
3	Maharashtra	1578.00	1187.73	4671.00	1315.29	975.49	0.6182	4
4	Karnataka	865.97	982.00	1859.65	642.23	302.43	0.3492	5
5	Gujarat	1686.79	2159.00	6161.50	1725.48	1385.68	0.8215	2
6	Uttar Pradesh	1317.89	955.00	4941.00	1364.31	1024.51	0.7774	3

It can be seen from the table given above that UPPTCL is obtaining the rank no. 3.

The graphical representation of the COLS method is shown in the figure below:

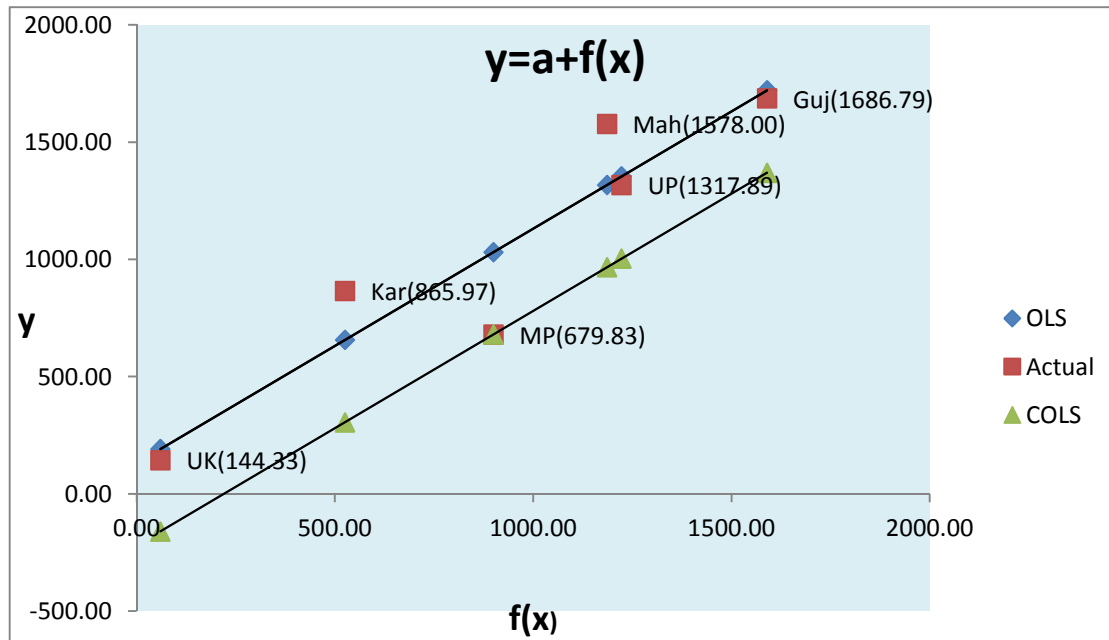


Figure 59: COLS for the FY 2013-14 for Capitalization

### Analysis for FY 2014-15

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

Table 128: Capitalization, Line Length & Transformation Capacity of different states for FY 2014-15

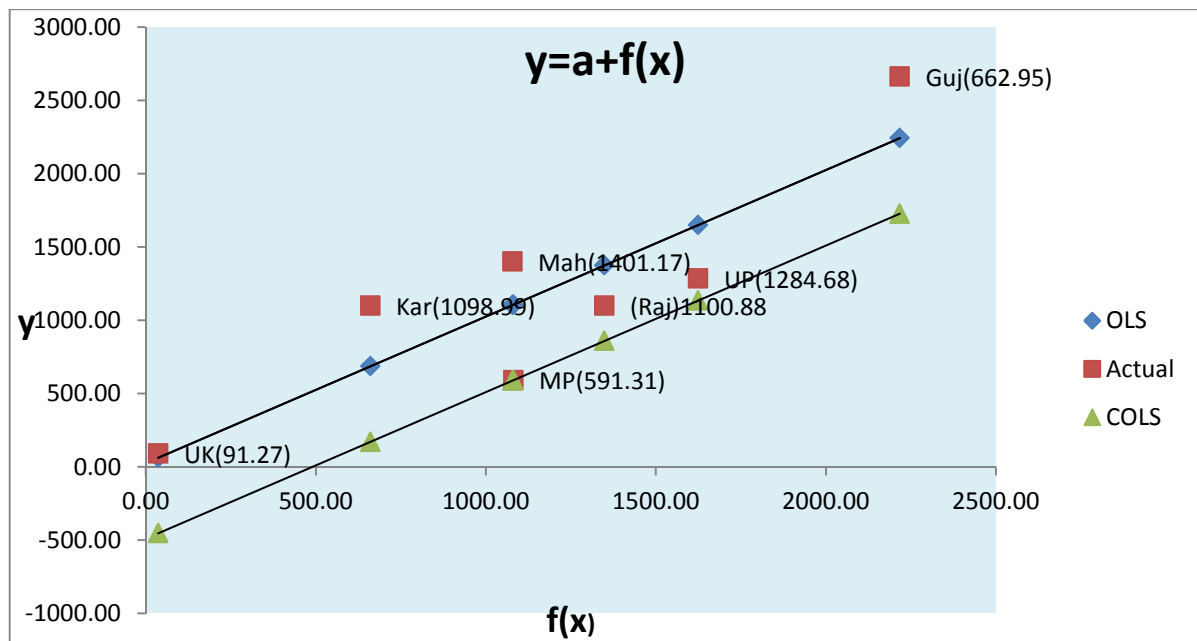
S.No.	State	Capitalization (Rs. Crore)	Addition in Line Length (Ckt Km)	Addition in Transformation Capacity (MVA)
1	Uttarakhand	91.27	36.00	485.00
2	Madhya Pradesh	591.31	1185.22	4294.00
3	Maharashtra	1401.17	1187.20	3887.00
4	Rajasthan	1100.88	1421.77	10129.50
5	Karnataka	1098.99	733.00	1859.65
6	Gujarat	2662.95	2400.00	11383.00
7	Uttar Pradesh	1284.68	1802.00	4674.00

Following the steps carried out for FY 2013-14, the following ranking is obtained for the utilities for the FY 2014-15:

**Table 129: Ranking of Utilities for FY 2014-15**

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)	Regressed Value (Rs. Crore) (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	91.27	36.00	485.00	62.74	-453.39	-4.9676	7
2	Madhya Pradesh	591.31	1185.22	4294.00	1107.44	591.31	1.0000	1
3	Maharashtra	1401.17	1187.20	3887.00	1104.93	588.80	0.4202	5
4	Rajasthan	1100.88	1421.77	10129.50	1375.10	858.97	0.7803	3
5	Karnataka	1098.99	733.00	1859.65	686.61	170.47	0.1551	6
6	Gujarat	2662.95	2400.00	11383.00	2243.64	1727.51	0.6487	4
7	Uttar Pradesh	1284.68	1802.00	4674.00	1650.79	1134.66	0.8832	2

The graphical representation of the COLS method is shown in the figure below:

**Figure 60: COLS for the FY 2014-15 for Capitalization****Analysis for FY 2015-16**

The following table gives the details of the eight states (DMUs) for the FY 2015-16:

**Table 130: Capitalization, Line Length & Transformation Capacity of different states for the FY 2015-16**

S.No.	State	Capitalization (Rs. Crore)	Addition in Line Length (Ckt Km)	Addition in Transformation Capacity (MVA)
1	Uttarakhand	69.77	3.00	1290.00
2	Madhya Pradesh	1349.49	1169.09	3892.00
3	Maharashtra	2150.70	2110.00	5381.00
4	Rajasthan	1528.13	1445.75	4657.50
5	Karnataka	1042.03	590.00	1653.40
6	Gujarat	2525.45	2925.00	11431.00
7	Uttar Pradesh	1900.31	1473.00	8260.00

Following the steps carried out for FY 2013-14, the following ranking is obtained for the utilities for the FY 2015-16:

**Table 131: Ranking of utilities for the FY 2015-16**

S.No.	State	Capitalization (Rs. Crore) (a)	Addition in Line Length (Ckt Km) (b)	Addition in Transformation Capacity (MVA) (c)	Regressed Values (d)	COLS Value (Rs. Crore) (e)	(e/a)	Ranking
1	Uttarakhand	69.77	3.00	1290.00	391.90	69.77	1.0000	1
2	Madhya Pradesh	1349.49	1169.09	3892.00	1326.51	1004.38	0.7443	5
3	Maharashtra	2150.70	2110.00	5381.00	2075.23	1753.11	0.8151	3
4	Rajasthan	1528.13	1445.75	4657.50	1549.56	1227.44	0.8032	4
5	Karnataka	1042.03	590.00	1653.40	853.99	531.87	0.5104	7
6	Gujarat	2525.45	2925.00	11431.00	2765.92	2443.79	0.9677	2
7	Uttar Pradesh	1900.31	1473.00	8260.00	1602.76	1280.64	0.6739	6

The graphical representation of the COLS method is shown in the figure below:

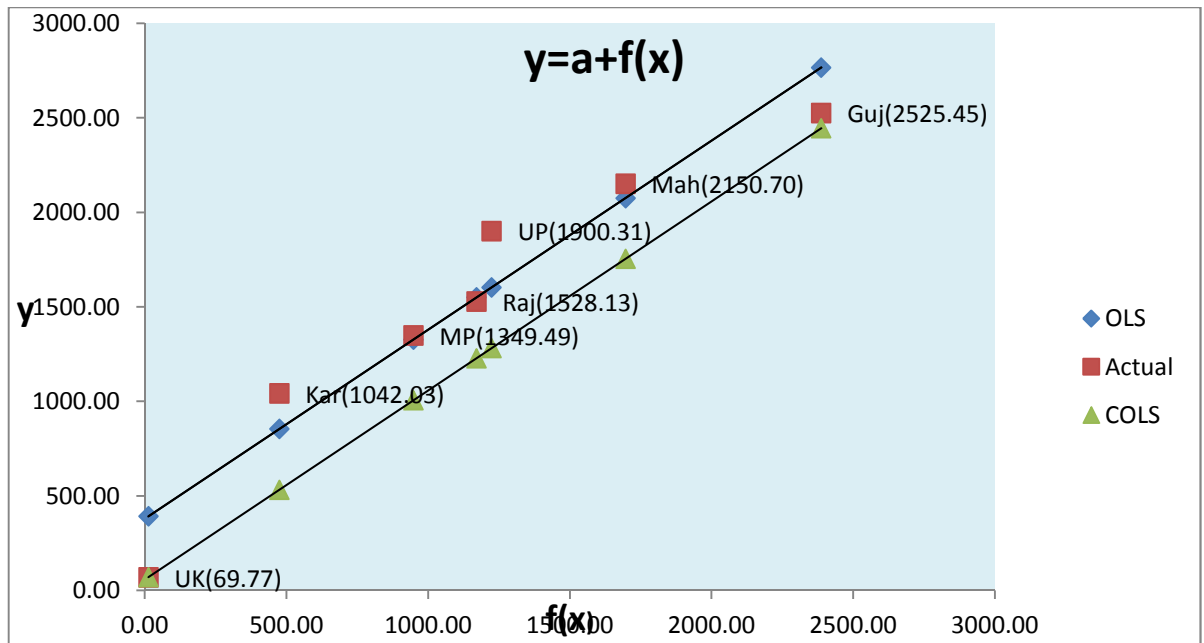


Figure 61: COLS for the FY 2015-16 for Capitalization



## 6. Chapter6: Benchmarking of Technical Parameters

### 6.1 Transmission Losses:-

During the transmission of electricity some energy is lost from the transmission system, usually in the form of heat. This lost energy is known as transmission losses.

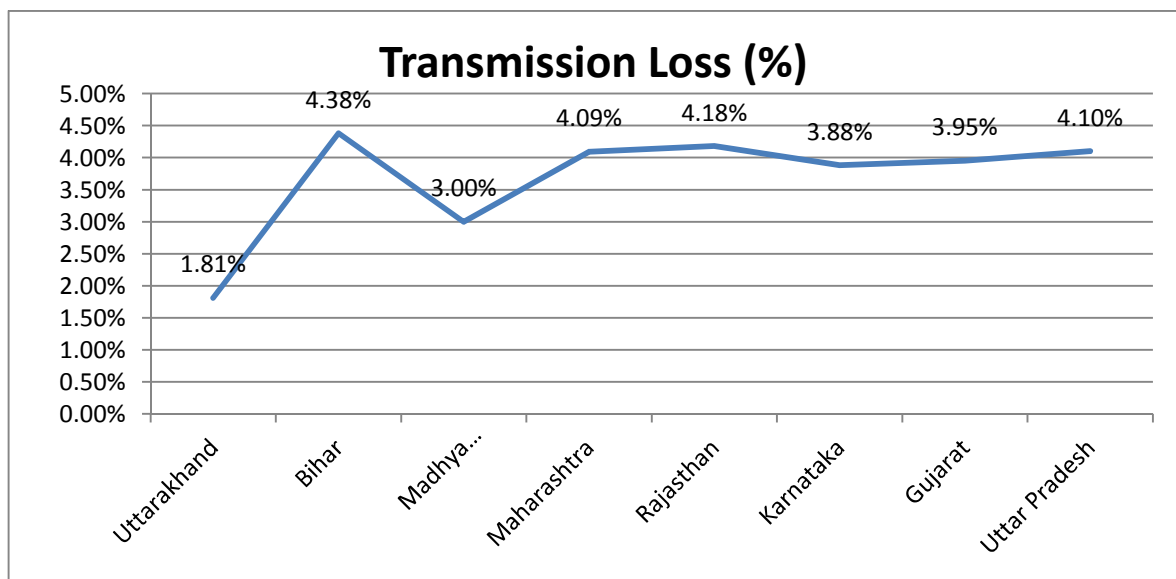
### 6.2 Benchmarking of Transmission Loss:-

#### Analysis for FY 2013-14

The transmission loss of UPPTCL along with the seven other STUs for the FY 2013-14 has been given in the following table:

**Table 132: Transmission Loss for FY 2013-14**

S.No.	State	Transmission Loss (%)
1	Uttarakhand	1.81%
2	Bihar	4.38%
3	Madhya Pradesh	3.00%
4	Maharashtra	4.09%
5	Rajasthan	4.18%
6	Karnataka	3.88%
7	Gujarat	3.95%
8	Uttar Pradesh	4.10%



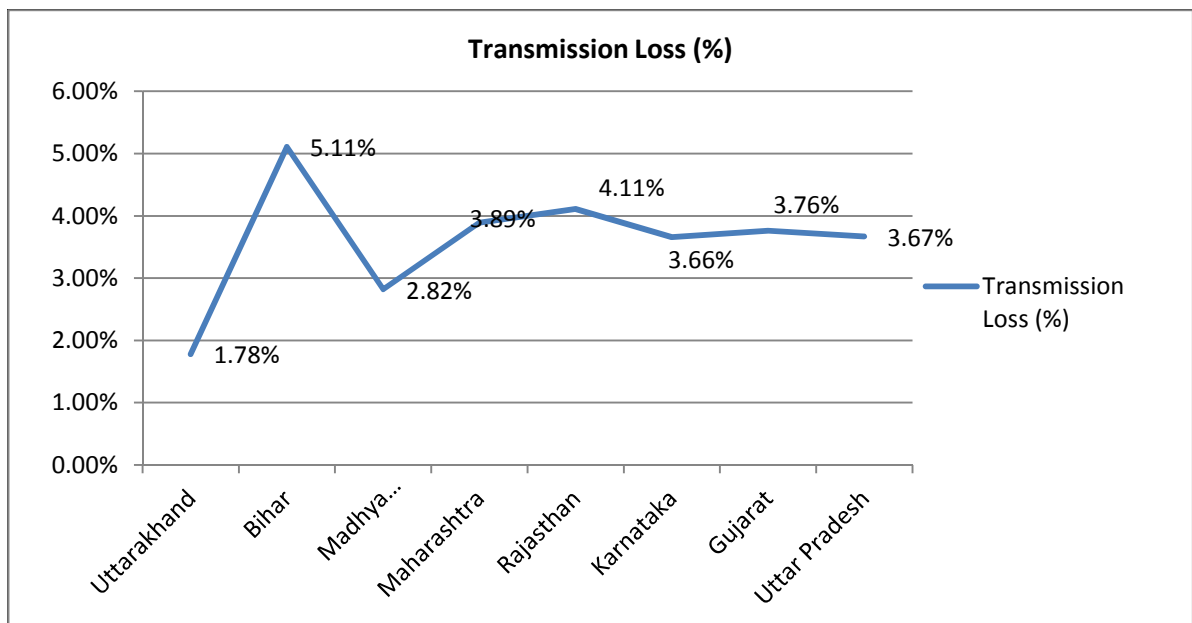
**Figure 62: Transmission Loss (%) (FY 2013-14)**

## Analysis for FY 2014-15

The transmission loss of UPPTCL along with the seven other STUs for the FY 2014-15 has been given in the following table:

**Table 133: Transmission Loss for FY 2014-15**

S.No.	State	Transmission Loss (%)
1	Uttarakhand	1.78%
2	Bihar	5.11%
3	Madhya Pradesh	2.82%
4	Maharashtra	3.89%
5	Rajasthan	4.11%
6	Karnataka	3.66%
7	Gujarat	3.76%
8	Uttar Pradesh	3.67%



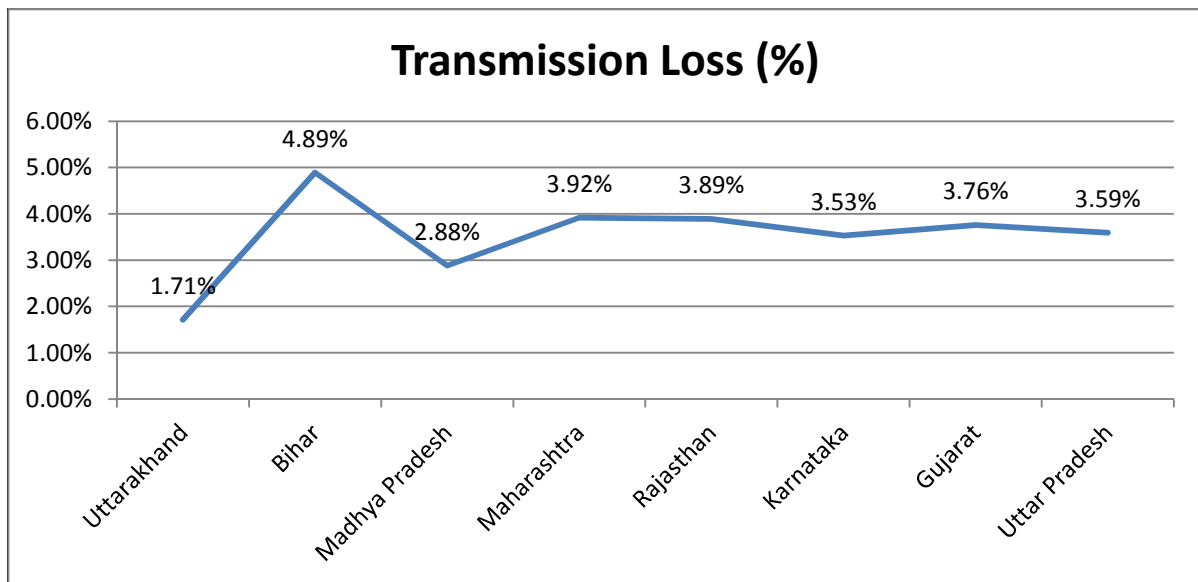
**Figure 63: Transmission Loss (%) (FY 2014-15)**

## Analysis for FY 2015-16

The transmission loss of UPPTCL along with the seven other STUs for the FY 2015-16 has been given in the following table:

**Table 134: Transmission Loss for FY 2015-16**

S.No.	State	Transmission Loss (%)
1	Uttarakhand	1.71%
2	Bihar	4.89%
3	Madhya Pradesh	2.88%
4	Maharashtra	3.92%
5	Rajasthan	3.89%
6	Karnataka	3.53%
7	Gujarat	3.76%
8	Uttar Pradesh	3.59%

**Figure 64: Transmission Loss (%) (FY 2015-16)**

The benchmarking of the Transmission Losses has been carried out using the Regression Analysis and the Total Factor Productivity Method.

### ***a. Application of Regression Analysis***

#### **Analysis for FY 2013-14**

Benchmarking of the Transmission Loss for FY 2013-14 has been carried out by considering the following variables as given in the table below:

**Table 135: Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2013-14**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
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S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
1	Uttarakhand	1.81%	2981.00	13227.00	6097.00
2	Bihar	4.38%	8394.00	13786.16	9499.00
3	Madhya Pradesh	3.00%	29009.77	50300.00	41163.00
4	Maharashtra	4.09%	43019.81	117289.13	101547.00
5	Rajasthan	4.18%	31092.40	63851.02	53249.00
6	Karnataka	3.88%	32471.00	56733.00	50221.85
7	Gujarat	3.95%	49520.00	70712.07	68730.00
8	Uttar Pradesh	4.10%	26876.00	77760.69	63791.00

The Transmission Losses have been benchmarked with respect to line length (Ckm), energy transmitted (MUs) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the Transmission Losses as given in the table below:

**Table 136: Regressed Values of Transmission Loss for FY 2013-14**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	1.81%	2981.00	13227.00	6097.00	3.06%
2	Bihar	4.38%	8394.00	13786.16	9499.00	3.26%
3	Madhya Pradesh	3.00%	29009.77	50300.00	41163.00	3.36%
4	Maharashtra	4.09%	43019.81	117289.13	101547.00	4.36%
5	Rajasthan	4.18%	31092.40	63851.02	53249.00	3.57%
6	Karnataka	3.88%	32471.00	56733.00	50221.85	3.76%
7	Gujarat	3.95%	49520.00	70712.07	68730.00	4.28%
8	Uttar Pradesh	4.10%	26876.00	77760.69	63791.00	3.73%

### Analysis for FY 2014-15

**Table 137: Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2014-15**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
1	Uttarakhand	1.78%	3017.00	13612.23	6582.00
2	Bihar	5.11%	8617.00	16986.53	11560.00
3	Madhya Pradesh	2.82%	30194.99	55206.00	45457.00
4	Maharashtra	3.89%	44207.00	130107.38	105434.00
5	Rajasthan	4.11%	32514.17	67257.92	63378.50

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
6	Karnataka	3.66%	33204.00	59420.35	52081.50
7	Gujarat	3.76%	51634.00	78933.59	80113.00
8	Uttar Pradesh	3.67%	28678.00	82413.86	68465.00

The Transmission Losses have been benchmarked with respect to line length (Ckm), energy transmitted (MUs) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the Transmission Losses as given in the table below:

**Table 138: Regressed Values of Transmission Loss for FY 2014-15**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	1.78%	3017.00	13612.23	6582.00	3.29%
2	Bihar	5.11%	8617.00	16986.53	11560.00	3.30%
3	Madhya Pradesh	2.82%	30194.99	55206.00	45457.00	3.26%
4	Maharashtra	3.89%	44207.00	130107.38	105434.00	3.72%
5	Rajasthan	4.11%	32514.17	67257.92	63378.50	3.99%
6	Karnataka	3.66%	33204.00	59420.35	52081.50	3.46%
7	Gujarat	3.76%	51634.00	78933.59	80113.00	4.01%
8	Uttar Pradesh	3.67%	28678.00	82413.86	68465.00	3.77%

It can be seen from the table given above that considering the transmission losses of other STUs and their transmission system, the transmission losses of UPPTCL can be 3.77% which means that considering the national average, the transmission losses of UPPTCL are on a lower side.

### Analysis for FY 2015-16

Benchmarking of the Transmission Losses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

**Table 139: Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2015-16**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
1	Uttarakhand	1.71%	3020.00	13734.00	7872.00
2	Bihar	4.89%	9573.90	21485.35	14779.90
3	Madhya Pradesh	2.88%	31364.08	59335.00	49349.00
4	Maharashtra	3.92%	46317.00	136215.34	110815.00

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)
	a				
5	Rajasthan	3.89%	33959.92	75567.74	68036.00
6	Karnataka	3.53%	33794.00	61957.51	53734.90
7	Gujarat	3.76%	54665.00	84889.83	91544.00
8	Uttar Pradesh	3.59%	30151.00	88402.14	76725.00

The Transmission Losses have been benchmarked with respect to line length (Ckm), energy transmitted (MUs) and transformation capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the Transmission Losses as given in the table below:

**Table 140: Regressed Values of Transmission Loss for FY 2015-16**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	1.71%	3020.00	13734.00	7872.00	3.06%
2	Bihar	4.89%	9573.90	21485.35	14779.90	3.16%
3	Madhya Pradesh	2.88%	31364.08	59335.00	49349.00	3.52%
4	Maharashtra	3.92%	46317.00	136215.34	110815.00	3.92%
5	Rajasthan	3.89%	33959.92	75567.74	68036.00	3.58%
6	Karnataka	3.53%	33794.00	61957.51	53734.90	3.55%
7	Gujarat	3.76%	54665.00	84889.83	91544.00	3.81%
8	Uttar Pradesh	3.59%	30151.00	88402.14	76725.00	3.57%

## ***b. Benchmarking using Total Factor Productivity Method***

### **Analysis for FY 2013-14**

The total factor productivity of the following State Transmission Utilities (STUs) for the FY 2013-14 has been computed below:

**Table 141: Benchmarking of Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2013-14**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Total Factor Productivity	Rank
1	Uttarakhand	1.81%	2981.00	13227.00	6097.00	0.001940283	7
2	Bihar	4.38%	8394.00	13786.16	9499.00	0.003659958	8

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Total Factor Productivity	Rank
3	Madhya Pradesh	3.00%	29009.77	50300.00	41163.00	0.00066587	4
4	Maharashtra	4.09%	43019.81	117289.13	101547.00	0.000405981	1
5	Rajasthan	4.18%	31092.40	63851.02	53249.00	0.000742777	5
6	Karnataka	3.88%	32471.00	56733.00	50221.85	0.000751146	6
7	Gujarat	3.95%	49520.00	70712.07	68730.00	0.000586659	2
8	Uttar Pradesh	4.10%	26876.00	77760.69	63791.00	0.000625621	3

**Table 142: The share of the respective input factors**

S. No.	Parameter	%age Weightage
1	Line Length (Ckt Km) - $\alpha$	12%
2	Energy Transmitted (MU) - $\beta$	66%
3	Transformation Capacity (MVA) - $\gamma$	22%

**The total factor productivity of Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) is 0.000625621 and is ranked no. 3. The total factor productivity of Maharashtra is 0.000405981 and is ranked no. 1.**

### Analysis for FY 2014-15

The total factor productivity of the following State Transmission Utilities (STUs) for the FY 2014-15 has been computed below:

**Table 143: Benchmarking of Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2014-15**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Total Factor Productivity	Rank
1	Uttarakhand	1.78%	3017.00	13612.23	6582.00	0.001838395	7
2	Bihar	5.11%	8617.00	16986.53	11560.00	0.003551881	8
3	Madhya Pradesh	2.82%	30194.99	55206.00	45457.00	0.000573157	4
4	Maharashtra	3.89%	44207.00	130107.38	105434.00	0.000356448	1
5	Rajasthan	4.11%	32514.17	67257.92	63378.50	0.000675546	5
6	Karnataka	3.66%	33204.00	59420.35	52081.50	0.00067994	6
7	Gujarat	3.76%	51634.00	78933.59	80113.00	0.000499606	2
8	Uttar Pradesh	3.67%	28678.00	82413.86	68465.00	0.000526498	3

**Table 144: The share of the respective input factors**

S. No.	Parameter	%age Weightage
1	Line Length (Ckt Km) - $\alpha$	12%
2	Energy Transmitted (MU) - $\beta$	66%
3	Transformation Capacity (MVA) - $\gamma$	22%

**The total factor productivity of Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) is 0.000528633 and is ranked no. 3. The total factor productivity of Maharashtra is 0.000356448 and is ranked no. 1.**

### Analysis for FY 2015-16

The total factor productivity of the following State Transmission Utilities (STUs) for the FY 2015-16 has been computed below:

**Table 145: Benchmarking of Transmission Loss, Line Length, Energy Transmitted and Transformation Capacity of different states for FY 2015-16**

S.No.	State	Transmission Loss (%)	Line Length (Ckt Km)	Energy Transmitted (MU)	Transformation Capacity (MVA)	Total Factor Productivity	Rank
1	Uttarakhand	1.71%	3020.00	13734.00	7872.00	0.001687759	7
2	Bihar	4.89%	9573.90	21485.35	14779.90	0.002722929	8
3	Madhya Pradesh	2.88%	31364.08	59335.00	49349.00	0.00054565	4
4	Maharashtra	3.92%	46317.00	136215.34	110815.00	0.000342765	1
5	Rajasthan	3.89%	33959.92	75567.74	68036.00	0.000579868	5
6	Karnataka	3.53%	33794.00	61957.51	53734.90	0.000632231	6
7	Gujarat	3.76%	54665.00	84889.83	91544.00	0.000459261	2
8	Uttar Pradesh	3.59%	30151.00	88402.14	76725.00	0.00047668	3

**Table 146: The share of the respective input factors**

S. No.	Parameter	%age Weightage
1	Line Length (Ckt Km) - $\alpha$	12%
2	Energy Transmitted (MU) - $\beta$	66%
3	Transformation Capacity (MVA) - $\gamma$	22%

**The total factor productivity of Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) is 0.00047668 and is ranked no. 3. The total factor productivity of Maharashtra is 0.000342765 and is ranked no. 1.**



### 6.3 Transmission System Availability:-

The Transmission System Availability for the UPPTCL and the seven other STUs for the FY 2014-15 is given in the following table:

**Table 147: Transmission System Availability for FY 2014-15**

S.No.	State	Transmission System Availability (%)
1	Uttarakhand	99.33%
2	Madhya Pradesh	99.35%
3	Maharashtra	99.73%
4	Rajasthan	99.75%
5	Karnataka	99.81%
6	Gujarat	99.63%
7	Uttar Pradesh	99.64%

It can be seen in the table given above that the transmission system availability of Rajasthan is highest at 99.75% among all the STUs considered for the study.

## 7. Chapter7: Benchmarking of Operational Parameters

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### 7.1 Classification of Failures of a Transformer:-

Faults can be classified into three classes:

#### Failure attributed by users

- Prolonged over loading
- Single phase loading
- Un-balanced loading
- Faulty terminations
- Faulty earth connection to tank body as well as LV terminal
- Failures due to external short-circuit
- Less maintenance
- Improper installation

#### Failure causes at the manufacturer's end

- Faulty design
- Poor quality of material
- Bad workmanship
- Improper transportation
- Sharp edges of conductor
- Incomplete drying
- Bad insulation covering on conductor
- Improper joints or connection

#### Failure during working condition

- Deterioration of oil
- Faults in magnetic circuit
- Inadequate pre shrinkage of the winding
- Inter turn faults

- Fire or Explosion
- Line surges
- Lightening
- Moisture ingress

#### Major failures in power transformers

- Oil leakage
- Deterioration of oil
- Ventilation failure
- Loose clamping
- Bushing flashover
- Fault in OLTC
- Inter-turn fault

### **7.2 Transformer Failure Rate:-**

The transformer failure rate during the FY 2014-15 as obtained from Maharashtra, Gujarat and Uttar Pradesh is being given in the following table:

**Table 148: Transmission Failure Rate**

S.No.	State	Transformer Failure Rate (%)
1	Maharashtra	1.35%
2	Gujarat	0.76%
3	Uttar Pradesh	6.94%

## 8. Chapter8: International Benchmarking

### 8.1 Transmission Network Service Providers in Australia:-

The Transmission Network Service Providers of Australia have been considered as the international utilities to carry out the benchmarking study. The following four utilities have been considered for the study:

#### 1. ElectraNet

**ElectraNet Pty Ltd** is an electricity transmission company in South Australia. It is owned by a consortium of companies. It operates the high-voltage electricity transmission infrastructure in South Australia.

#### 2. Powerlink

**Powerlink Queensland** (formally **Queensland Electricity Transmission Corporation Limited**) is an electricity transmission system operator owned by the Government of Queensland which operates the high-voltage electricity transmission infrastructure in Queensland.

#### 3. TasNetworks

**TasNetworks** is a Tasmanian Government-owned corporation that is responsible for electricity transmission and distribution throughout Tasmania. TasNetworks is a participant in the Australian National Electricity Market (NEM) that operates an interconnected power system that extends from Queensland to South Australia.

#### 4. TransGrid

**TransGrid** is the manager and operator of the high voltage electricity transmission network in the Australian state of New South Wales.

The details of the transmission service providers of Australia considered in this report have been taken from the data available in the official website of the Australian Energy Regulator (AER).

The value of the O&M Expenses has been provided in Australian Dollars in the AER. For the purpose of computation in this study, the Australian Dollar has been converted to INR based on the average exchange rate of the Australian Dollar to the INR for the respective years. The average exchange rate considered for the period FY 2011-12 to FY 2015-16 is given below:

1. FY 2011-12 – 1 AUD = Rs. 47.95
2. FY 2012-13 – 1 AUD = Rs. 55.36
3. FY 2013-14 – 1 AUD = Rs. 56.54
4. FY 2014-15 – 1 AUD = Rs. 55.05
5. FY 2015-16 – 1 AUD = Rs. 48.18

## 8.2 Transmission Network Details :-

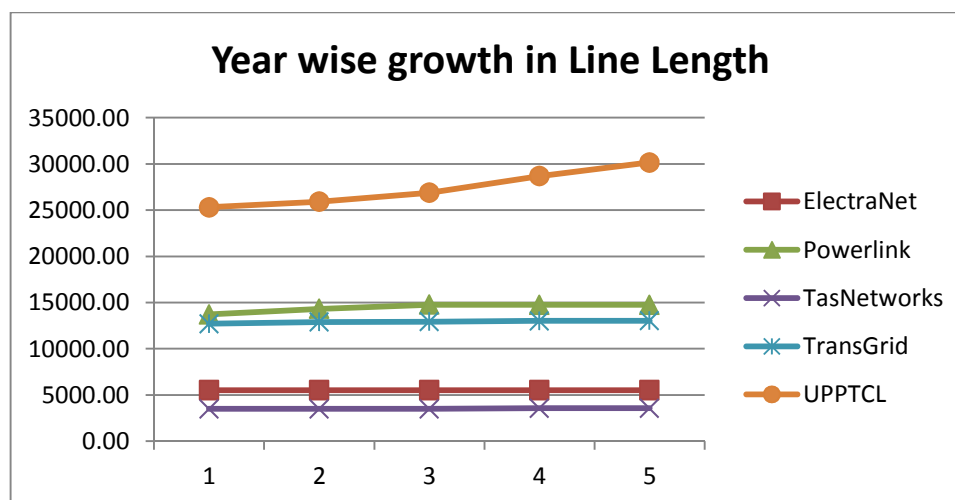
The network details of the four companies along with the energy transmitted, peak demand met and transmission losses during the period FY 2011-12 to FY 2015-16 is as follows:

### A. Line Length

The detail of line length (Ckm) during the last five years of the four companies along with UPPTCL is given in the following table:

**Table 149: Line Length (Ckm)**

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
1	ElectraNet	5526.07	5527.35	5529.40	5521.35	5524.35
2	Powerlink	13702.40	14313.50	14772.50	14754.50	14755.50
3	TasNetworks	3493.30	3503.19	3503.80	3563.70	3563.70
4	TransGrid	12697.21	12893.62	12929.67	13024.76	13039.20
5	UPPTCL	25301.00	25921.00	26876.00	28678.00	30151.00



**Figure 65: Line Length (Ckm)**

### B. Transformation Capacity

The detail of transformation capacity (MVA) during the last five years of the four companies along with UPPTCL is given in the following table:

**Table 150: Transformation Capacity (MVA)**

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
1	ElectraNet	11734.00	12249.00	12519.00	12408.60	12857.60
2	Powerlink	37616.00	40274.00	41033.00	42093.00	44377.00
3	TasNetworks	8421.00	8591.50	8606.00	8581.50	8591.00
4	TransGrid	54195.30	54556.30	56144.30	57806.30	57814.08

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
5	UPPTCL	54452.00	58850.00	63791.00	68465.00	76725.00

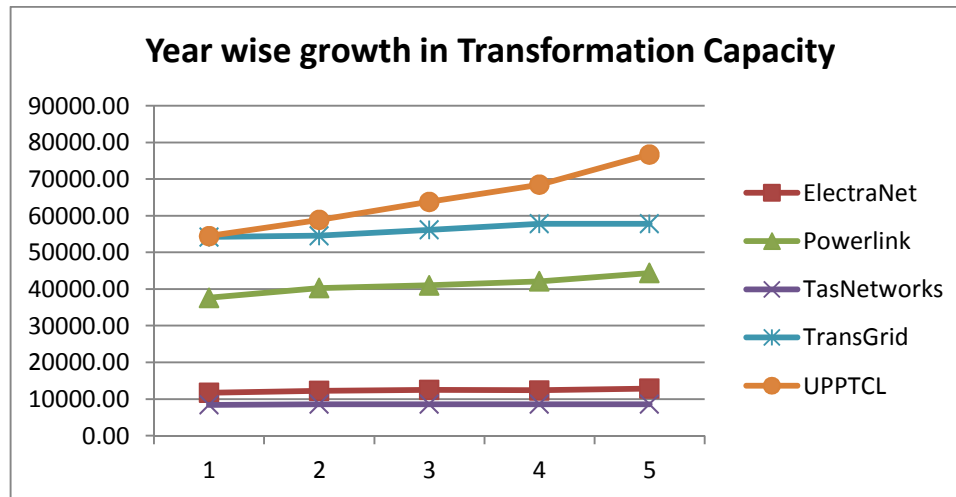


Figure 66: Transformation Capacity (MVA)

### C. Energy Transmitted (MU)

The detail of energy transmitted (MU) during the last five years of the four companies along with UPPTCL is given in the following table:

Table 151: Energy Transmitted (MU)

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
1	ElectraNet	14062.88	14283.59	13957.00	13455.33	14247.98
2	Powerlink	50878.58	49333.94	47613.58	53087.56	52872.39
3	TasNetworks	12589.84	12866.19	13359.96	13109.62	7919.42
4	TransGrid	68200.00	65200.00	67800.00	74400.00	72200.00
5	UPPTCL	70371.05	73897.66	77760.69	82413.86	88402.14

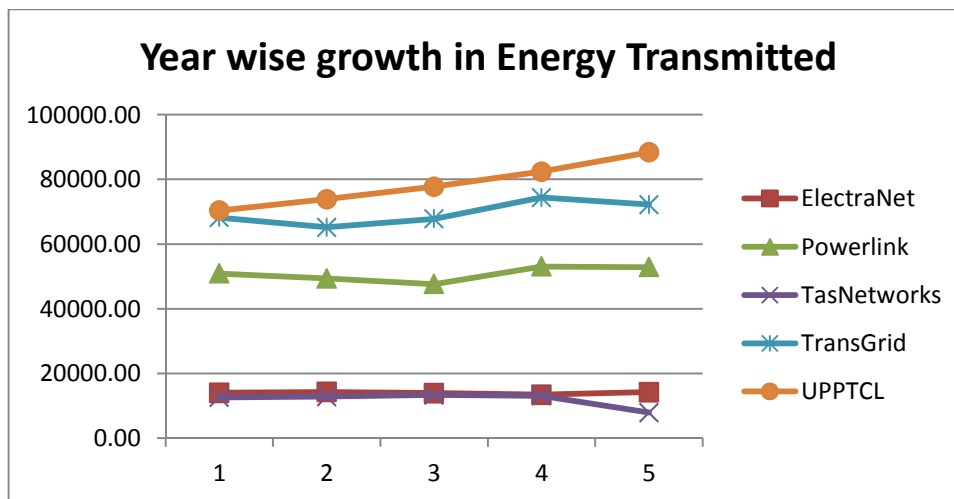


Figure 67: Energy Transmitted (MU)

### D. Peak Demand (MW)

The detail of Peak Demand (MVA) during the last five years of the four companies along with UPPTCL is given in the following table:

Table 152: Peak Demand (MW)

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
1	ElectraNet	2807.68	2913.56	3115.14	2668.46	2804.48
2	Powerlink	7740.01	7681.44	7637.88	8105.06	8272.12
3	TasNetworks	2264.05	2184.59	2132.00	2143.16	2218.90
4	TransGrid	11900.00	12700.00	12100.00	10900.00	11900.00
5	UPPTCL	12038.00	13940.00	13089.00	15670.00	16988.00

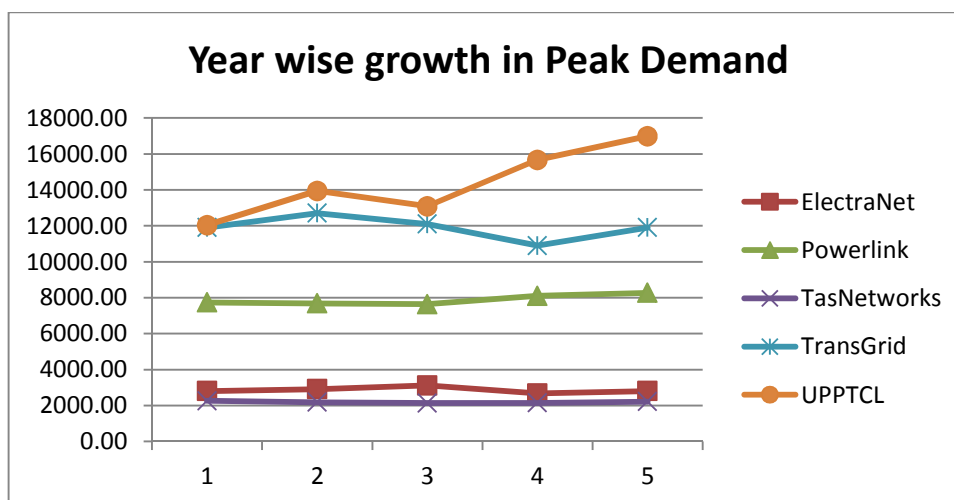


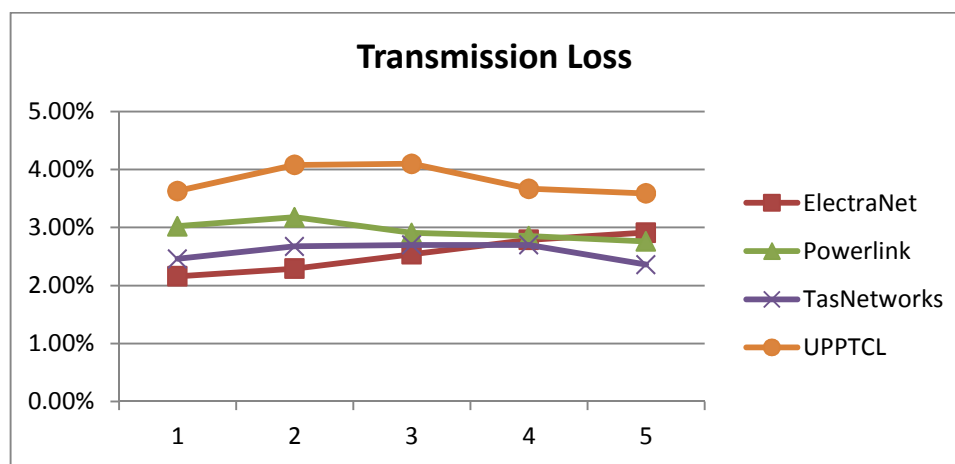
Figure 68: Peak Demand (MW)

### E. Transmission Loss (%)

The detail of Transmission Loss (%) during the last five years of the companies along with UPPTCL is given in the following table:

**Table 153: Transmission Loss (%)**

S.No.	State/Utility	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
1	ElectraNet	2.16%	2.29%	2.54%	2.79%	2.91%
2	Powerlink	3.02%	3.18%	2.91%	2.85%	2.76%
3	TasNetworks	2.46%	2.68%	2.70%	2.70%	2.36%
4	UPPTCL	3.63%	4.08%	4.10%	3.67%	3.59%



**Figure 69: Transmission Loss (%)**

### 8.3 Benchmarking of O&M Expenses:-

The benchmarking of the O&M Expenses has been carried out using the Partial Performance Indicator and Econometric Method using the Cobb Douglas Production Function.

#### a. Partial Performance Indicator (PPI)

- O&M Expense /Ckm

The O&M Expense/Ckm of the eleven STUs along with UPPTCL for the FY 2013-14 is given in the table below:



**Table 154: O&M Expenses/Ckm for FY 2013-14**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	O&M Expenses/Ckm (c)	Ranking
1	Uttarakhand	82.24	2981.00	2.76	6
2	Bihar	152.99	8394.00	1.82	3
3	Madhya Pradesh	374.30	29009.77	1.29	1
4	Maharashtra	1202.88	43019.81	2.80	7
5	Rajasthan	1210.53	31092.40	3.89	8
6	Karnataka	865.53	32471.00	2.67	5
7	Gujarat	894.68	50131.56	1.78	2
8	Uttar Pradesh	587.00	26876.00	2.18	4
9	ElectraNet	355.62	5529.40	6.43	11
10	Powerlink	868.04	14772.50	5.88	9
11	TasNetworks	218.65	3503.80	6.24	10
12	TransGrid	842.23	12929.67	6.51	12

The O&M Expense/Ckm of the eleven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 155: O&M Expenses/Ckm for FY 2014-15**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	O&M Expenses/Ckm (c)	Ranking
1	Uttarakhand	85.01	3017.00	2.82	5
2	Bihar	141.52	8617.00	1.64	2
3	Madhya Pradesh	411.89	30194.99	1.36	1
4	Maharashtra	1284.32	44207.00	2.91	6
5	Rajasthan	1134.34	32514.17	3.49	8
6	Karnataka	1012.63	33204.00	3.05	7
7	Gujarat	962.59	52531.56	1.83	3
8	Uttar Pradesh	626.91	28678.00	2.19	4
9	ElectraNet	381.73	5521.35	6.91	12
10	Powerlink	1013.05	14754.50	6.87	11
11	TasNetworks	166.42	3563.70	4.67	9
12	TransGrid	806.70	13024.76	6.19	10

The O&M Expense/Ckm of the eleven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

Table 156: O&amp;M Expenses/Ckm for FY 2015-16

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	O&M Expenses/Ckm (c)	Ranking
1	Uttarakhand	102.76	3020.00	3.40	7
2	Bihar	158.95	9573.90	1.66	2
3	Madhya Pradesh	441.43	31364.08	1.41	1
4	Maharashtra	1399.09	46317.00	3.02	6
5	Rajasthan	1171.69	33959.92	3.45	8
6	Karnataka	968.59	33794.00	2.87	5
7	Gujarat	1068.46	55456.56	1.93	3
8	Uttar Pradesh	724.62	30151.00	2.40	4
9	ElectraNet	408.12	5524.35	7.39	12
10	Powerlink	1043.74	14755.50	7.07	11
11	TasNetworks	180.32	3563.70	5.06	9
12	TransGrid	812.96	13039.20	6.23	10

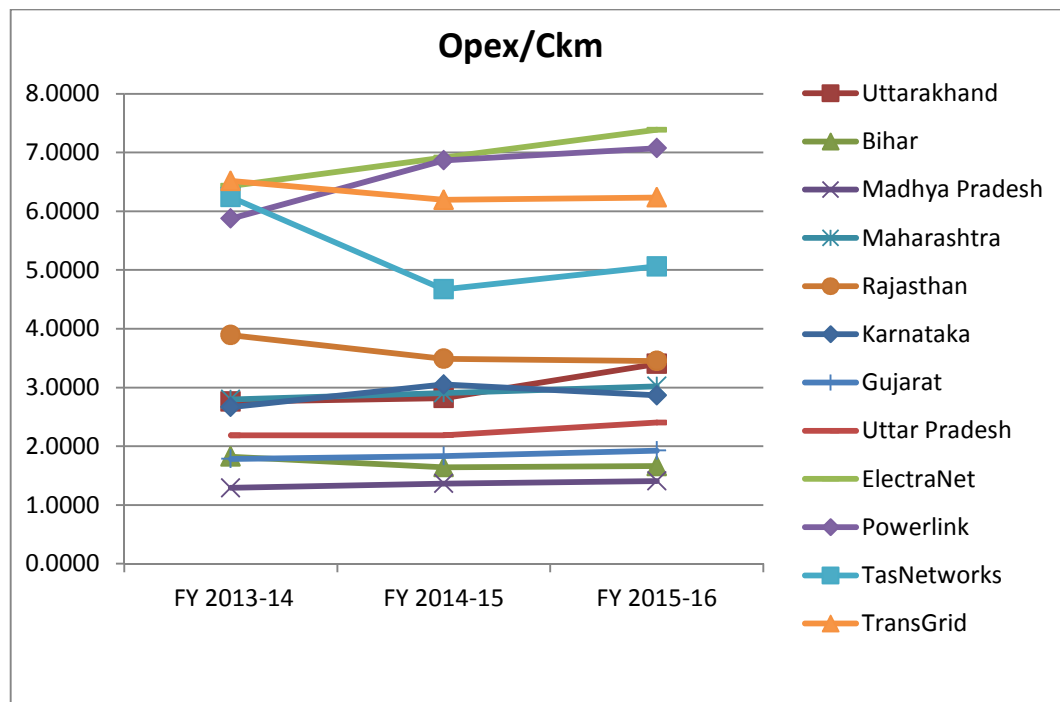


Figure 70: Opex/Ckm

It can be seen that the utility of Madhya Pradesh is having the lowest Opex/Ckm with UPPTCL ranked at number 4.

- **O&M Expense /MVA**

The O&M Expense/MVA of the eleven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 157: O&M Expenses/MVA for FY 2013-14**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Transformation Capacity (MVA) (b)	O&M Expenses/MVA (c)	Ranking
1	Uttarakhand	82.24	6097.00	1.35	5
2	Bihar	152.99	9499.00	1.61	7
3	Madhya Pradesh	374.30	41163.00	0.91	1
4	Maharashtra	1202.88	101547.00	1.18	3
5	Rajasthan	1210.53	53249.00	2.27	10
6	Karnataka	865.53	50221.85	1.72	8
7	Gujarat	894.68	68730.00	1.30	0
8	Uttar Pradesh	587.00	63791.00	0.92	2
9	ElectraNet	355.62	12519.00	2.84	0
10	Powerlink	868.04	41033.00	2.12	9
11	TasNetworks	218.65	8606.00	2.54	11
12	TransGrid	842.23	56144.30	1.50	6

The O&M Expense/MVA of the eleven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 158: O&M Expenses/MVA for FY 2014-15**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Transformation Capacity (MVA) (b)	O&M Expenses/MVA (c)	Ranking
1	Uttarakhand	85.01	6582.00	1.2915	6
2	Bihar	141.52	11560.00	1.2242	5
3	Madhya Pradesh	411.89	45457.00	0.9061	1
4	Maharashtra	1284.32	105434.00	1.2181	4
5	Rajasthan	1134.34	63378.50	1.7898	8
6	Karnataka	1012.63	52081.50	1.9443	10
7	Gujarat	962.59	80113.00	1.2015	3
8	Uttar Pradesh	626.91	68465.00	0.9157	2
9	ElectraNet	381.73	12408.60	3.0763	12

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Transformation Capacity (MVA) (b)	O&M Expenses/MVA (c)	Ranking
10	Powerlink	1013.05	42093.00	2.4067	11
11	TasNetworks	166.42	8581.50	1.9393	9
12	TransGrid	806.70	57806.30	1.3955	7

The O&M Expense/MVA of the eleven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 159: O&M Expenses/MVA for FY 2015-16**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Transformation Capacity (MVA) (b)	O&M Expenses/MVA (c)	Ranking
1	Uttarakhand	102.76	7872.00	1.31	6
2	Bihar	158.95	14779.90	1.08	3
3	Madhya Pradesh	441.43	49349.00	0.89	1
4	Maharashtra	1399.09	110815.00	1.26	5
5	Rajasthan	1171.69	68036.00	1.72	8
6	Karnataka	968.59	53734.90	1.80	9
7	Gujarat	1068.46	91544.00	1.17	4
8	Uttar Pradesh	724.62	76725.00	0.94	2
9	ElectraNet	408.12	12857.60	3.17	12
10	Powerlink	1043.74	44377.00	2.35	11
11	TasNetworks	180.32	8591.00	2.10	10
12	TransGrid	812.96	57814.08	1.41	7

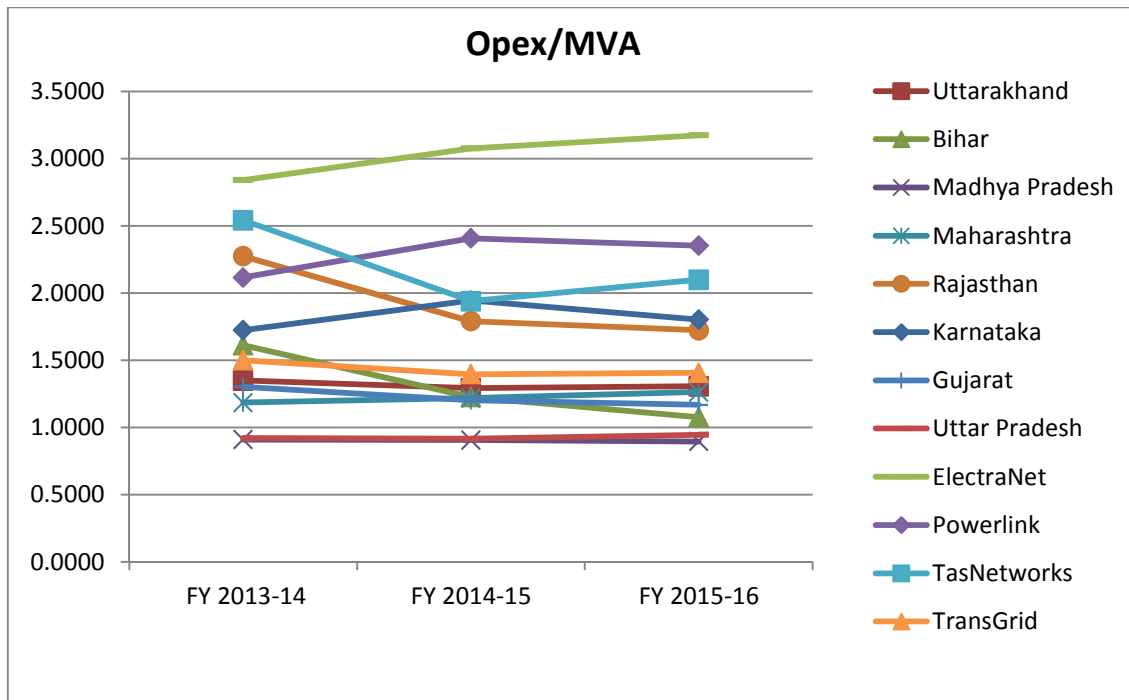


Figure 71: Opex/MVA

It can be seen that the utility of Madhya Pradesh is having the lowest Opex/MVA with UPPTCL ranked at number 2.

• **O&M Expense /MU**

The O&M Expense/MU of the eleven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

Table 160: O&M Expenses/MU for FY 2013-14

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Energy Transmitted (MU) (b)	O&M Expenses/MU (c)	Ranking
1	Uttarakhand	82.24	13227.00	0.62	1
2	Bihar	152.99	13786.16	1.11	5
3	Madhya Pradesh	374.30	50300.00	0.74	2
4	Maharashtra	1202.88	117289.13	1.03	4
5	Rajasthan	1210.53	63851.02	1.90	11
6	Karnataka	865.53	56733.00	1.53	8
7	Gujarat	894.68	70712.07	1.27	7
8	Uttar Pradesh	587.00	77760.69	0.75	3
9	ElectraNet	355.62	13957.00	2.55	12

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Energy Transmitted (MU) (b)	O&M Expenses/MU (c)	Ranking
10	Powerlink	868.04	47613.58	1.82	10
11	TasNetworks	218.65	13359.96	1.64	9
12	TransGrid	842.23	67800.00	1.24	6

The O&M Expense/MU of the eleven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 161: O&M Expenses/MU for FY 2014-15**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Energy Transmitted (MU) (b)	O&M Expenses/MU (c)	Ranking
1	Uttarakhand	85.01	13612.23	0.62	1
2	Bihar	141.52	16986.53	0.83	4
3	Madhya Pradesh	411.89	55206.00	0.75	2
4	Maharashtra	1284.32	130107.38	0.99	5
5	Rajasthan	1134.34	67257.92	1.69	9
6	Karnataka	1012.63	59420.35	1.70	10
7	Gujarat	962.59	78933.59	1.22	7
8	Uttar Pradesh	626.91	82413.86	0.76	3
9	ElectraNet	381.73	13455.33	2.84	12
10	Powerlink	1013.05	53087.56	1.91	11
11	TasNetworks	166.42	13109.62	1.27	8
12	TransGrid	806.70	74400.00	1.08	6

The O&M Expense/MU of the eleven STUs along with UPPTCL for the FY 2015-16 is given in the table below:

**Table 162: O&M Expenses/MU for FY 2015-16**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Energy Transmitted (MU) (b)	O&M Expenses/MU (c)	Ranking
1	Uttarakhand	102.76	13734.00	0.7482	3
2	Bihar	158.95	21485.35	0.7398	1
3	Madhya Pradesh	441.43	59335.00	0.7440	2
4	Maharashtra	1399.09	136215.34	1.0271	5

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Energy Transmitted (MU) (b)	O&M Expenses/MU (c)	Ranking
5	Rajasthan	1171.69	75567.74	1.5505	8
6	Karnataka	968.59	61957.51	1.5633	9
7	Gujarat	1068.46	84889.83	1.2586	7
8	Uttar Pradesh	724.62	88402.14	0.8197	4
9	ElectraNet	408.12	14247.98	2.8644	12
10	Powerlink	1043.74	52872.39	1.9741	10
11	TasNetworks	180.32	7919.42	2.2769	11
12	TransGrid	812.96	72200.00	1.1260	6

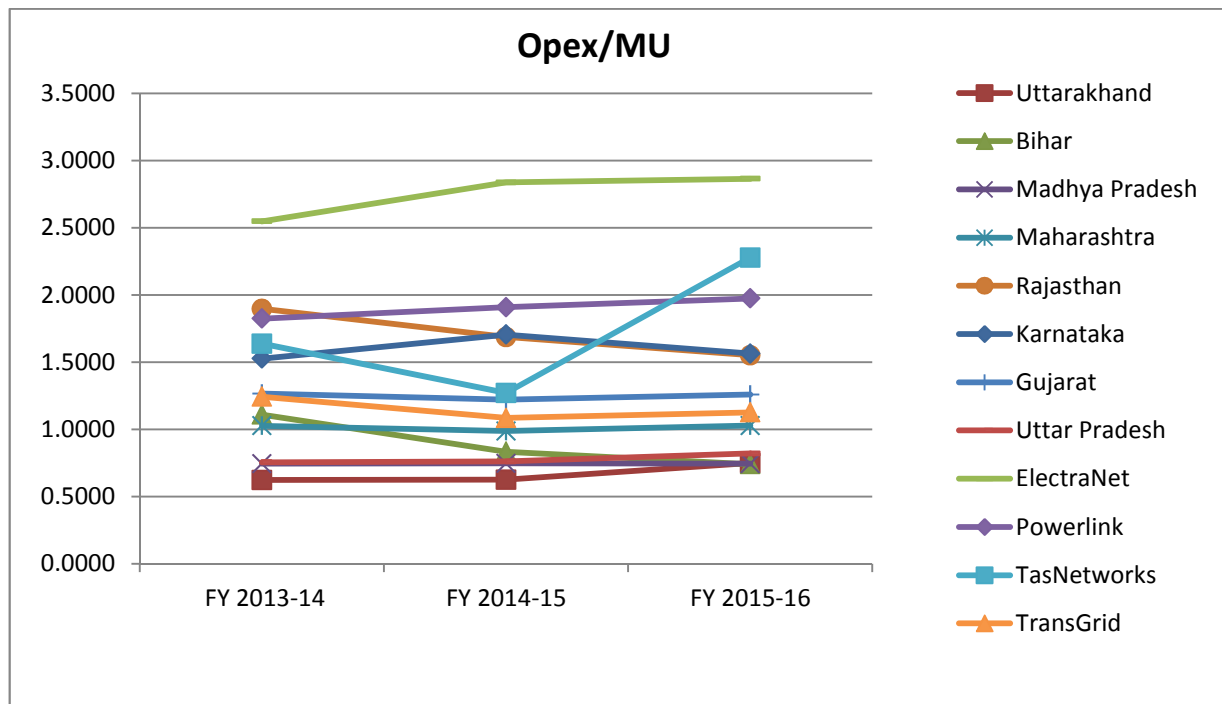


Figure 72: Opex/MU

It can be seen that the utility of Uttarakhand is having the lowest Opex/MVA in two out of three years considered with UPPTCL ranked at number 3.

- O&M Expense /MW**

The O&M Expense/MW of the eleven STUs along with UPPTCL for the FY 2013-14 is given in the table below:

**Table 163: O&M Expenses/MW for FY 2013-14**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Peak Demand (MW) (b)	O&M Expenses/MW (c)	Ranking
1	Uttarakhand	82.24	1826.00	4.50	3
2	Bihar	152.99	2465.00	6.21	4
3	Madhya Pradesh	374.30	9716.00	3.85	1
4	Maharashtra	1202.88	19276.00	6.24	5
5	Rajasthan	1210.53	10047.00	12.05	12
6	Karnataka	865.53	9940.00	8.71	8
7	Gujarat	894.68	12201.00	7.33	7
8	Uttar Pradesh	587.00	13089.00	4.48	2
9	ElectraNet	355.62	3115.14	11.42	11
10	Powerlink	868.04	7637.88	11.36	10
11	TasNetworks	218.65	2132.00	10.26	9
12	TransGrid	842.23	12100.00	6.96	6

The O&M Expense/MW of the eleven STUs along with UPPTCL for the FY 2014-15 is given in the table below:

**Table 164: O&M Expenses/MW for FY 2014-15**

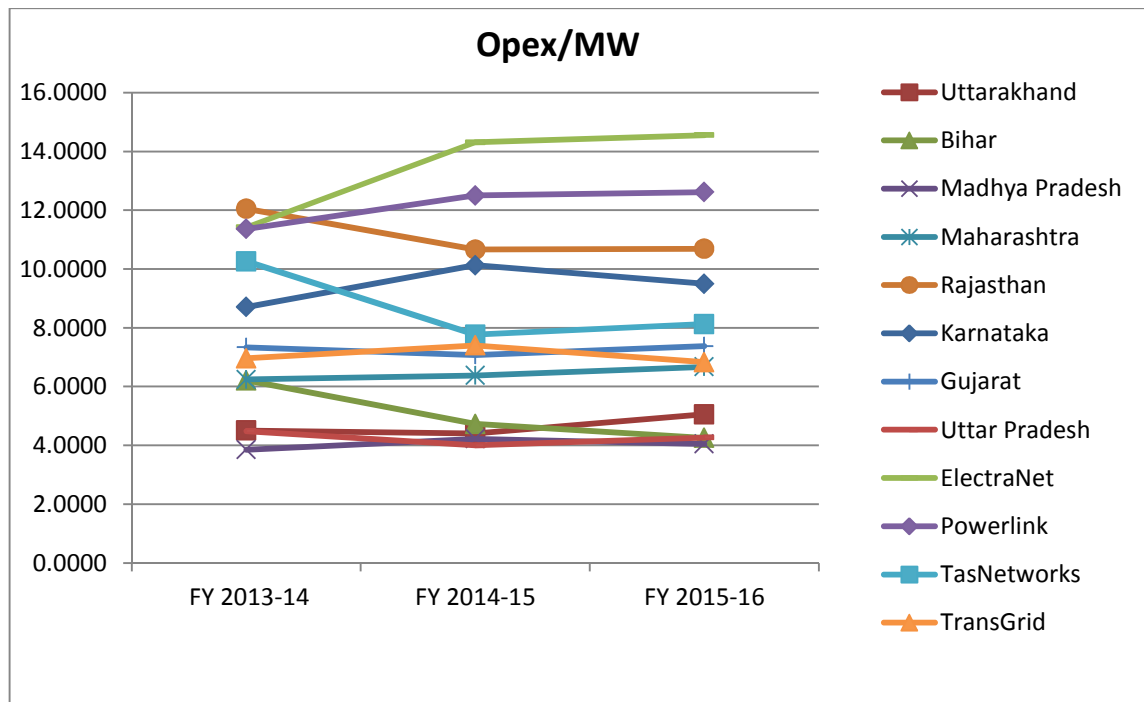
S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Peak Demand (MW) (b)	O&M Expenses/MW (c)	Ranking
1	Uttarakhand	85.01	1930.00	4.40	3
2	Bihar	141.52	2994.00	4.73	4
3	Madhya Pradesh	411.89	9755.00	4.22	2
4	Maharashtra	1284.32	20147.00	6.37	5
5	Rajasthan	1134.34	10642.00	10.66	10
6	Karnataka	1012.63	10001.00	10.13	9
7	Gujarat	962.59	13603.00	7.08	6
8	Uttar Pradesh	626.91	15670.00	4.00	1
9	ElectraNet	381.73	2668.46	14.31	12
10	Powerlink	1013.05	8105.06	12.50	11
11	TasNetworks	166.42	2143.16	7.77	8
12	TransGrid	806.70	10900.00	7.40	7

The O&M Expense/MW of the eleven STUs along with UPPTCL for the FY 2015-16 is given in the table below:



**Table 165: O&M Expenses/MW for FY 2015-16**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Peak Demand (MW) (b)	O&M Expenses/MW (c)	Ranking
1	Uttarakhand	102.76	2034.00	5.05	4
2	Bihar	158.95	3735.00	4.26	2
3	Madhya Pradesh	441.43	10902.00	4.05	1
4	Maharashtra	1399.09	20973.00	6.67	5
5	Rajasthan	1171.69	10961.00	10.69	10
6	Karnataka	968.59	10202.00	9.49	9
7	Gujarat	1068.46	14495.00	7.37	7
8	Uttar Pradesh	724.62	16988.00	4.27	3
9	ElectraNet	408.12	2804.48	14.55	12
10	Powerlink	1043.74	8272.12	12.62	11
11	TasNetworks	180.32	2218.90	8.13	8
12	TransGrid	812.96	11900.00	6.83	6

**Figure 73: Opex/MW**

It can be seen that the utility of Madhya Pradesh is having the lowest Opex/MVA with UPPTCL ranked at number 3 during FY 2015-16.

## b. Econometric Method

### FY 2013-14

- **The selection of variables**

Benchmarking of the O&M Expenses for FY 2013-14 has been carried out by considering the following variables as given in the table below:

**Table 166: O&M Expenses, Line Length and Transformation Capacity for different States/Utilities for FY 2013-14**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	82.24	2981.00	6097.00
2	Bihar	152.99	8394.00	9499.00
3	Madhya Pradesh	374.30	29009.77	41163.00
4	Maharashtra	1202.88	43019.81	101547.00
5	Rajasthan	1210.53	31092.40	53249.00
6	Karnataka	865.53	32471.00	50221.85
7	Gujarat	894.68	50131.56	68730.00
8	Uttar Pradesh	587.00	26876.00	63791.00
9	ElectraNet	355.62	5529.40	12519.00
10	Powerlink	868.04	14772.50	41033.00
11	TasNetworks	218.65	3503.80	8606.00
12	TransGrid	842.23	12929.67	56144.30

Doing the regression analysis on the values obtained after considering log of the values in table 152 we obtain the following values:

**Table 167: Application of Regression Analysis**

S.No.	State/Utility	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
1	Uttarakhand	4.41	8.00	8.72	4.86
2	Bihar	5.03	9.04	9.16	5.09
3	Madhya Pradesh	5.93	10.28	10.63	6.35
4	Maharashtra	7.09	10.67	11.53	7.21
5	Rajasthan	7.10	10.34	10.88	6.60

S.No.	State/Utility	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)
6	Karnataka	6.76	10.39	10.82	6.53
7	Gujarat	6.80	10.82	11.14	6.76
8	Uttar Pradesh	6.38	10.20	11.06	6.83
9	ElectraNet	5.87	8.62	9.44	5.48
10	Powerlink	6.77	9.60	10.62	6.50
11	TasNetworks	5.39	8.16	9.06	5.19
12	TransGrid	6.74	9.47	10.94	6.86

Having obtained the regressed value the efficiency of the STUs have been obtained in the following table:

**Table 168: Ranking of Utilities (FY 2013-14)**

S.No.	State/Utility	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.41	8.00	8.72	4.86	0.9074	1
2	Bihar	5.03	9.04	9.16	5.09	0.9888	6
3	Madhya Pradesh	5.93	10.28	10.63	6.35	0.9334	2
4	Maharashtra	7.09	10.67	11.53	7.21	0.9837	5
5	Rajasthan	7.10	10.34	10.88	6.60	1.0750	12
6	Karnataka	6.76	10.39	10.82	6.53	1.0355	8
7	Gujarat	6.80	10.82	11.14	6.76	1.0051	7
8	Uttar Pradesh	6.38	10.20	11.06	6.83	0.9337	3
9	ElectraNet	5.87	8.62	9.44	5.48	1.0727	11
10	Powerlink	6.77	9.60	10.62	6.50	1.0408	10
11	TasNetworks	5.39	8.16	9.06	5.19	1.0389	9
12	TransGrid	6.74	9.47	10.94	6.86	0.9815	4

It can be seen from the table given above that the rank obtained by UPPTCL is no. 3.

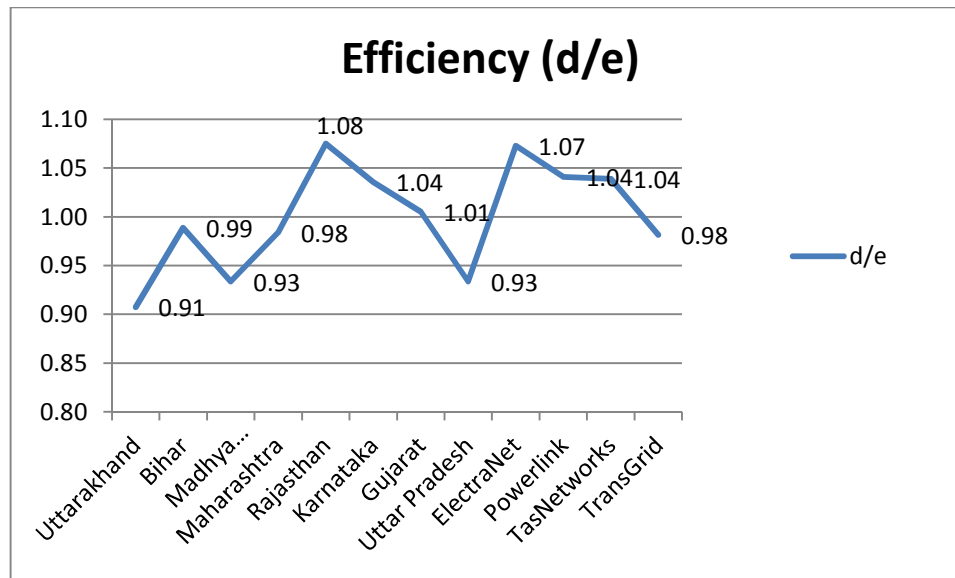


Figure 74: Efficiency (FY 2013-14)

### Analysis for FY 2014-15

Benchmarking of the employee expenses for FY 2014-15 has been carried out by considering the following variables as given in the table below:

**Table 169: O&M Expenses, Line Length and Transformation Capacity of different States/Utilities for FY 2014-15**

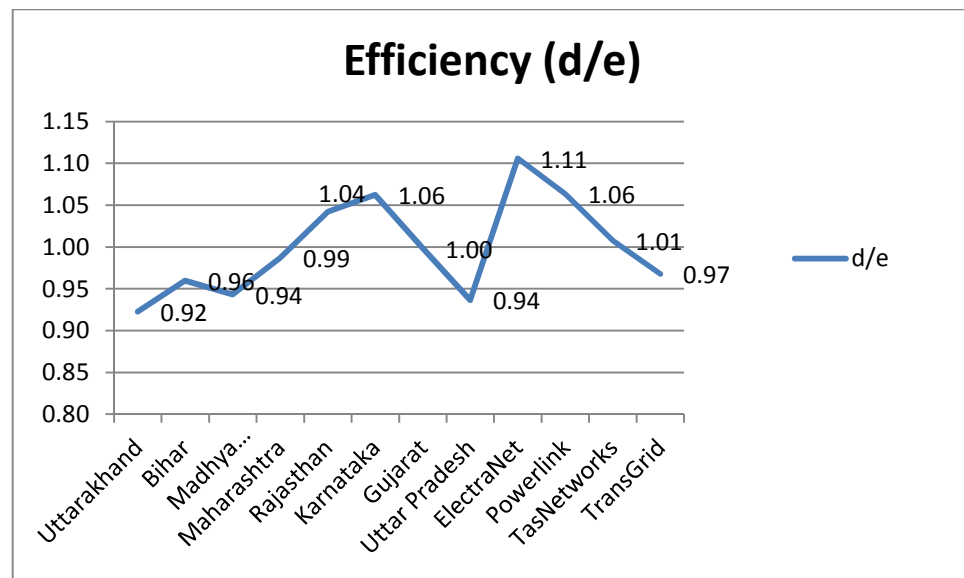
S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	85.01	3017.00	6582.00
2	Bihar	141.52	8617.00	11560.00
3	Madhya Pradesh	411.89	30194.99	45457.00
4	Maharashtra	1284.32	44207.00	105434.00
5	Rajasthan	1134.34	32514.17	63378.50
6	Karnataka	1012.63	33204.00	52081.50
7	Gujarat	962.59	52531.56	80113.00
8	Uttar Pradesh	626.91	28678.00	68465.00
9	ElectraNet	381.73	5521.35	12408.60
10	Powerlink	1013.05	14754.50	42093.00
11	TasNetworks	166.42	3563.70	8581.50
12	TransGrid	806.70	13024.76	57806.30

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

**Table 170: Ranking of STUs for FY 2014-15**

S.No.	State/Utility	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.44	8.01	8.79	4.82	0.9226	1
2	Bihar	4.95	9.06	9.36	5.16	0.9597	4
3	Madhya Pradesh	6.02	10.32	10.72	6.38	0.9430	3
4	Maharashtra	7.16	10.70	11.57	7.25	0.9869	6
5	Rajasthan	7.03	10.39	11.06	6.75	1.0420	9
6	Karnataka	6.92	10.41	10.86	6.51	1.0622	10
7	Gujarat	6.87	10.87	11.29	6.88	0.9984	7
8	Uttar Pradesh	6.44	10.26	11.13	6.88	0.9365	2
9	ElectraNet	5.94	8.62	9.43	5.38	1.1059	12
10	Powerlink	6.92	9.60	10.65	6.51	1.0634	11
11	TasNetworks	5.11	8.18	9.06	5.08	1.0077	8
12	TransGrid	6.69	9.47	10.96	6.92	0.9678	5

It can be seen from the table given above that the rank obtained by UPPTCL is no. 2.



**Figure 75: Efficiency (FY 2014-15)**

## Analysis for FY 2015-16

Benchmarking of the employee expenses for FY 2015-16 has been carried out by considering the following variables as given in the table below:

**Table 171: O&M Expenses, Line Length and Transformation capacity of different States/Utilities for FY 2015-16**

S.No.	State/Utility	O&M Expenses (Rs. Crore) (a)	Line Length (Ckt Km) (b)	Transformation Capacity (MVA) (c)
1	Uttarakhand	102.76	3020.00	7872.00
2	Bihar	158.95	9573.90	14779.90
3	Madhya Pradesh	441.43	31364.08	49349.00
4	Maharashtra	1399.09	46317.00	110815.00
5	Rajasthan	1171.69	33959.92	68036.00
6	Karnataka	968.59	33794.00	53734.90
7	Gujarat	1068.46	55456.56	91544.00
8	Uttar Pradesh	724.62	30151.00	76725.00
9	ElectraNet	408.12	5524.35	12857.60
10	Powerlink	1043.74	14755.50	44377.00
11	TasNetworks	180.32	3563.70	8591.00
12	TransGrid	812.96	13039.20	57814.08

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2015-16:

**Table 172: Ranking obtained for FY 2015-16**

S.No.	State	LN (a) (d)	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
1	Uttarakhand	4.63	8.01	8.97	5.03	0.9202	1
2	Bihar	5.07	9.17	9.60	5.41	0.9372	2
3	Madhya Pradesh	6.09	10.35	10.81	6.44	0.9450	4
4	Maharashtra	7.24	10.74	11.62	7.27	0.9967	6
5	Rajasthan	7.07	10.43	11.13	6.79	1.0399	9
6	Karnataka	6.88	10.43	10.89	6.52	1.0544	10
7	Gujarat	6.97	10.92	11.42	6.99	0.9980	7
8	Uttar Pradesh	6.59	10.31	11.25	6.97	0.9445	3
9	ElectraNet	6.01	8.62	9.46	5.42	1.1096	12
10	Powerlink	6.95	9.60	10.70	6.56	1.0600	11

S.No.	State	$\frac{LN(a)}{(d)}$	LN (b)	LN (c)	Regressed Value (e)	d/e	Rank
11	TasNetworks	5.19	8.18	9.06	5.08	1.0217	8
12	TransGrid	6.70	9.48	10.96	6.90	0.9705	5

It can be seen from the table given above that the rank obtained by UPPTCL is no. 3.

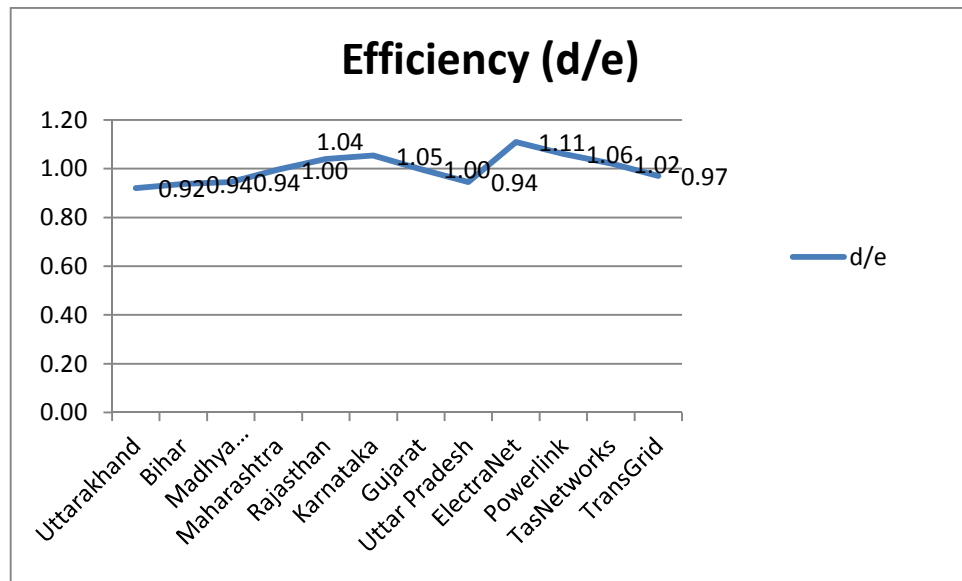


Figure 76: Efficiency (FY 2015-16)

## 9. Chapter9: Total System Benchmarking

### 9.1 Total System Benchmarking of UPPTCL

The benchmarking of UPPTCL has been carried out with the seven STUs to determine the rank of UPPTCL considering the overall performance of the STUs in terms of their financial and technical performance. The total expenditure comprising the O&M expenses and the Average GFA has been considered as the input and the Energy Transmitted, Line Length and Transformation Capacity have been considered as the output.

The total system benchmarking has been carried out using the Econometric Method using the Cobb Douglas Production Function and the Corrected Ordinary Least Square Method.

#### a. Econometric Method

- **The selection of variables**

Total System Benchmarking has been carried out by considering the following variables as given in the table below:

**Table 173: Variables considered for Benchmarking for FY 2013-14**

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)
1	Uttarakhand	989.22	13227.00	2981.00	6097.00
2	Bihar	3701.19	13786.16	8394.00	9499.00
3	Madhya Pradesh	6258.42	50300.00	29009.77	41163.00
4	Maharashtra	20163.74	117289.13	43019.81	101547.00
5	Rajasthan	12778.70	63851.02	31092.40	53249.00
6	Karnataka	12660.44	56733.00	32471.00	50221.85
7	Gujarat	12908.91	70712.07	50131.56	68730.00
8	Uttar Pradesh	9839.64	77760.69	26876.00	63791.00

Doing the regression analysis on the values obtained after considering log of the values in table 173 we obtain the following values:



**Table 174: Regression Analysis**

S.No.	State	LN (a) (e)	LN (b)	LN (c)	LN (d)	Regressed Value (f)
1	Uttarakhand	6.90	9.49	8.00	8.72	6.95
2	Bihar	8.22	9.53	9.04	9.16	8.08
3	Madhya Pradesh	8.74	10.83	10.28	10.63	8.95
4	Maharashtra	9.91	11.67	10.67	11.53	9.66
5	Rajasthan	9.46	11.06	10.34	10.88	9.21
6	Karnataka	9.45	10.95	10.39	10.82	9.38
7	Gujarat	9.47	11.17	10.82	11.14	9.64
8	Uttar Pradesh	9.19	11.26	10.20	11.06	9.46

Having obtained the regressed value the efficiency of the STUs has been obtained in the following table:

**Table 175: Rank Obtained**

S.No.	State	LN (a) (e)	LN (b)	LN (c)	LN (d)	Regressed Value (f)	e/f	Rank
1	Uttarakhand	6.90	9.49	8.00	8.72	6.95	0.99274	4
2	Bihar	8.22	9.53	9.04	9.16	8.08	1.01661	6
3	Madhya Pradesh	8.74	10.83	10.28	10.63	8.95	0.97648	2
4	Maharashtra	9.91	11.67	10.67	11.53	9.66	1.02646	7
5	Rajasthan	9.46	11.06	10.34	10.88	9.21	1.02655	8
6	Karnataka	9.45	10.95	10.39	10.82	9.38	1.00744	5
7	Gujarat	9.47	11.17	10.82	11.14	9.64	0.98209	3
8	Uttar Pradesh	9.19	11.26	10.20	11.06	9.46	0.97142	1

It can be seen from the table given above that the rank obtained by UPPTCL is no. 1.

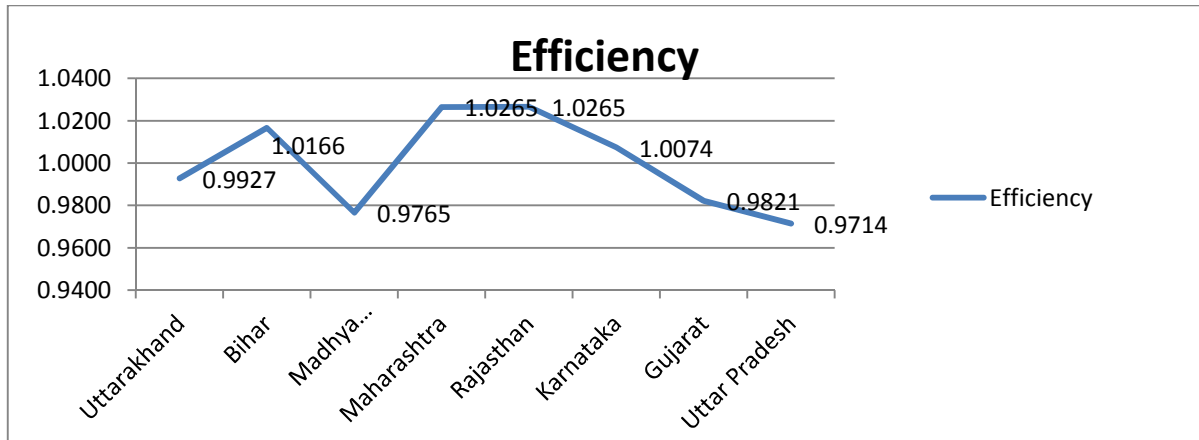


Figure 77: Efficiency (FY 2013-14)

### Analysis for FY 2014-15

Total System Benchmarking for FY 2014-15 has been carried out by considering the following variables as given in the table below:

Table 176: Variables considered for Benchmarking for FY 2014-15

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)
1	Uttarakhand	1098.96	13612.23	3017.00	6582.00
2	Bihar	3912.59	16986.53	8617.00	11560.00
3	Madhya Pradesh	6900.78	55206.00	30194.99	45457.00
4	Maharashtra	21694.02	130107.38	44207.00	105434.00
5	Rajasthan	14280.32	67257.92	32514.17	63378.50
6	Karnataka	13659.65	59420.35	33204.00	52081.50
7	Gujarat	15151.69	78933.59	52531.56	80113.00
8	Uttar Pradesh	11044.78	82413.86	28678.00	68465.00

Following the steps carried out for FY 2013-14, the efficiency of the STUs have been obtained in the following table for FY 2014-15:

Table 177: Rank Obtained for FY 2014-15

S.No.	State	LN (a) (e)	LN (b) (b)	LN (c) (c)	LN (d) (d)	Regressed Value (f)	e/f	Rank
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S.No.	State	$\frac{LN(a)}{(e)}$	$\frac{LN(b)}{(b)}$	$\frac{LN(c)}{(c)}$	$\frac{LN(d)}{(d)}$	Regressed Value (f)	e/f	Rank
1	Uttarakhand	7.00	9.52	8.01	8.79	7.15	0.9795	2
2	Bihar	8.27	9.74	9.06	9.36	7.98	1.0361	8
3	Madhya Pradesh	8.84	10.92	10.32	10.72	9.19	0.9619	1
4	Maharashtra	9.98	11.78	10.70	11.57	9.73	1.0259	7
5	Rajasthan	9.57	11.12	10.39	11.06	9.51	1.0063	5
6	Karnataka	9.52	10.99	10.41	10.86	9.34	1.0196	6
7	Gujarat	9.63	11.28	10.87	11.29	9.81	0.9816	3
8	Uttar Pradesh	9.31	11.32	10.26	11.13	9.42	0.9887	4

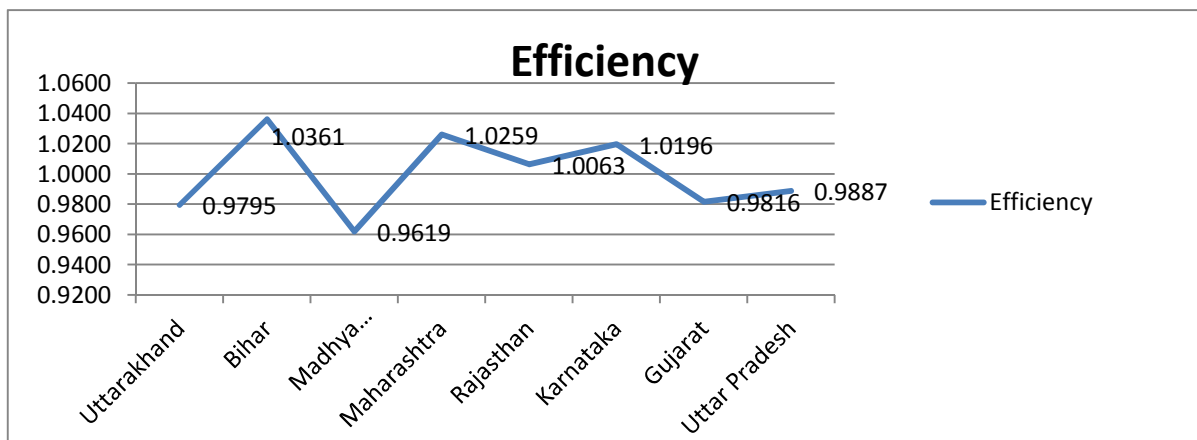


Figure 78: Efficiency (FY 2014-15)

### Analysis for FY 2015-16

Total System Benchmarking for FY 2015-16 has been carried out by considering the following variables as given in the table below:

Table 178: Variables considered for Benchmarking for FY 2015-16

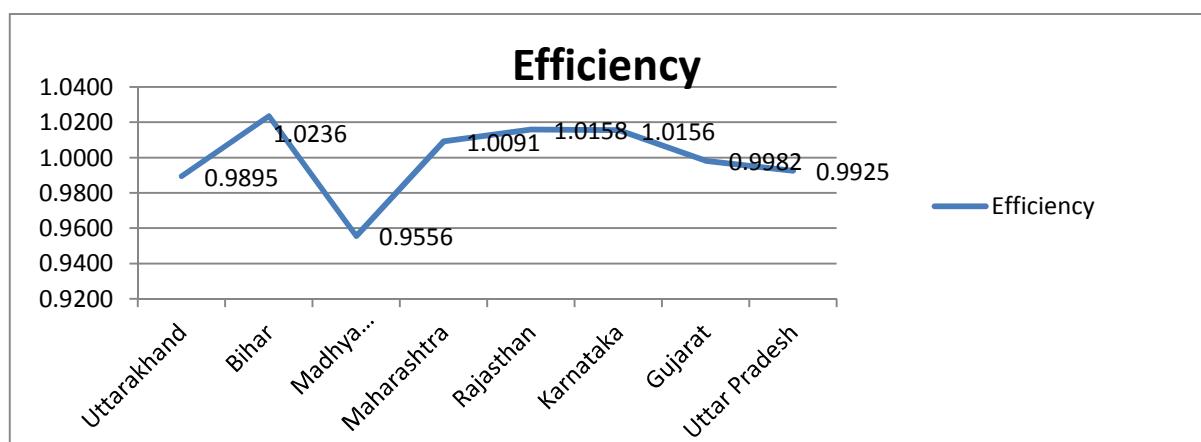
S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)
1	Uttarakhand	1186.39	13734.00	3020.00	7872.00
2	Bihar	4120.52	21485.35	9573.90	14779.90
3	Madhya Pradesh	7900.72	59335.00	31364.08	49349.00
4	Maharashtra	26681.57	136215.34	46317.00	110815.00

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)
5	Rajasthan	15609.14	75567.74	33959.92	68036.00
6	Karnataka	14553.91	61957.51	33794.00	53734.90
7	Gujarat	17851.76	84889.83	55456.56	91544.00
8	Uttar Pradesh	12585.26	88402.14	30151.00	76725.00

Following the steps carried out for FY 2014-15, the efficiency of the STUs have been obtained in the following table for FY 2015-16:

**Table 179: Rank Obtained for FY 2015-16**

S.No.	State	LN (a) (e)	LN (b)	LN (c)	LN (d)	Regressed Value (f)	e/f	Rank
1	Uttarakhand	7.08	9.53	8.01	8.97	7.15	0.989496	2
2	Bihar	8.32	9.98	9.17	9.60	8.13	1.023561	8
3	Madhya Pradesh	8.97	10.99	10.35	10.81	9.39	0.955568	1
4	Maharashtra	10.19	11.82	10.74	11.62	10.10	1.009127	5
5	Rajasthan	9.66	11.23	10.43	11.13	9.51	1.015840	7
6	Karnataka	9.59	11.03	10.43	10.89	9.44	1.015566	6
7	Gujarat	9.79	11.35	10.92	11.42	9.81	0.998181	4
8	Uttar Pradesh	9.44	11.39	10.31	11.25	9.51	0.992538	3



**Figure 79: Efficiency (FY 2015-16)**

## ***b. Corrected Ordinary Least Square Method***

The Corrected Ordinary Least Square Method has been used along with regression analysis to arrive at the desired results.

- **Establishment of Data Management Units (DMUs)**

The Data Management Units have been established by considering the Total Expenditure (O&M Expenses, Average GFA) along with Energy Transmitted (MUs), Circuit Kilometers (Ckm) and the Transformation Capacity (MVA). The Total Expenditure (O&M Expenses, Average GFA) is the input variable and Energy Transmitted (MUs), Circuit Kilometers (Ckm) and the Transformation Capacity (MVA) is the output achieved. The following table gives the details of the eight states (DMUs) considered for the benchmarking study:

**Table 180: Variables considered for Benchmarking for FY 2013-14**

S.No.	State	Total Expenditure (Rs. Crore)	Energy Transmitted (MU)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	989.22	13227.00	2981.00	6097.00
2	Bihar	3701.19	13786.16	8394.00	9499.00
3	Madhya Pradesh	6258.42	50300.00	29009.77	41163.00
4	Maharashtra	20163.74	117289.13	43019.81	101547.00
5	Rajasthan	12778.70	63851.02	31092.40	53249.00
6	Karnataka	12660.44	56733.00	32471.00	50221.85
7	Gujarat	12908.91	70712.07	50131.56	68730.00
8	Uttar Pradesh	9839.64	77760.69	26876.00	63791.00

- **Regression Analysis**

The Total Expenditure (O&M Expenses, Average GFA) has been benchmarked with respect to Energy Transmitted (MUs), Circuit Kilometers (Ckm) and the Transformation Capacity (MVA) of other State Transmission utilities. Carrying out the multiple regression analysis the following values are obtained for the Total Expenditure (O&M Expenses, Average GFA) as given in the table below:

**Table 181: Regression Analysis of Total Expenditure**

S.No.	State	Total Expenditure (Rs. Crore)	Energy Transmitted (MU)	Line Length (Ckt Km)	Transformation Capacity (MVA)	Regressed Values
1	Uttarakhand	989.22	13227.00	2981.00	6097.00	1841.66
2	Bihar	3701.19	13786.16	8394.00	9499.00	2924.88
3	Madhya Pradesh	6258.42	50300.00	29009.77	41163.00	7829.95

S.No.	State	Total Expenditure (Rs. Crore)	Energy Transmitted (MU)	Line Length (Ckt Km)	Transformation Capacity (MVA)	Regressed Values
4	Maharashtra	20163.74	117289.13	43019.81	101547.00	19519.54
5	Rajasthan	12778.70	63851.02	31092.40	53249.00	10185.97
6	Karnataka	12660.44	56733.00	32471.00	50221.85	10323.54
7	Gujarat	12908.91	70712.07	50131.56	68730.00	14503.14
8	Uttar Pradesh	9839.64	77760.69	26876.00	63791.00	12171.58

It can be seen from the table given above that the Total Expenditure of UPPTCL was Rs. 9839.64 Crores during the FY 2013-14. However, after carrying out the regression analysis the Total Expenditure comes out to Rs. 12171.58 Crores. This difference of Rs. 2331.94 Crores indicates that the Total Expenditure by UPPTCL is on a lower side as compared to other STUs and the same can be increased by Rs.2331.94 Crores considering the Total Expenditure by other STUs.

### • Ranking of the Utilities

Having obtained the regressed values of the utilities, the corrected value of the utilities is obtained by subtracting the largest non-negative integer (obtained as the difference between the regressed values and the actual values) from the regressed values. The ranking is done based on the ratio of the actual value and the corrected value of employee expenses. The utility with the maximum value of the ratio is ranked 1 and the one with the lowest ratio is ranked the last. The ranking if the utilities are given in the table below:

**Table 182: Ranking of the utilities for FY 2013-14**

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)	Regressed Values (e)	COLS Value (Rs. Crore) (f)	(f/a)	Ranking
1	Uttarakhand	989.22	13227.00	2981.00	6097.00	1841.66	-490.29	-0.4956	8
2	Bihar	3701.19	13786.16	8394.00	9499.00	2924.88	592.94	0.1602	7
3	Madhya Pradesh	6258.42	50300.00	29009.77	41163.00	7829.95	5498.01	0.8785	3
4	Maharashtra	20163.74	117289.13	43019.81	101547.00	19519.54	17187.60	0.8524	4
5	Rajasthan	12778.70	63851.02	31092.40	53249.00	10185.97	7854.03	0.6146	6
6	Karnataka	12660.44	56733.00	32471.00	50221.85	10323.54	7991.59	0.6312	5
7	Gujarat	12908.91	70712.07	50131.56	68730.00	14503.14	12171.19	0.9429	2
8	Uttar Pradesh	9839.64	77760.69	26876.00	63791.00	12171.58	9839.64	1.0000	1

It can be seen from the table given above that UPPTCL is obtaining the rank no. 1.

The graphical representation of the COLS method is shown in the figure below:

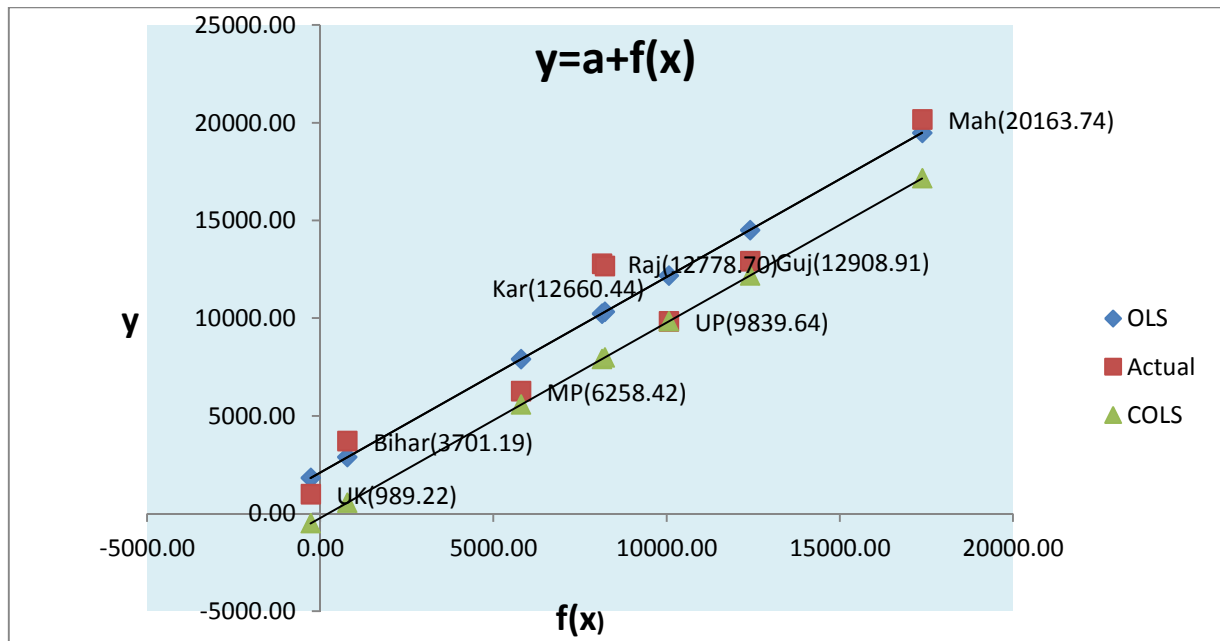


Figure 80: COLS for Total System Benchmarking for FY 2013-14

### Analysis for FY 2014-15

The following table gives the details of the eight states (DMUs) for the FY 2014-15:

Table 183: Variables considered for Benchmarking for FY 2014-15

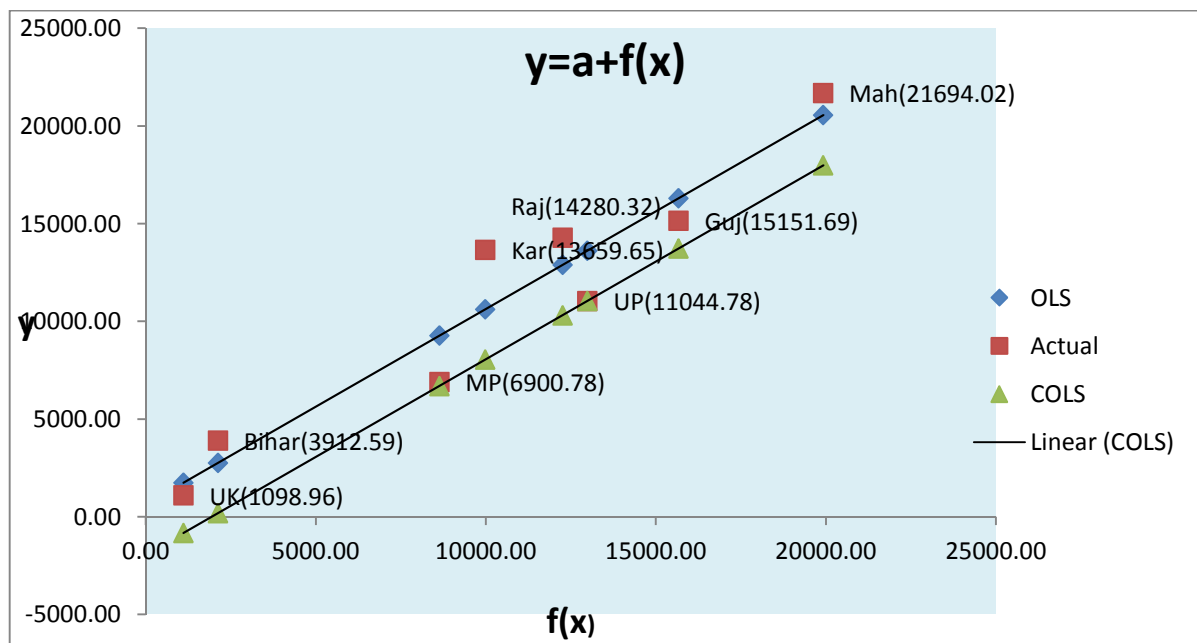
S.No.	State	Total Expenditure (Rs. Crore)	Energy Transmitted (MU)	Line Length (Ckt Km)	Transformation Capacity (MVA)
1	Uttarakhand	1098.96	13612.23	3017.00	6582.00
2	Bihar	3912.59	16986.53	8617.00	11560.00
3	Madhya Pradesh	6900.78	55206.00	30194.99	45457.00
4	Maharashtra	21694.02	130107.38	44207.00	105434.00
5	Rajasthan	14280.32	67257.92	32514.17	63378.50
6	Karnataka	13659.65	59420.35	33204.00	52081.50
7	Gujarat	15151.69	78933.59	52531.56	80113.00
8	Uttar Pradesh	11044.78	82413.86	28678.00	68465.00

Following the steps carried out for FY 2013-14, the following ranking has been obtained for the utilities for the FY 2014-15:

**Table 184: Ranking of Utilities for FY 2014-15**

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)	Regressed Values (e)	COLS Value (Rs. Crore) (f)	(f/a)	Ranking
1	Uttarakhand	1098.96	13612.23	3017.00	6582.00	1758.26	-852.78	-0.7760	8
2	Bihar	3912.59	16986.53	8617.00	11560.00	2759.86	148.82	0.0380	7
3	Madhya Pradesh	6900.78	55206.00	30194.99	45457.00	9208.66	6597.62	0.9561	2
4	Maharashtra	21694.02	130107.38	44207.00	105434.00	20552.65	17941.61	0.8270	4
5	Rajasthan	14280.32	67257.92	32514.17	63378.50	12939.26	10328.22	0.7232	5
6	Karnataka	13659.65	59420.35	33204.00	52081.50	10580.61	7969.57	0.5834	6
7	Gujarat	15151.69	78933.59	52531.56	80113.00	16287.66	13676.62	0.9026	3
8	Uttar Pradesh	11044.78	82413.86	28678.00	68465.00	13655.82	11044.78	1.0000	1

The graphical representation of the COLS method is shown in the figure below:

**Figure 81: COLS for Total System Benchmarking for FY 2014-15**

### Analysis for FY 2015-16

The following table gives the details of the eight states (DMUs) for the FY 2015-16:



**Table 185: Variables considered for Benchmarking for FY 2015-16**

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)
1	Uttarakhand	1186.39	13734.00	3020.00	7872.00
2	Bihar	4120.52	21485.35	9573.90	14779.90
3	Madhya Pradesh	7900.72	59335.00	31364.08	49349.00
4	Maharashtra	26681.57	136215.34	46317.00	110815.00
5	Rajasthan	15609.14	75567.74	33959.92	68036.00
6	Karnataka	14553.91	61957.51	33794.00	53734.90
7	Gujarat	17851.76	84889.83	55456.56	91544.00
8	Uttar Pradesh	12585.26	88402.14	30151.00	76725.00

Following the steps carried out for FY 2013-14, the following ranking has been obtained for the utilities for the FY 2015-16:

**Table 186: Ranking of Utilities for the FY 2015-16**

S.No.	State	Total Expenditure (Rs. Crore) (a)	Energy Transmitted (MU) (b)	Line Length (Ckt Km) (c)	Transformation Capacity (MVA) (d)	Regressed Value (e)	COLS Value (Rs. Crore) (f)	(f/a)	Ranking
1	Uttarakhand	1186.39	13734.00	3020.00	7872.00	751.012	-3305.886	-2.7865	8
2	Bihar	4120.52	21485.35	9573.90	14779.90	3014.407	-1042.491	-0.2530	7
3	Madhya Pradesh	7900.72	59335.00	31364.08	49349.00	11957.615	7900.717	1.0000	1
4	Maharashtra	26681.57	136215.34	46317.00	110815.00	25359.010	21302.113	0.7984	3
5	Rajasthan	15609.14	75567.74	33959.92	68036.00	14017.495	9960.597	0.6381	5
6	Karnataka	14553.91	61957.51	33794.00	53734.90	12528.724	8471.826	0.5821	6
7	Gujarat	17851.76	84889.83	55456.56	91544.00	17667.074	13610.176	0.7624	4
8	Uttar Pradesh	12585.26	88402.14	30151.00	76725.00	15193.932	11137.034	0.8849	2

The graphical representation of the COLS method is shown in the figure below:

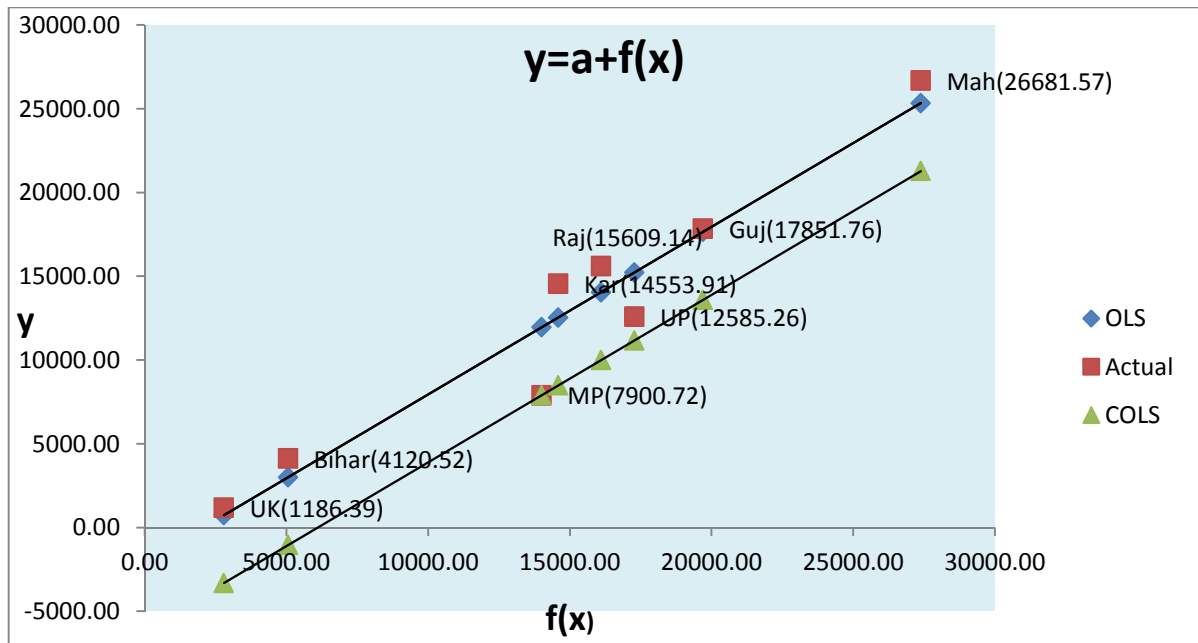


Figure 82: COLS for Total System Benchmarking for FY 2015-16

A summary of the ranking obtained by all the utilities using the Econometric Method and the COLS Method is given in the table below:

Table 187: Summary of Rank Obtained – Econometric Method (FY 2013-14)

S.No.	State	Rank Obtained						
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization	Transmission loss (TFP Method)	Total System Benchmarking
1	Uttarakhand	6	2	8	6	2	7	4
2	Bihar	4	8	2	5	-	8	6
3	Madhya Pradesh	1	1	3	1	1	4	2
4	Maharashtra	5	5	6	4	6	1	7
5	Rajasthan	8	4	7	8	-	5	8
6	Karnataka	7	3	4	7	5	6	5
7	Gujarat	3	7	5	3	4	2	3
8	Uttar Pradesh	2	6	1	2	3	3	1

Table 188: Summary of Rank Obtained – Econometric Method (FY 2014-15)

S.No.	State	Rank Obtained						
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization	Transmission loss (TFP Method)	Total System Benchmarking
1	Uttarakhand	6	3	7	6	4	7	2
2	Bihar	4	8	2	3	-	8	8

S.No.	State	Rank Obtained						Transmission loss (TFP Method)	Total System Benchmarking
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization			
3	Madhya Pradesh	2	1	3	1	1	4	1	
4	Maharashtra	5	4	8	5	5	1	7	
5	Rajasthan	8	2	4	7	3	5	5	
6	Karnataka	7	5	6	8	6	6	6	
7	Gujarat	3	7	5	4	7	2	3	
8	Uttar Pradesh	1	6	1	2	2	3	4	

Table 189: Summary of Rank Obtained – Econometric Method (FY 2015-16)

S.No.	State	Rank Obtained						Transmission loss (TFP Method)	Total System Benchmarking
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization			
1	Uttarakhand	6	4	7	6	4	7	2	
2	Bihar	3	5	3	3	-	8	8	
3	Madhya Pradesh	2	1	2	1	1	4	1	
4	Maharashtra	5	3	8	5	5	1	5	
5	Rajasthan	8	2	6	7	2	5	7	
6	Karnataka	7	8	5	8	6	6	6	
7	Gujarat	4	6	4	4	3	2	4	
8	Uttar Pradesh	1	7	1	2	7	3	3	

Table 190: Summary of Rank Obtained – COLS Method (FY 2013-14)

S.No.	State	Rank Obtained						Transmission loss (TFP Method)	Total System Benchmarking
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization			
1	Uttarakhand	8	8	7	8	6	7	8	
2	Bihar	7	7	8	7	-	8	7	
3	Madhya Pradesh	1	1	6	1	1	4	3	
4	Maharashtra	4	2	2	4	4	1	4	
5	Rajasthan	6	4	4	6	-	5	6	
6	Karnataka	5	3	5	5	5	6	5	
7	Gujarat	2	5	3	3	2	2	2	
8	Uttar Pradesh	3	6	1	2	3	3	1	

**Table 191: Summary of Rank Obtained – COLS Method (FY 2014-15)**

S.No.	State	Rank Obtained						Transmission loss (TFP Method)	Total System Benchmarking
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization			
1	Uttarakhand	8	8	7	8	7	7	8	
2	Bihar	7	7	8	7	-	8	7	
3	Madhya Pradesh	3	1	6	1	1	4	2	
4	Maharashtra	4	2	2	4	5	1	4	
5	Rajasthan	6	3	4	5	3	5	5	
6	Karnataka	5	5	5	6	6	6	6	
7	Gujarat	2	4	3	3	4	2	3	
8	Uttar Pradesh	1	6	1	2	2	3	1	

**Table 192: Summary of Rank Obtained – COLS Method (FY 2015-16)**

S.No.	State	Rank Obtained						Transmission loss (TFP Method)	Total System Benchmarking
		Employee Expenses	R&M Expenses	A&G Expenses	O&M Expenses	Capitalization			
1	Uttarakhand	8	8	8	8	4	7	8	
2	Bihar	7	7	7	7	-	8	7	
3	Madhya Pradesh	3	3	6	1	1	4	1	
4	Maharashtra	4	2	3	4	5	1	3	
5	Rajasthan	6	1	4	5	2	5	5	
6	Karnataka	5	6	5	6	6	6	6	
7	Gujarat	2	4	2	3	3	2	4	
8	Uttar Pradesh	1	5	1	2	7	3	2	

## 10. Recommendation

### 10.1 Norms for O&M Expenses

The proposed norms of O&M expenses for the UPPTCL for the MYT Control Period are given below:

### 10.2 Employee Expenses

#### FY 2013-14

The actual employee expenses of UPPTCL for the FY 2013-14 were Rs. 395.28 Crore. However, after running the regression analysis the employee expenses obtained is Rs. 549.98 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2013-14 for employee expenses are given below:

**Table 193: Employee Expenses for FY 2013-14**

Particulars	Uttar Pradesh	Average
Total Employee Cost (Rs. Crore)	575.16	
25% Employee Cost (Rs. Crore) (A1)	143.79	
Line Length (Ckm) (A2)	28678.00	
75% Employee Cost (Rs. Crore) (A3)	431.37	
Transformation Capacity (MVA) (A4)	68465.00	
Norms per ckm (A1/A2)	0.005014	0.005014
Norms per MVA (A3/A4)	0.00630	0.006301

25% of the Gross Employee expenses is attributed to the Transmission Lines and remaining 75% to the Transformation capacity.

#### FY 2014-15 and the MYT Control Period

The actual employee expenses of UPPTCL for the FY 2014-15 were Rs. 396.88 Crore. However, after running the regression analysis the employee expenses obtained is Rs. 579.16 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2014-15 for employee expenses are given below:

**Table 194: Employee Expenses for FY 2014-15**

Particulars	Uttar Pradesh	Average
Total Employee Cost (Rs. Crore)	579.16	
25% Employee Cost (Rs. Crore) (A1)	144.79	
Line Length (Ckm) (A2)	28678.00	

Particulars	Uttar Pradesh	Average
75% Employee Cost (Rs. Crore) (A3)	434.37	
Transformation Capacity (MVA) (A4)	68465.00	
Norms per ckm (A1/A2)	0.005049	0.005049
Norms per MVA (A3/A4)	0.00634	0.006344

25% of the Gross Employee expenses is attributed to the Transmission Lines and remaining 75% to the Transformation capacity.

Escalating the norms (based on the CPI inflation Index) obtained for the FY 2014-15 which is the base year, the norms for the MYT Control Period have been obtained as follows:

**Table 195: Projected Norms of Employee Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
CPI Inflation		5.65%	4.32%	7.21%	7.21%	7.21%
Norms per ckm	0.005049	0.005334	0.005564	0.005966	0.006396	0.006857
Norms per MVA	0.006344	0.006703	0.006992	0.007497	0.008037	0.008617

### 10.3 R&M Expenses

#### FY 2013-14

The actual R&M Expenses of UPPTCL for the FY 2013-14 were Rs. 162.70 Crore. However, after running the regression analysis the R&M expenses obtained is Rs. 130.27 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2013-14 for R&M Expenses are given below:

**Table 196: R&M Expenses for FY 2013-14**

Particulars	Uttar Pradesh	Average
Average GFA (Rs. Crore) (A)	9252.64	
R&M Expense (Rs. Crore) (B)	130.27	
Kb (D=B/A)	1.41%	1.41%

#### FY 2014-15 and the MYT Control Period

The actual R&M Expenses of UPPTCL for the FY 2014-15 were Rs. 195.96 Crore. However, after running the regression analysis the R&M Expenses obtained is Rs. 149.92 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2014-15 for R&M Expenses are given below:

**Table 197: R&M Expenses for FY 2014-15**

Particulars	Uttar Pradesh	Average
Average GFA (Rs. Crore) (A)	10417.87	

Particulars	Uttar Pradesh	Average
R&M Expense (Rs. Crore) (B)	149.92	
Kb (D=B/A)	1.44%	1.44%

Escalating the norms (as per WPI Inflation Index) obtained for the FY 2014-15 which is the base year, the norms for the MYT Control Period have been obtained as follows:

**Table 198: Projected Norms for R&M Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
WPI Inflation		-2.52%	3.24%	1.82%	1.82%	1.82%
Kb	1.44%	1.40%	1.45%	1.47%	1.50%	1.53%

## 10.4 A&G Expenses

### FY 2013-14

The actual A&G Expenses of UPPTCL for the FY 2013-14 were Rs. 29.03 Crore. However, after running the regression analysis the A&G expenses obtained is Rs. 93.06 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2013-14 for A&G Expenses are given below:

**Table 199: A&G Expenses for FY 2013-14**

Particulars	Uttar Pradesh	Average
Total A&G Cost (Rs. Crore)	93.06	
25% A&G Cost (Rs. Crore) (A1)	23.27	
Line Length (Ckm) (A2)	26876.00	
75% A&G (Rs. Crore) (A3)	69.80	
Transformation Capacity (MVA) (A4)	63791.00	
Norms per ckm (A1/A2)	0.000866	0.000866
Norms per MVA (A3/A4)	0.00109	0.001094

25% of the Gross A&G expenses is attributed to the Transmission Lines and remaining 75% to the Transformation capacity.

### FY 2014-15 and the MYT Control Period

The actual A&G Expenses of UPPTCL for the FY 2014-15 were Rs. 34.07 Crore. However, after running the regression analysis the A&G Expenses obtained is Rs. 107.13 Crores. Hence, based on the outcome of the regression analysis, the norms for the FY 2014-15 for A&G Expenses are given below:

**Table 200: A&G Expenses for FY 2014-15**

Particulars	Uttar Pradesh	Average
Total A&G Cost (Rs. Crore)	107.13	
25% A&G Cost (Rs. Crore) (A1)	26.78	
Line Length (Ckm) (A2)	28678.00	
75% A&G (Rs. Crore) (A3)	80.35	
Transformation Capacity (MVA) (A4)	68465.00	
Norms per ckm (A1/A2)	0.000934	0.000934
Norms per MVA (A3/A4)	0.00117	0.001174

25% of the Gross A&G expenses is attributed to the Transmission Lines and remaining 75% to the Transformation capacity.

Escalating the norms (WPI Inflation Index) obtained for the FY 2014-15 which is the base year, the norms for the MYT Control Period have been obtained as follows:

**Table 201: Projected Norms for A&G Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
WPI Inflation		-2.52%	3.24%	1.82%	1.82%	1.82%
Norms per ckm	0.000934	0.000910	0.000940	0.000957	0.000974	0.000992
Norms per MVA	0.00117	0.001144	0.001181	0.001203	0.001224	0.001247

## 10.5 Recommendation

The benchmarking study has been carried out using the regression analysis wherein eight State Transmission Utilities have been considered to derive the optimum benchmarked values. It is recommended that the value obtained after carrying out the regression analysis may be considered as the benchmark value. The recommended values of the O&M expenses considering FY 2014-15 as the base year have been given below:

**Table 202: Recommended Norms of Employee Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
Norms per ckm	0.005049	0.005334	0.005564	0.005966	0.006396	0.006857
Norms per MVA	0.006344	0.006703	0.006992	0.007497	0.008037	0.008617

**Table 203: Recommended Norms for R&M Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
Kb	1.44%	1.40%	1.45%	1.47%	1.50%	1.53%



**Table 204: Recommended Norms for A&G Expenses for the MYT Control Period**

Particulars	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20
Norms per ckm	0.000934	0.000910	0.000940	0.000957	0.000974	0.000992
Norms per MVA	0.00117	0.001144	0.001181	0.001203	0.001224	0.001247