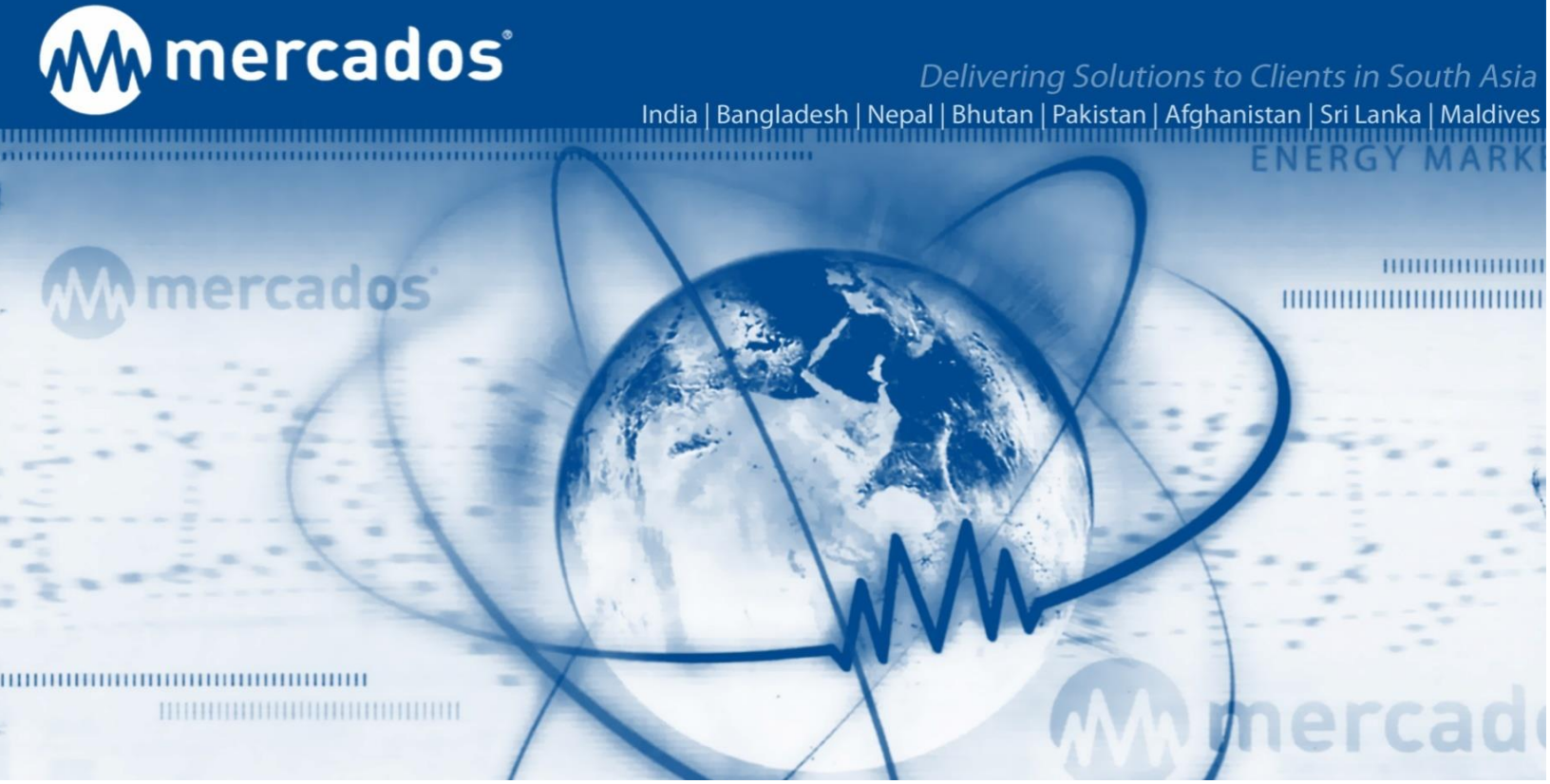

Benchmarking of performance parameters in compliance with the Uttar Pradesh Electricity Regulatory Commission (Multi-Year Distribution Tariff) Regulations 2014

Report on the Benchmarking of performance (Electricity Distribution in India) parameters.

Prepared for: Paschimanchal Vidyut Vitran Nigam Limited (PVVNL)

Prepared by: MERCADOS ENERGY MARKETS INDIA PVT. LTD.

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I. ABBREVIATIONS

Table 1: Abbreviations

S.No	Abbreviation	Full Form
1	A&G	Administrative & General
2	APEPDCL	Andhra Pradesh East Power Distribution Company Limited
3	APPC	Average Power Purchase Cost
4	APSPDCL	Andhra Pradesh South Power Distribution Company Limited
5	AT&C	Aggregate Technical and Commercial Loss
6	AVVNL	Ajmer Vidyut Vitran Nigam Limited
7	BESCOM	Bengaluru Electricity Supply Company
8	CAIDI	Consumer Average Interruption Duration Index
9	CHESCOM	Chamundeshwari Electricity Supply Company
10	ckt	Circuit
11	CSPDCL	Chhattisgarh State Power Distribution Company Limited
12	CT	Current Transformers
13	DEA	Data Envelopment Analysis
14	DGVCL	Dakshin Gujarat Vij Company Limited
15	DHBVN	Dakshin Haryana Bijli Vitran Nigam Limited
16	DIPP	Department of Industrial Policy Promotion
17	DMU	Decision Making Unit
18	DVVNL	Dakshinanchal Vidyut Vitran Nigam Limited
19	EoDB	Ease of Doing Business
20	FY	Financial Year
21	GESCOM	Gulburga Electricity Supply Company
22	GFA	Gross Fixed Asset
23	GoUP	Government of Uttar Pradesh
24	HESCOM	Hubli Electricity Supply Company
25	HT	High Tension
26	IEEE	Institute of Electrical and Electronics Engineers
27	JBVNL	Jharkhand Bijli Vitran Nigam Limited
28	JdVVNL	Jodhpur Vidyut Vitran Nigam Limited
29	JVVNL	Jaipur Vidyut Vitran Nigam Limited
30	KESA	Kanpur Electricity Supply Authority
31	KESCO	Kanpur Electricity Supply Company
32	kV	Kilo Volt
33	LT	Low Tension
34	MESCOM	Mangalore Electricity Supply Company
35	MGVCL	Madhya Gujarat Vij Company Limited
36	MP-Central	Madhyra Pradesh - Central

S.No	Abbreviation	Full Form
37	MP-East	Madhya Pradesh - East
38	MPMKVVCL	Madhya Pradesh Madya Kshetra Vidyut Vitran Company Limited
39	MPPKVVCL	Madhya Pradesh Paschim Kshetra Vidyut Vitran Company Limited
40	MPPuKVVCL	Madhya Pradesh Purv Kshetra Vidyut Vitran Company Limited
41	MP-West	Madhya Pradesh - West
42	MSEDCL	Maharashtra State Electricity Distribution Company Limited
43	MU	Million Units
44	MVVNL	Madhyanchal Vidyut Vitran Nigam Limited
45	MW	Mega Watt
46	MYDT	Multi Year Distribution Tariff
47	NBPDCL	North Bihar Power Distribution Company Limited
48	NPP	National Power Portal
49	O&M	Operation and Maintenance
50	PAT	Profit After Tax
51	PCA	Principal Component Analysis
52	PFA	Power For All
53	PFC	Power Finance Corporation
54	PGVCL	Pashchim Gujarat Vij Company Limited
55	PSPCL	Punjab State Power Corporation Limited
56	PT	Power Transformers
57	PuVVNL	Purvanchal Vidyut Vitran Nigam Limited
58	PVVNL	Paschimanchal Vidyut Vitran Nigam Limited
59	R&M	Repair and Maintenance
60	R-APDRP	Restructured Accelerated Power Development and Reforms Program
61	SAIDI	System Average Interruption Duration Index
62	SAIFI	System Average Interruption Frequency Index
63	SBPDCL	South Bihar Power Distribution Company Limited
64	SERC	State Electricity Regulatory Commission
65	SoP	Standards of Performance
66	TPP	Thermal Power Plant
67	TSNPDCL	Telangana State North Power Distribution Company Limited
68	TSSPDCL	Telangana State South Power Distribution Company Limited
69	UDAY	Ujwal Discom Assurance Yojana
70	UGVCL	Uttar Gujarat Vij Company Limited
71	UHBVN	Uttar Haryana Bijli Vitran Nigal Limited
72	UPERC	Uttar Pradesh Electricity Regulatory Commission
73	UPJVNL	Uttar Pradesh Jal Vidyut Nigam Limited
74	UPPCL	Uttar Pradesh Power Corporation Limited
75	UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited
76	UPSEB	Uttar Pradesh State Electricity Board

S.No	Abbreviation	Full Form
77	WBSEDCL	West Bengal State Electricity Distribution Company Limited
78	AES Electropaulo	Eletropaulo Metropolitana - Electricidade de São Paulo S.A
79	A$	Australian Dollar
80	Tk	Taka (Bangladesh Currency)
81	DESCO	Dhaka Electricity Supply Company
82	BERC	Bangladesh Energy Regulatory Commission
83	R$	Brazilian Real
84	MME	Ministry of Mines and Energy
85	ONS	National System Operator (Portuguese)
86	SIN	National Interconnected System (Portuguese)
87	CCEE	Chamber of Electric Energy Commercialization
88	EPE	Energy Research Company
89	ABRADEE	Brazilian Association of Electric Power Distributors
90	BRPL	BSES Rajdhani Private Limited
91	BYPL	BSES Yamuna Private Limited
92	TPDDL	Tata Power Delhi Distribution Limited
93	R-Infra D	Reliance Infra - Distribution
94	TPL-Surat	Torrent Power Limited

II. EXECUTIVE SUMMARY

The Hon'ble Uttar Pradesh Electricity Regulatory Commission (Hon'ble UPERC or Hon'ble Commission) has come up with the first Uttar Pradesh Electricity Regulatory Commission (Multi Year Distribution Tariff) Regulations, 2014 for the control period FY 2017-18 to FY 2019-20. The Hon'ble UPERC, in this regard has directed the Distribution licensees to conduct a Benchmarking study to assess the performance of the electricity distribution companies (Discoms) in their peer group.

This study comprises the benchmarking of PVVNL with the state owned Discoms at pan India level. The outcome of the study will enable the decision makers of PVVNL and the Hon'ble UPERC to establish the positioning and set the targets for the control period as per the UPERC MYDT Regulations 2014.

The functional areas which were selected for benchmarking are segregated into a number of parameters which stand as the performance indicator of the Discoms. These parameters encompass a variety of aspects including but not limited to power supply interruption instances & interruption duration along with the AT&C losses and distribution losses.

The Discoms were initially ranked based on such parameters, to enable PVVNL to understand its position on pan India basis. Then the ranks of all the Discoms are processed with Principal Component Analysis – Data Envelopment Analysis method (PCA-DEA method) to compute the efficiency of PVVNL with the given input and output variables.

PVVNL ranks 23rd in the league of 33 Discoms with efficiency score of 3.49. The list is topped by the Discoms of Gujarat and Andhra Pradesh with efficiency scores ranging between 7.52 and 6.09. PVVNL lags in the parameters like Feeders with high SAIDI and SAIFI, HT to LT ratio and a weak complaint redressal system. PVVNL also needs to focus on the feeder monitoring and thus reducing the feeder wise losses and interruptions, which will help in reducing inefficiency in power distribution to reduce the distribution losses and focus on cost management to improve the financial position of the Discom.

The results also suggest that PVVNL ought to focus on improving collection efficiency, power purchase portfolio and credit dues, which may help the Discom to improve its rank at faster pace.

III. INTRODUCTION

About Paschimanchal Vidyut Vitran Nigam limited (PVVNL)

The Honorable UPERC was formed under U.P. Electricity Reforms Act, 1999 by the Government of Uttar Pradesh (GoUP) in one of the first steps of reforms and restructuring process of the power sector in the State of Uttar Pradesh. Thereafter, in pursuance of the reforms and restructuring process, the erstwhile Uttar Pradesh State Electricity Board (UPSEB) was unbundled into the following three separate entities through the first reforms Transfer Scheme dated 14th January, 2000:

- **Uttar Pradesh Power Corporation Limited (UPPCL):** vested with the function of Transmission and Distribution within the State.
- **Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited (UPRVUNL):** vested with the function of Thermal Generation within the State.
- **Uttar Pradesh Jal Vidyut Nigam Limited (UPJVNL):** vested with the function of Hydro Generation within the State.

Through another Transfer Scheme dated 15th January, 2000, assets, liabilities and personnel of Kanpur Electricity Supply Authority (KESA) under UPSEB were transferred to Kanpur Electricity Supply Company Limited (KESCO), a company registered under the Companies Act, 1956.

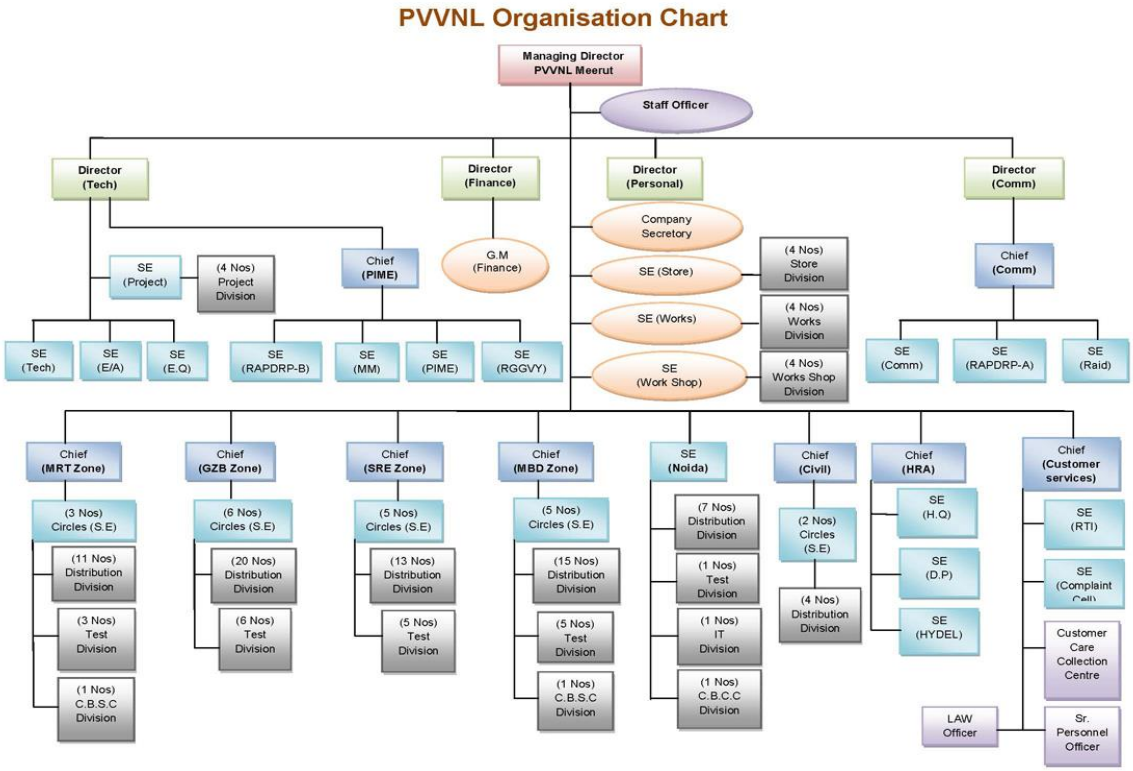
After the enactment of the Electricity Act, 2003 (Electricity Act) the need was felt for further unbundling of UPPCL (responsible for both Transmission and Distribution functions) along functional lines. Therefore, the following four new Distribution companies (Discoms / Distribution Licensees) were created vide Uttar Pradesh Transfer of Distribution Undertaking Scheme, 2003 dated 12th August, 2003 to undertake distribution and supply of electricity in the areas under their respective zones specified in the scheme:

- Dakshinanchal Vidyut Vitran Nigam Limited (Agra Discom or DVVNL)
- Madhyanchal Vidyut Vitran Nigam Limited (Lucknow Discom or MVVNL)
- Paschimanchal Vidyut Vitran Nigam Limited (Meerut Discom or PVVNL)
- Purvanchal Vidyut Vitran Nigam Limited (Varanasi Discom or PuVVNL)

PVVNL covers in its jurisdiction the areas of District Meerut, Baghpat, Ghaziabad, Gautambudh Nagar, Hapur, Shamli, Bulandshahar, Muzaffarnagar, Saharanpur, Bijnor, Moradabad, Amroha, Sambhal and Rampur. The Discom comprises of four distribution zones based at Meerut, Saharanpur, Ghaziabad and Moradabad and each is headed by an officer of the rank of Chief Engineer.

Organizational chart of PVVNL is as below:

Figure 1: Organizational Chart of PVVNL



Context Setting

The Hon'ble UPERC has notified the Uttar Pradesh Electricity Regulatory Commission (Multi Year Distribution Tariff) Regulations, 2014 (UPERC MYDT Regulations, 2014) on 12.5.2014 which inter-alia provide the procedure and guidelines for determination of distribution and retail tariff in the State of Uttar Pradesh. It is for the first time, that the Hon'ble Commission has issued tariff regulations for Multi Year Tariff control period encompassing the financial years 2017-18 to 2019-20 as before the said period, the tariff was being framed on annual basis.

The Revised Tariff Policy, 2016 issued on 28.1.2016 under clause 5.11 h) 2) [same provision was also contained in the Tariff Policy, 2006] identifies the necessity of Benchmarking studies before the commencement of the control period under the Multi Year Tariff regime as under:

> *"**h)Multi Year Tariff***
>
> *1) Section 61 of the Act states that the Appropriate Commission for determining the terms and conditions for the determination of tariff shall be guided, inter-alia, by Multi-Year Tariff (MYT) principles. The framework should feature a five-year control period. The initial control period may, however, be of 3 year duration for transmission*

> *and distribution if deemed necessary by the Regulatory Commission on account of data uncertainties and other practical considerations. In cases of lack of reliable data, the Appropriate Commission may state assumptions in MYT for first control period and a fresh control period may be started as and when more reliable data becomes available.*
>
> *2) In cases where operations have been much below the norms for many previous years, the initial starting point in determining the revenue requirement and the improvement trajectories should be recognized at "relaxed" levels and not the "desired" levels.* ***Suitable benchmarking studies may be conducted to establish the "desired" performance standards.*** *Separate studies may be required for each utility to assess the capital expenditure necessary to meet the minimum service standards."* ***(Emphasis supplied)***

Thus, the Tariff Policy states that when a Multi-Year Tariff regime is undertaken by any State Commission for the first time, it is imperative, that the starting point in determining the revenue requirement and operating parameters, including improvement trajectories therein, should be recognized at relaxed levels (closer to actuals) and not at the desired levels. The underlying objective is that to make the MYT regulations a success, it is imperative that the improvement trajectory is defined from the actual level up to the desired level. The desired levels would not be attained if the assumptions in setting the baseline levels are inaccurate.

In view of the provisions of the Tariff Policy, the Hon'ble Commission vide its regulation 4.2.1 of the UPERC MYDT Regulations, 2014 has directed the distribution licensees to undertake a study involving benchmarking of the performance of the Discoms with the other distribution licensees of the country, with the objective to establish the baseline norms and determine the desired performance standards for the distribution licensees of the State.

Benchmarking

Benchmarking is a process that develops performance indices for specific entities and compares them to industry norms for the purpose of measuring entity performance and identifying areas needing improvement. This benchmarking process can reveal potential areas where a particular Discom's performance is lacking and point to directions for further detailed examination to identify any underlying contributing causes or mitigating factors to the performance gap. It can provide useful ways to understand what drives the efficiency of a company. Having a clear assessment of its

strengths and weaknesses, a Discom can formulate a better corporate strategy to improve its competitive position in the market place.[1]

This instant report of Benchmarking is to establish the actual positioning of PVVNL for each parameter of the functional areas (deliberated in the later chapters) with other Discoms. Parameters regarding the operational, O&M expenses and financial are considered for comparison and benchmarking. In the process of benchmarking, PVVNL is compared with all the similarly placed Discoms of the country.

This Benchmarking study covers around 38 parameters to establish the positioning of the Discom in the country among the peers. The overall positioning (ranking) of the Discom in this Benchmarking study is established by broadly classifying various operational, O&M expenses and financial parameters into Financial and Technical Parameters.

Significance of the Project

The intended outcome of the Project is to determine the current position of PVVNL in terms of overall efficiency considering the factors such as operational, O&M expenses and financial parameters. Based on the results, PVVNL may set a target for itself and also assist the Hon'ble Commission to set the targets for PVVNL for the Control Period. The expected outcome of this Benchmarking study is also to establish where PVVNL stands among its peers; and which are the areas it lags, and can improve by focused attention and strategy. This Benchmarking study includes the statistical ranking of the Discoms for each parameter, both independently and overall Rank based on scores. This is followed by the grouping of parameters into principal components and later processing the parameters with Data Envelopment Analysis to identify the final efficiency scores of the Discoms.

Few Discoms in India often use quantitative measures to compare operational performance among their distribution units usually designated as Zones/circles within the Discom area, to ensure that each and every consumer gets quality and reliable power supply, as they understand the importance of the same in driving the economy and human development of the State. This also helps the Discoms in anticipating problems, planning network growth and infrastructure improvement, designing their capital expenditure plan and increasingly to monitor their competitiveness. Discoms in few developed countries spend huge resources, both time and money, in preparing proprietary benchmarking tools to enable comparison with the peers.

State Electricity Regulatory Commissions in India have started following, tracking and relying on inter-Discom studies of losses, quality of service and cost of supply / service for a wide variety of tasks especially when the Discom seeks increase in consumer tariffs. The Ministry of Power, Government of India has also come up with the Discom rating to improve the competitiveness and also to provide a basis to the lenders, investors and other stakeholders to evaluate the risk of the investment / funding

[1]Concept Paper: Performance Benchmarks for Electricity Distribution Companies in South Asia by USAID

associated with the Discom. These exercises help in tracking the performance of the Discoms as well as for evaluating the risks associated with the company.

The Discoms of Uttar Pradesh are no different from their top rated (As per 4th Annual Discom Ratings by Ministry of Power) counterparts in their desire to direct and realise performance improvement in their companies. The development of performance benchmarks including a reliable database of performance indicators is the need of the hour for PVVNL to optimise the costs of service for providing electricity and improving the quality of supply.

The principal beneficiaries of this Benchmarking study are:

Distribution Company (Discom): The Benchmarking study and database will provide PVVNL specific performance standards for key function areas. The benchmarks are intended to assist Discoms to compare their operations with peer Discoms, set performance targets, evaluate costs, allocate resources, develop capital expenditure requirements, and monitor performance.

Consumers: This Benchmarking study will provide an opportunity to the customers to bargain for improvement in distribution services from the Discom and also in evaluation of the standards of performance of the Discom, from which they are availing the service.

Regulatory Commission: The Benchmarking study and database will provide Hon'ble UPERC specific performance standards for key function areas, which will guide and assist it, in setting the targets for the state owned Discoms for the first control period.

IV. APPROACH & METHODOLOGY

1. Collect, clean, polish and synthesize the data for consistency (by running the analysis on the entire dataset, and then eliminating those points which do not meet mathematical 'control limits' for variability from a trend, and then repeating the analysis on the remaining data) of data set.

2. Segregate the data set of into Input Variables and Output Variable. For illustration, in this instant study, PAT as % of expenditure for FY 2014-15 and Distribution loss for FY 2014-15 is considered as Output Variables.

3. The data set is to be processed to fit in the Data Envelopment Analysis (DEA)[2] by processing the data sets to the form of Output to Input Ratio. This data processing is done for identifying the largest contributor to the Output i.e. the unit which has the highest ratio of Output to Input variable and thus establishes a relationship of being "highly efficient" in contributing to the Output.

4. But in the absence of Cause-Effect Relationship between the Variables and its weight in determining the Output Variable, Principal Component Analysis (PCA)[3] needs to be applied before solving with Data Envelopment Analysis.

5. The PCA+DEA Hybrid method is the approach used in determining the Efficiencies of each Discom in this Benchmarking study.

6. After solving the variables with Data Envelopment Method, the final Ranking of Discoms can be obtained in the form of the efficiency column matrix.

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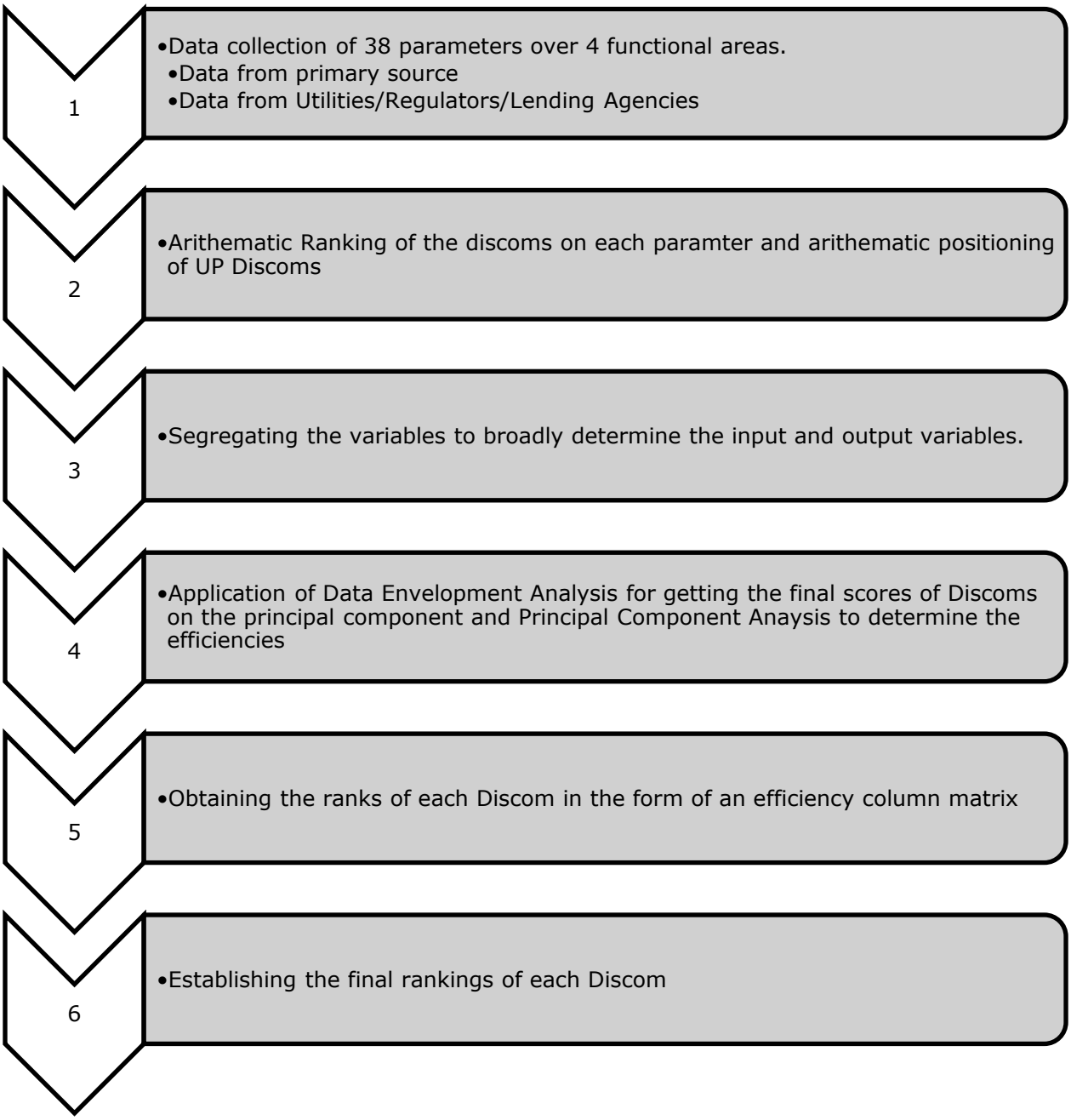
[2]**Data Envelopment Analysis:** Data envelopment analysis (DEA) is a non-parametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs). Although DEA has a strong link to production theory in economics, the tool is also used for benchmarking in operations management, where a set of measures is selected to benchmark the performance of manufacturing and service operations. In the circumstance of benchmarking, the efficient DMUs, as defined by DEA, may not necessarily form a "production frontier", but rather lead to a "best-practice frontier" (Cook, Tone and Zhu, 2014). DEA is referred to as "balanced benchmarking" by Sherman and Zhu (2013). Non-parametric approaches have the benefit of not assuming a particular functional form/shape for the frontier; however they do not provide a general relationship (equation) relating output and input.

[3]**Principal Component Analysis:** Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables.

A process flow-chart of the Benchmarking study is depicted below:

Figure 2: Approach and Methodology of the Benchmarking Study



V. FUNCTIONAL AREAS & PARAMETERS FOR BENCHMARKING

The key functional areas and operational parameters for the benchmarking study have been prescribed by the Hon'ble Commission vide letter UPERC/Secy/D(Tariff)/15-1219 to the state owned Discoms dated 14th September, 2015. Further, with a view to rationalize some of the prescribed parameters and in view of the data constraints, we have evolved some additional parameters by the Delphi Technique[4] involving experts from the electricity distribution function.

The current benchmarking study is intended to focus on the functional areas and parameters which can be quantified and which are controllable as the Discoms are expected to work on these parameters and the results obtained in this study. The functional areas which were selected for benchmarking are further segregated into number of parameters which stand as the performance indicator of the Discoms. In the context of introspection and improvement, the study has considered the data only from the authentic sources and from the disclosures of the Discoms which are available in public domain. The outcome of the study will enable the decision makers of the PVVNL and the Hon'ble UPERC to establish the positioning and set the targets for the control period as per the UPERC MYDT Regulations 2014. These metrics are developed and identified considering the availability of data and the exhaustiveness for conducting the comprehensive Benchmarking study of the Discoms.

The key functional areas considered for benchmarking are

A. Operational Performance Parameters

i. Aggregate Technical and Commercial (AT&C) losses
ii. Distribution Losses
iii. Collection Efficiency
iv. Reliability Index – SAIFI
v. Reliability Index – SAIDI
vi. Reliability Index – CAIDI
vii. Restoration Rate of Distribution Transformers
viii. Distribution Transformer Reliability
ix. HT to LT Ratio.
x. Accidents
xi. Employee Engagement
xii. Lead time for New Connections
xiii. Lead time for Complaint Redressal
xiv. Feeder monitoring

[4]The Delphi technique is a forecasting method based on the results of questionnaires sent to a panel of experts and pertains to subjective/intuitive methods of foresight. The Delphi technique is a proven tool in information system research for identifying and prioritizing issues for managerial decision making.

xv. Feeders with high SAIFI
xvi. Feeders with high SAIDI
xvii. Peak Demand Supply Availability

B. Operational & Maintenance Expenses

xviii. O&M Expenses per unit of Energy Sales
xix. O&M Expenses per unit of Energy Input
xx. Employees Cost per unit of Energy Sales
xxi. Employee Cost per 1000 Consumers and Employee
xxii. A&G Expenses per unit of Energy Sales
xxiii. A&G Expenses per 1000 Consumers and Employee
xxiv. R&M Expenses per unit sales
xxv. R&M Expenses as % of Gross Fixed Asset (GFA)

C. Financial Performance

xxvi. Average Cost of Supply (ACS)
xxvii. Average Power Purchase Cost (APPC)
xxviii. Average Cost of Supply (ACS) - Average Revenue Realized (ARR) Gap
xxix. APPC to ACS Ratio
xxx. Age of Debtors
xxxi. Age of Creditors
xxxii. Average Wheeling Cost
xxxiii. Profit after Tax (PAT) as a % of Expenditure

D. Capital Cost

xxxiv. Per ckm. Cost of 33KV Line
xxxv. Per ckm. Cost of 11KV Line
xxxvi. 33/11KV Sub-Station Cost
xxxvii. 11/0.4KV Sub-Station Cost
xxxviii. LT Line

A. Operational Performance

The first parameter of Benchmarking study is the Operational Performance. Performance data on these indices of the Discoms are available and useful for target setting by the Discom. There are 17 sub-parameters under the Operational Performance which are detailed below:

i. Aggregate Technical and Commercial (AT&C) Losses

The AT&C losses in the distribution system comprise two major components i.e. technical loss and commercial loss. The technical loss refers to the distribution network loss that is inherent in the delivery of the electrical energy. It includes losses in the conductors, transformers, switchgears and loss in the measurement system. The commercial loss is energy loss that is caused by external factors to the distribution system and is caused by direct energy theft, and deficiencies in the energy metering, billing and collection systems etc.

In the context of operational performance, parameter of AT&C losses plays an important role in determining the operational efficiency of any Discom. The technical loss in the distribution system is an engineering issue. The technical loss beyond a reasonable limit represents shortcomings in the distribution system planning and infrastructure. The commercial loss, on the other hand is an avoidable financial loss for the Discom.

Data Consideration:

This data component is readily available for most Discoms and the lending agency like PFC have been regularly monitoring this parameter for the Discoms and was available for all the stakeholders in the public domain. However, the data of UP Discoms is computed from the Audited Accounts of FY 2014-15.

Current Positioning of PVVNL:

PVVNL with AT&C losses at 22% stands at 14th position out of 33 Discoms of the sample. PVVNL is trailing CESCOM of Karnataka which has observed losses of 22%. This list is topped by APEPDCL of Andhra Pradesh with AT&C loss at significantly low level of 8%.

Table 2: Aggregate Technical and Commercial Loss

S. No.	State	Utility	Net Input Energy (Mkwh)	Energy Realised (Mkwh)	AT&C Losses (%)	Rank of AT&C Losses (%)
1	Andhra Pradesh	APEPDCL	15,037	13,884	8%	1
2		APSPDCL	29,666	26,102	12%	5
3	Bihar	NBPDCL	5,849	3,406	42%	29
4		SBPDCL	10,148	5,553	45%	30
5	Chhattisgarh	CSPDCL	21,964	15,848	28%	20
6	Gujarat	DGVCL	17,140	15,286	11%	3
7		MGVCL	9,455	8,371	11%	4
8		PGVCL	26,472	19,807	25%	16
9		UGVCL	18,422	16,541	10%	2
10	Haryana	DHBVNL	24,488	16,969	31%	22
11		UHBVNL	19,312	12,586	35%	26
12	Jharkhand	JSEB/JBVNL	11,105	5,885	47%	31
13	Karnataka	BESCOM	28,256	23,291	18%	10
14		GESCOM	7,564	5,957	21%	12
15		HESCOM	11,059	8,904	19%	11
16		MESCOM	4,689	3,951	16%	7
17		CHESCOM	6,085	4,768	22%	13
18	Madhya Pradesh	Central	17,868	12,067	32%	25
19		East	16,106	11,742	27%	19
20		West	21,626	14,967	31%	23
21	Maharashtra	MSEDCL	110,458	85,503	23%	15
22	Punjab	PSPCL	47,640	39,282	18%	9
23	Rajasthan	AVVNL	17,450	12,542	28%	17
24		JVVNL	25,156	17,107	32%	24
25		JDVVNL	20,927	15,280	27%	18
26	Telangana	TSSPDCL	32,816	27,943	15%	6
27		TSNPDCL	12,802	10,699	16%	8
28	West Bengal	WBSEDCL	31,355	21,753	31%	21
29	Uttar Pradesh	DVVNL	19,129	9,531	50%	33
30		MVVNL	15,067	7,815	48%	32
31		PVVNL	25,946	20,290	22%	14
32		PuVVNL	18,252	10,860	40%	28
33		KESCO	3,491	2,226	36%	27

Recommendation:

The performance of the UP Discoms on the AT&C loss parameter has been lackluster with PVVNL being ranked better as compared to the other UP Discoms. The performance of the UP Discoms is particularly poor in respect of collection efficiency, which has dragged them down in the AT&C loss rankings.

A focused strategy involving all the three aspects of the AT&C loss namely technical loss, commercial loss and collection losses needs to be evolved by the Discom and strict monitoring and pursuance of the same would be required to achieve meaningful reduction in AT&C losses, at a level comparable with other states.

ii. Distribution Losses

Distribution Losses consists of both technical losses as well as commercial losses. The technical losses are due to energy dissipated in the conductors and equipment used for distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The commercial losses are caused by pilferage, unauthorized use, defective meters, and errors in meter reading and in estimating unmetered supply of energy.

The Distribution Loss levels along with the collection efficiency are the most important parameters for gauging the efficiency quotient of any Discom.

Data Consideration:

The Distribution Losses of the Discoms are taken from the PFC report "Performance of State Power Utilities" published in June 2016 and Audited Accounts of FY 2014-15.

Current Positioning of PVVNL:

PVVNL with distribution losses at 20% stands at 15th position out of 33 Discoms of the sample. PVVNL is trailing GESCOM of Karnataka which has observed losses of 19%. This list is topped by APEPDCL of Andhra Pradesh with distribution loss at significantly low level of 5%.

Table 3: Distribution Loss

S. No.	State	Utility	Net Input Energy (Mkwh)	Net Energy Sold (Mkwh)	Distribution Losses (%)	Rank of distribution losses (%)
1	Andhra Pradesh	APEPDCL	15,037	14,314	5%	1
2		APSPDCL	29,666	26,362	11%	4
3	Bihar	NBPDCL	5,849	3,823	35%	31

S. No.	State	Utility	Net Input Energy (Mkwh)	Net Energy Sold (Mkwh)	Distribution Losses (%)	Rank of distribution losses (%)
4		SBPDCL	10,148	5,574	45%	33
5	Chhattisgarh	CSPDCL	21,964	17,102	22%	17
6	Gujarat	DGVCL	17,140	15,572	9%	2
7		MGVCL	9,455	8,295	12%	6
8		PGVCL	26,472	19,958	25%	22
9		UGVCL	18,422	16,412	11%	3
10	Haryana	DHBVNL	24,488	18,496	24%	21
11		UHBVNL	19,312	13,406	31%	29
12	Jharkhand	JSEB/JBVNL	11,105	7,646	31%	30
13	Karnataka	BESCOM	28,256	24,436	14%	8
14		GESCOM	7,564	6,132	19%	14
15		HESCOM	11,059	9,208	17%	13
16		MESCOM	4,689	4,146	12%	5
17		CHESCOM	6,085	5,240	14%	9
18	Madhya Pradesh	Central	17,868	13,350	25%	23
19		East	16,106	12,613	22%	16
20		West	21,626	15,620	28%	26
21	Maharashtra	MSEDCL	110,458	94,805	14%	10
22	Punjab	PSPCL	47,640	40,403	15%	12
23	Rajasthan	AVVNL	17,450	12,899	26%	24
24		JVVNL	25,156	17,494	30%	28
25		JDVVNL	20,927	15,845	24%	20
26	Telangana	TSSPDCL	32,816	28,079	14%	11
27		TSNPDCL	12,802	11,105	13%	7
28	West Bengal	WBSEDCL	31,355	22,509	28%	27
29	Uttar Pradesh	DVVNL	19,129	12,248	36%	32
30		MVVNL	15,067	11,665	23%	18
31		PVVNL	25,946	20,845	20%	15
32		PuVVNL	18,252	13,893	24%	19
33		KESCO	3,491	2,582	26%	25

Recommendations:

The Regulation 18.1 - Distribution Losses of the UPERC MYDT Regulations, 2014 stipulate:

> "Distribution loss shall be considered as a controllable parameter. Based on the assessment of metered and un-metered sales as per Regulations 16 and 17 of these regulations, the Commission shall update existing baseline of distribution losses."

It is imperative to mention that clause 5.11 h) 2) of the Revised Tariff Policy 2016 dated 28.01.2016, stipulates that while framing the norms at the commencement of any Multi Year Tariff period, *"In cases where operations have been much below the norms for many previous years, the initial starting point in determining the revenue requirement and the improvement trajectories should be recognized at "relaxed" levels and not the "desired" levels. Suitable benchmarking studies may be conducted to establish the "desired" performance standards. Separate studies may be required for each utility to assess the capital expenditure necessary to meet the minimum service standards."*

PVVNL fares best among the state owned Discom of Uttar Pradesh. Distribution Losses of PVVNL is above the median of the sample Discoms considered in this study, but there is still immense room for improvement in this parameter.

The technical losses can be minimized by (i) optimizing HT to LT ratio, (ii) using energy efficient high quality conductors, transformers etc., (iii) optimizing capacity utilization at power and distribution transformer level, (iv) input energy measurement and accounting.

The commercial losses can be optimized by (i) improving metering and using smart meters and GIS mapping for consumer indexing, (ii) addressing billing errors for accurate and timely meter reading, prepaid metering using smart meters, effective control on bill amendment process, (iii) addressing theft/unauthorized usage of electricity through granular energy audit, direct theft/unregistered consumer identification and filing of FIR & court cases with clinching evidence using tampered data and using press and media campaign to spread the message of social offence and legal offence.

iii. Collection Efficiency

Collection efficiency is the ratio of the total revenue realized to the total revenue billed to the consumers for the relevant year.

Data Consideration:

The Collection Efficiency of the Discoms are taken from the PFC report "Performance of State Power Utilities" published in June 2016 and Audited Accounts of FY 2014-15.

Current Positioning of PVVNL:

PVVNL with collection efficiency of 97% stands at 9th position out of 33 Discoms considered for the study. This list is topped by MGVCL with collection efficiency of 101% (including the recovery of arrears/thefts).

Table 4: Collection Efficiency

S. No.	State	Utility	Collection Efficiency (%)	Rank of Collection Efficiency (%)
1	Andhra Pradesh	APEPDCL	97%	13
2		APSPDCL	99%	6
3	Bihar	NBPDCL	89%	28
4		SBPDCL	100%	3
5	Chhattisgarh	CSPDCL	93%	24
6	Gujarat	DGVCL	98%	7
7		MGVCL	101%	1
8		PGVCL	99%	5
9		UGVCL	101%	2
10	Haryana	DHBVNL	92%	25
11		UHBVNL	94%	22
12	Jharkhand	JSEB/JBVNL	77%	32
13	Karnataka	BESCOM	95%	19
14		GESCOM	97%	12
15		HESCOM	97%	14
16		MESCOM	95%	20
17		CHESCOM	91%	26
18	Madhya Pradesh	Central	90%	27
19		East	93%	23
20		West	96%	18
21	Maharashtra	MSEDCL	94%	21
22	Punjab	PSPCL	97%	10
23	Rajasthan	AVVNL	97%	10
24		JVVNL	98%	8
25		JDVVNL	96%	16
26	Telangana	TSSPDCL	100%	4
27		TSNPDCL	96%	17
28	West Bengal	WBSEDCL	97%	15
29	Uttar Pradesh	DVVNL	78%	31
30		MVVNL	67%	33

S. No.	State	Utility	Collection Efficiency (%)	Rank of Collection Efficiency (%)
31		PVVNL	97%	9
32		PuVVNL	78%	30
33		KESCO	86%	29

Recommendations:

The UP Discoms fare very poorly on the collection efficiency front, with PVVNL being an outlier with 97% collection efficiency in FY 2014-15. Even in the case of PVVNL, the performance has not been consistent over the years. The fact that most of the Discoms in the country have collection efficiency of around 95% demonstrates that such level is very much achievable. It is one area which would lead to maximum revenue generation with minimal capital expenditure and hence this aspect needs to be addressed with utmost priority by the UP Discoms.

The collection efficiency can be improved by (i) dunning and recovery process (ii) disconnection/ reconnection, (iii) naming and shaming of defaulters, (iv) pre-paid billing using smart meters, (v) credit rating based recovery actions ranging from SMS reminders, call centre reminder, door-step collection, disconnection, legal action.

iv. Reliability Indices

Reliability can be defined as the ability of the Discom to deliver electricity to all points of consumption, in the quantity demanded & with the quality expected by the consumer. Reliability is often measured by the outage indices defined in one international standard called IEEE 1366. (IEEE is the Institution of Electrical & Electronics Engineers, the biggest professional body of Electrical & Electronics Engineers. IEEE has its head office in the USA & has presence in most countries). These outage indices are based on the duration of each power supply interruption and the frequency of interruption.

SAIFI, SAIDI and CAIDI are some of the indices used to measure distribution system reliability. A power supply outage is an unplanned event and can be described in terms of the frequency, duration and duration per interruptions.

For very few Discoms, faults and interruptions are measured and computed throughout the license area, after R-APDRP almost all the Discoms have reached a level of 50% metering of feeders and boundaries. So, the interruptions and faults are measured in metered feeders and switchyards / substations. Most distribution companies have not reached 100% meter coverage at substation level.

The interruption may be identified and recorded, and the number of customers served by each feeder is also known. With R-APDRP, the accountability of the Discoms has increased. Most Discoms exhibited

an interest in tracking this performance measure and are expected to continue the practice. For Discoms with the town wise data of interruptions, only the SAIFI, SAIDI and CAIDI of the main town is considered for consistency in sampling. However, the Discoms which have the ready populated data are considered for the study.

Data Considerations

The data which is generally captured by the Discoms is not uniform across the country. Few Discoms carefully capture the data and others just capture the data on a sample basis, which is a serious concern while considering the data for the study. Functioning of PTs, CTs and information capturing devices is another constraint in authenticity of the data recorded. The data collected for the study is from the post "Go-Live" reports of R-APDRP towns. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. Data from January 2016 to Dec 2016 is considered for the Discoms. For few Discoms, this data is available only for 8-9 months and in such cases, the data is extrapolated for 12 months.

a. SAIFI

SAIFI (System Average Interruption Frequency Index): This measures the average number of sustained interruptions (outages) that a customer experiences in a year. It is a ratio of the number of customer-interruptions in a year to the total number of customers. Customer interruptions are determined from estimates of the number of customers affected by each interruption.

Current Positioning of PVVNL:

PVVNL with system average frequency interruption index of 525.96 stands in 24th position out of 30 Discoms of the sample. This list is topped by MGVCL with index of 18.12.

Table 5: System Average Interruption Frequency Index

S. No	State	Discom	SAIFI	SAIFI Rank
1	Andhra Pradesh	APEPDCL	63.85	5
2		APSPDCL	119.27	11
3	Bihar	NBPDCL	1,236.43	29
4		SBPDCL	1,163.33	28
5	Chhattisgarh	CSPDCL	89.56	7
6	Gujarat	DGVCL	128.23	12
7		MGVCL	18.12	1
8		PGVCL	43.84	4
9		UGVCL	24.41	2
10	Jharkhand	JBVNL	1,557.39	30

S. No	State	Discom	SAIFI	SAIFI Rank
11	Haryana	DHBVNL	96.95	8
12		UHBVNL	191.12	16
13	Karnataka	BESCOM	789.96	27
14		GESCOM	703.96	26
15		HESCOM	413.60	22
16		MESCOM	442.05	23
17		CHESCOM	200.79	17
18	Madhya Pradesh	MKVVCL	245.79	18
19		PoKVVCL	299.37	19
20		PKVVCL	133.76	13
21	Maharashtra	MSEDCL	37.75	3
22	Punjab	PSPCL	145.96	14
23	Telangana	TSSPDCL	69.05	6
24		TSNPDCL	108.51	10
25	West Bengal	WBSEDCL	103.55	9
26	Uttar Pradesh	DVVNL	566.37	25
27		MVVNL	370.11	21
28		PVVNL	525.96	24
29		PuVVNL	165.92	15
30		KESCO	339.15	20

b. SAIDI

SAIDI (System Average Interruption Duration Index): SAIDI is the average duration of interruptions per consumer during the year. It is the ratio of the annual duration of interruptions (sustained) to the number of consumers. If duration is specified in minutes, SAIDI is given as consumer minutes.

Current Positioning of PVVNL:

PVVNL with system average interruption duration index of 2527:07:14 stands in 30th position out of 30 Discoms of the sample. This list is topped by MGVCL of Gujarat with an index of 16:04:00.

Table 6: System Average Interruption Duration Index

S. No	State	Discom	SAIDI (Hrs.)	SAIDI Rank
1	Andhra Pradesh	APEPDCL	69:02:40	13
2		APSPDCL	55:42:40	10
3	Bihar	NBPDCL	786:24:00	24
4		SBPDCL	812:28:00	25
5	Chhattisgarh	CSPDCL	47:40:00	6
6	Gujarat	DGVCL	31:53:20	3
7		MGVCL	16:04:00	1
8		PGVCL	53:30:40	8
9		UGVCL	35:01:20	4
10	Jharkhand	JBVNL	334:27:29	23
11	Haryana	DHBVNL	1122:12:00	26
12		UHBVNL	1423:24:00	28
13	Karnataka	BESCOM	220:55:22	20
14		GESCOM	310:02:40	22
15		HESCOM	194:44:00	18
16		MESCOM	211:28:00	19
17		CHESCOM	49:37:20	7
18	Madhya Pradesh	MKVVCL	116:20:00	16
19		PoKVVCL	261:33:20	21
20		PKVVCL	74:24:00	14
21	Maharashtra	MSEDCL	66:34:40	12
22	Punjab	PSPCL	104:42:40	15
23	Telangana	TSSPDCL	30:38:40	2
24		TSNPDCL	65:29:20	11
25	West Bengal	WBSEDCL	55:13:30	9
26	Uttar Pradesh	DVVNL	1280:54:53	27
27		MVVNL	2342:18:03	29
28		PVVNL	2527:07:14	30
29		PuVVNL	139:01:20	17
30		KESCO	38:44:34	5

c. CAIDI

CAIDI (Consumer Average Interruption Duration Index): CAIDI is the average duration of an interruption, calculated based on the total number of sustained interruptions in a year. It is the ratio of the total duration of interruptions to the total number of interruptions during the year

Current Position of PVVNL:

PVVNL with index of 0.20 for consumer average interruption duration stands in 27th position out of 30 Discoms of the sample. This list is topped by KESCO of Uttar Pradesh with an index of 0.005.

Table 7: Consumer Average Interruption Duration Index

S. No	State	Discom	SAIDI (Hrs.)	SAIFI	CAIDI	CAIDI Rank
1	Andhra Pradesh	APEPDCL	69:02:40	63.85	0.05	22
2		APSPDCL	55:42:40	119.27	0.02	8
3	Bihar	NBPDCL	786:24:00	1,236.43	0.03	16
4		SBPDCL	812:28:00	1,163.33	0.03	17
5	Chhattisgarh	CSPDCL	47:40:00	89.56	0.02	12
6	Gujarat	DGVCL	31:53:20	128.23	0.01	4
7		MGVCL	16:04:00	18.12	0.04	21
8		PGVCL	53:30:40	43.84	0.05	23
9		UGVCL	35:01:20	24.41	0.06	24
10	Jharkhand	JBVNL	334:27:29	1,557.39	0.01	2
11	Haryana	DHBVNL	1122:12:00	96.95	0.48	30
12		UHBVNL	1423:24:00	191.12	0.31	29
13	Karnataka	BESCOM	220:55:22	789.96	0.01	5
14		GESCOM	310:02:40	703.96	0.02	6
15		HESCOM	194:44:00	413.60	0.02	9
16		MESCOM	211:28:00	442.05	0.02	11
17		CHESCOM	49:37:20	200.79	0.01	3
18	Madhya Pradesh	MKVVCL	116:20:00	245.79	0.02	10
19		PoKVVCL	261:33:20	299.37	0.04	20
20		PKVVCL	74:24:00	133.76	0.02	14
21	Maharashtra	MSEDCL	66:34:40	37.75	0.07	25
22	Punjab	PSPCL	104:42:40	145.96	0.03	18
23	Telangana	TSSPDCL	30:38:40	69.05	0.02	7
24		TSNPDCL	65:29:20	108.51	0.03	15
25	West Bengal	WBSEDCL	55:13:30	103.55	0.02	13

S. No	State	Discom	SAIDI (Hrs.)	SAIFI	CAIDI	CAIDI Rank
26	Uttar Pradesh	DVVNL	1280:54:53	566.37	0.09	26
27		MVVNL	2342:18:03	370.11	0.26	28
28		PVVNL	2527:07:14	525.96	0.20	27
29		PuVVNL	139:01:20	165.92	0.03	19
30		KESCO	38:44:34	339.15	0.005	1

Observations:

This list need not represent the actual positioning of Discoms as these results are based on the sample data obtained through feeder monitoring units which are installed only in the selected towns. Progressive Discoms in the country are monitoring their system performance for entire population, whereas the aspiring discoms have just started monitoring the performance on a sample basis. It is most likely that only the main areas/circles of the discoms are monitored, which may not represent the profile of entire supply area. It is therefore suggested to the UP Discoms that, all the rural and urban areas need to be monitored for interruptions to provide reliable and quality services to the consumers and thereby increase the consumer satisfaction. Further, it is pointed out that at this juncture it is not known whether the scheduled outages and the duration of outage therein are included in the number of interruptions and the duration of interruptions for computing the reliability indices. In order to compute the correct reliability indices, the scheduled outages should not be considered for computation of number of interruptions and durations of interruptions.

v. Restoration Rate of Distribution Transformers

Transformers form an integral part of power system. Reliable operations of a distribution transformer directly impact the quality of the power supply. A reliable power system operation requires the alignment of strategic directives by the utilities. Review of rate of distribution transformer failure becomes necessary since they can be used to influence transformer design & technology, maintenance & condition monitoring practices with changing system loading, operation and network configuration. Restoration rate of Distribution Transformers gives us a measure of the promptness of Discoms in customer service, complying with the Standards of Performance (SoP) regulations laid by the respective State Electricity Regulatory Commissions.

Data Consideration:

This data is mainly sourced from the websites of SERCs and the Discoms which have published the data on their websites. Data pertaining to the Discoms of Uttar Pradesh are provided by the Discoms upon request. The data of Andhra Pradesh and Telangana Discoms are taken for the year FY 2013-14.

Current Positioning of PVVNL:

The current position of PVVNL on distribution transformer restoration rate is 1st with 100% restoration of transformers, i.e all the transformers are restored within 72 hours of damage/complaint received by the Utility.

Table 8: Restoration Rate of Distribution Transformer

S. No	State	DISCOMS	Distribution Transformer Restoration Rate	Rank
1	Karnataka	BESCOM	98%	11
2		MESCOM	100%	1
3		CHESCOM	86%	18
4		HESCOM	100%	1
5		GESCOM	94%	17
6	Andhra Pradesh	APCPDCL	100%	1
7		APEPDCL	99%	10
8	Telangana	APNPDCL	100%	1
9		APSPDCL	44%	19
10	Maharashtra	MSEDCL	27%	20
11	Odisha	CESU	100%	1
12		NESCO	97%	13
13		WESCO	100%	1
14		SOUTHCO	100%	1
15	Uttar Pradesh	DVVNL	96%	14
16		MVVNL	95%	15
17		PVVNL	100%	1
18		PuVVNL	97%	12
19		KESCO	100%	1
20	Madhya Pradesh	East	94%	16

Observations:

The UP Discoms have started complying with the SoP Regulations stipulated by the Hon'ble UPERC, by compiling the data on 10 day basis. Two out of the five state owned Discoms, namely PVVNL and KESCO have already attained the stipulated SoP in respect of the restoration rate of Distribution Transformers. The restoration rate of Distribution Transformers in respect of the remaining three Discoms namely PuVVNL, DVVNL and MVVNL is varying between 95% - 97%. With proper recording

of the restoration rate and strict monitoring of the same, these Discoms are also poised to achieve the stipulated SoP in the near term.

vi. Distribution Transformer Reliability

Distribution transformer reliability is the ratio of the working/un-failed distribution transformers to the total distribution transformers.

Data Consideration:

This data is mainly sourced from the websites of SERCs and the Discoms which have published the data on their websites. Data pertaining to the Discoms of Uttar Pradesh are provided by the Discoms upon request.

Current Positioning of PVVNL:

The current position of PVVNL in Distribution transformer reliability is 11th in the list of 13 with only 83% of the transformers working without any damages/tripping in a year.

Table 9: Distribution Transformer Reliability Rate

S. No	State	Discoms	Total DT	Failed	Distribution Transformer Reliability Rate	Rank
1	Uttar Pradesh	DVVNL	230663	4835	98%	3
2		MVVNL	219142	2467	99%	1
3		PVVNL	238222	40225	83%	11
4		PuVVNL	272651	65359	76%	13
5		KESCO	4540	823	82%	12
6	Gujarat	UGVCL	222666	10852	95%	5
7		DGVCL	115076	8410	93%	9
8		MGVCL	111736	4365	96%	4
9		PGVCL	563381	9079	98%	2
10	Madhya Pradesh	East	146785	8380	94%	7
11		Central	135223	6819	95%	6
12		West	200362	25432	87%	10
13	Haryana	DHBVNL	240074	14371	94%	8

Observations:

There is a significant variance in the Distribution Transformer Reliability Rate between various UP Discoms, which is surprising as it is understood that the suppliers and O&M agencies for Distribution

Transformer upkeep are mostly common / similar within UP Discoms. High Distribution Transformer failure rate directly impacts not only the quality of supply of power but also the revenue of the Discoms. In view of the same, it is imperative for the Discoms to analyze the reasons for the variance and take suitable steps to minimize the Distribution Transformer failure rate.

vii. HT to LT Ratio

The ratio of primary line length to its concerned secondary line length is one of the important factors that influence the performance of distribution. Over the years, large scale expansion of the urban system and rural electrification program in the country has resulted in considerable expansion of Low Tension (LT) distribution network. The size of the distribution network has been constantly expanding to meet the increasing demand due to load growth. As a result of increase in the length of LT lines, high losses and excessive voltage drops have become more frequent.

Data Consideration:

Data for this parameter is taken from the Power for All (PFA) reports published jointly by the Central and State Governments. The data of LT and HT network of the UP Discoms is provided by the Discom upon request. For states, whose data for individual Discoms is not available, the state average is assumed for each Discom for consistency.

Current Positioning of PVVNL:

PVVNL with HT to LT ratio of 0.39 stands at 31st position out of 33 Discoms of the sample. PVVNL is trailing CSPDCL Discom which has observed ratio of 0.40. This list is topped by Rajasthan Discoms with HT to LT ratio of 1.68.

Table 10: HT to LT Ratio

S.No	State	Discom	HT/LT	Rank
1	Andhra Pradesh	APEPDCL	0.50	25
2		APSPDCL	0.50	25
3	Bihar	NBPDCL	0.71	16
4		SBPDCL	0.54	19
5	Chhattisgarh	CSPDCL	0.40	30
6	Gujarat	DGVCL	0.86	12
7		MGVCL	0.80	14
8		PGVCL	1.18	6
9		UGVCL	1.27	5
10	Haryana	DHVBN	1.15	7
11		UHVBN	1.09	8

S.No	State	Discom	HT/LT	Rank
12	Jharkhand	JBVNL	0.75	15
13	Karnataka	BESCOM	0.52	20
14		GESCOM	0.60	17
15		HESCOM	0.52	21
16		MESCOM	0.40	29
17		CHESCOM	0.51	23
18	Madhya Pradesh	Central	0.96	9
19		East	0.96	9
20		West	0.96	9
21	Maharashtra	MSEDCL	0.51	24
22	Punjab	PSPCL	1.50	4
23	Rajasthan	AVVNL	1.68	1
24		JVVNL	1.68	1
25		JdVVNL	1.68	1
26	Telangana	TSSPDCL	0.50	25
27		TSNPDCL	0.50	25
28	West Bengal	WBSEDCL	0.52	22
29	Uttar Pradesh	DVVNL	0.58	18
30		MVVNL	0.34	32
31		PVVNL	0.39	31
32		PuVVNL	0.20	33
33		KESCO	0.80	13

Observations:

The losses for a given quantum of power supplied by a line are inversely proportional to the square of its operating voltage. Higher the operating voltage, lower will be the line losses. It can be well inferred that for high HT to LT ratio, the technical losses will be low. Therefore, by increasing the HT lines i.e. by upgrading the existing distribution network to the HVDS system, technical losses can be reduced. Further, wherever feasible, the Discom should setup substation and/or distribution transformers closer to the consumption hub for minimizing the LT length.

viii. Accidents

Electrical accidents can result in serious injuries to both human beings and animals and sometimes even lead to death. Accidents also cost collateral damage to property. Many accidents occur due to

lack of operational safety and not following standard operating procedures during operation and maintenance of electrical network.

Data Consideration:

Data pertaining to number of accidents is related to the safety standards followed by the Discom. The best source of data on accidents of the Discoms is the information provided on their Website (FY 2015-16) and Crime Bureau Statistics of India (State level Data for FY 2014-15). Data regarding the UP Discoms is taken from their submission as the part of MYT filing formats. Data of Andhra Pradesh and Telangana are taken from the common data of post-demerged Andhra Pradesh for FY 2014-15.

Current Positioning of PVVNL:

PVVNL is positioned at 12th in the list of 17. The list is topped by KESCO with only 3 accidents in FY 2015-16.

Table 11: Details of Accidents

S.No	State	Discom	Fatal Human	Fatal Animal	Non Fatal Human	Total	Rank
1	Karnataka	Karnataka	214	0	6	202	8
2	Gujarat	UGVCL	78	81	43	202	8
3		DGVCL	64	75	77	216	11
4		MGVCL	20	57	23	100	3
5		PGVCL	102	186	101	389	14
6	Andhra Pradesh	APSPDCL	130	0	0	129	7
7		APEPDCL	130	0	0	128	4
8	Telangana	TSSPDCL	130	0	0	128	4
9		TSNPDCL	129	0	0	128	4
10	Maharashtra	MSEDCL	846	0	566	1412	17
11	Odisha	Odisha	214	0	1	211	10
12	Madhya Pradesh	Jabalpur	184	118	100	402	15
13	Uttar Pradesh	DVVNL	155	229	46	430	16
14		MVVNL	87	200	40	327	13
15		PVVNL	92	136	27	255	12
16		PuVVNL	22	10	5	42	2
17		KESCO	3	0	0	3	1

Observations:

The number of reported accidents in the case of KESCO and PuVVNL are very low, which is very encouraging. However, the number of reported accidents in the case of DVVNL, MVVNL and PVVNL is quite high. Most of the accidents occur in the case of outsourced agencies (commonly called as 'gang') hired for operation and maintenance of electrical network. The Discoms should frame an Operational Safety and Health Standards (thereby providing training standards, safety standards, health standards and insurance) with a view to minimize accidents and these should be compulsorily adhered by both the employees of the Discoms as well as the outsourced staff. The contract for any operation and maintenance of the electrical network awarded by the Discom should compulsorily provide that the agencies should undertake insurance for the employees and casual workers.

ix. Employee Engagement

An employee is a critical resource for any organization. To derive the best outcome from any human resource, he/she should be appropriately engaged. Ratio of number of employee for every 1000 consumers served and units of electricity handled gives as a picture on the actual engagement of an employee.

Data Consideration:

Data pertaining to employees and consumers are taken from the company information published in their respective websites and the tariff orders of the Discom by the respective State Electricity Regulatory Commission. Information of the UP Discoms is obtained from the data disclosures as the part of their MYT filing formats for FY 2015-16. For Haryana Discom, the data of FY 2015-16 and other Discom, the data of FY 2014-15 are considered.

Current Positioning of PVVNL:

The current position of PVVNL in the rank of number of employees per 1000 consumers is 2 in the list of 16 and in the rank of employee per MU of energy sales is 16 in the list of 16.

Table 12: Details of Employee Engagement

S. No	State	Discom	Number of Employees	Number of Consumers ('000)	Employees per 1000 consumers	Rank of Employee Occupancy (/'000 consumers)	Sales (MUs)	Employees per MU of electricity sold	Rank of Employee Occupancy (/MU of sales)
1	Uttar Pradesh	DVVNL	7,404	3,456	2.14	8	12,248	1.65	13
2		MVVNL	9,637	4,076	2.36	9	11,665	1.21	8
3		PVVNL	5,723	4,312	1.33	2	20,845	3.64	16
4		PuVVNL	7,408	4,776	1.55	3	13,893	1.88	14
5		KESCO	1,723	526	3.28	12	2,582	1.50	11

S. No	State	Discom	Number of Employees	Number of Consumers ('000)	Employees per 1000 consumers	Rank of Employee Occupancy (/'000 consumers)	Sales (MUs)	Employees per MU of electricity sold	Rank of Employee Occupancy (/MU of sales)
6	Karnataka	BESCOM	12,444	9,445	1.32	1	24,436	1.96	15
7		GESCOM	4,997	2,594	1.81	4	6,132	1.23	8
8		HESCOM	7,868	4,090	1.85	5	9,208	1.17	7
9		MESCOM	3,756	2,075	1.92	6	4,146	1.10	6
10		CHESCOM	5,048	2,736	1.93	7	5,240	1.04	5
11	Madhya Pradesh	MKVVCL	11,543	2,938	3.93	13	13,350	1.16	10
12		PuKVVCL	13,720	4,239	3.24	11	12,613	0.92	4
13		PKVVCL	11,085	3,832	2.89	10	17,805	1.61	12
14	Haryana	DHBVNL	18,970	3,025	6.27	16	15,626	0.82	3
15		UHBVNL	12,812	2,636	4.86	15	8,246	0.64	1
16	Rajasthan	AVVNL	16,411	3,971	4.13	14	12,899	0.79	2

Observations:

The number of personnel per 1000 consumers in case of PVVNL is 1.33 as compared to the statistical mean of the data of sample Discoms (excluding UP Discoms) which is 2.85. It is also submitted that the employee cost per unit of energy sale of PVVNL is the lowest in the country, which is owing to significant under deployment of personnel against sanctioned employee strength. Thus, the employee engagement has to be seen, not in isolation, but along with employee cost by unit of energy sales and working employee strength vs. sanctioned employee strength. Regulation 25(b) of the UPERC MYDT Regulations, 2014 provides for determination of the norm in respect of the number of personnel per 1000 consumers. It is recommended that the statistical mean of the sample Discoms (excluding UP Discoms) equivalent to 2.85 may be considered as the norm for number of personnel per 1000 consumers

x. Lead time for New Connections

Lead time for new connections is the time taken by the distribution companies to approve and grant new connections for the received applications. In this case, most of the SERCs prescribe the Discom to release the new connections within 30 days of the applications and completion of all formalities including payment of applicable fee.

Data Consideration:

The data collected for the study is from the post "Go-Live" reports of R-APDRP. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. Data from April 2016 to September 2016 is considered for the parameter.

Current Positioning of PVVNL:

PVVNL with the 31.21% connections pending to be released within 30 days of receipt of application stands in 10th position out of 32 Discoms whose data is available. PVVNL is trailing MGVCL of Gujarat, which have pending requests of around 26.92% of new connection applications. This list is topped by DGVCL and APEPDCL with 100% connections released till December 2016.

Table 13: Lead time for New Connections

S. No.	State	Utility	Pending Connections after 30 days of receipt of request (%)	Pending Connections Rank
1	Andhra Pradesh	APEPDCL	0	1
2		APSPDCL	7.34	5
3	Bihar	NBPDCL	79.6	23
4		SBPDCL	72.63	19
5	Chhattisgarh	CSPDCL	43.45	13
6	Gujarat	DGVCL	0	1
7		MGVCL	26.92	9
8		PGVCL	2.29	4
9		UGVCL	31.22	11
10	Haryana	DHVBN	78.31	22
11		UHVBN	76.32	21
12	Jharkhand	JBVNL	92.89	29
13	Karnataka	BESCOM	92.72	28
14		GESCOM	93.46	30
15		HESCOM	69.87	17
16		MESCOM	89.77	26
17		CHESCOM	68.43	16
18	Madhya Pradesh	Central	88.33	25
19		East	70.97	18
20		West	76.23	20
21	Maharashtra	MSEDCL	0.77	3
22	Punjab	PSPCL	81.16	24
23	Rajasthan	AVVNL	97.52	33
24		JVVNL	51.67	14
25		JDVVNL	62.49	15
26	Telangana	TSSPDCL	24.22	8
27		TSNPDCL	42.9	12

S. No.	State	Utility	Pending Connections after 30 days of receipt of request (%)	Pending Connections Rank
28	West Bengal	WBSEDCL	92.55	27
29	Uttar Pradesh	DVVNL	94.56	31
30		MVVNL	95.26	32
31		PVVNL	31.21	10
32		PuVVNL	18.47	7
33		KESCO	13.02	6

Recommendations:

The guidelines of the World Bank and the DIPP under Ease of Doing Business (EoDB) initiative mandate the disclosure of time taken for release of new electricity service connections by the licensees. Most of the state's Governments have issued directives to the state owned Discoms to mandatorily disclose the duration, list of documents & fee for a new service connection and abide by the timelines prescribed. UP Discoms should act swiftly in releasing connections within the stipulated time and no slippages on this account may be allowed under any circumstances.

xi. Lead time for Complaint Redressal

It is the ratio of the total number of complaints resolved within the SERC time limit to the total number of complaints registered in a period. The typical consumer complaints are in respect of the billing disputes, line faults etc.

Data Consideration:

The data source considered for the study is the post "Go-Live" reports of R-APDRP. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. Data from April 2016 to September 2016 is considered for the parameter.

Current Positioning of PVVNL:

PVVNL with the 28.79% complaints resolved within 30 days of receipt of application stands at 22nd position out of 32 Discoms under consideration. PVVNL is trailing MSEDCL, which has a complaint redressal rate of around 15.61% within stipulated time. This list is topped by Andhra Pradesh Discoms, Gujarat discoms, Punjab Discom and KESCO with 100% complaints resolved within 30 days' time period.

Table 14: Lead time for Complaint Redressal

S. No	State	Discom	Pending Complaints (%)	Pending Complaints Rank
1	Andhra Pradesh	APEPDCL	-	1
2		APSPDCL	-	1
3	Bihar	NBPDCL	71.81	27
4		SBPDCL	85.44	30
5	Chhattisgarh	CSPDCL	1.25	16
6	Gujarat	DGVCL	-	1
7		MGVCL	-	1
8		PGVCL	-	1
9		UGVCL	-	1
10	Haryana	DHVBN	70.51	26
11		UHVBN	80.37	28
12	Jharkhand	JBVNL	81.12	29
13	Karnataka	BESCOM	1.32	17
14		GESCOM	100.00	31
15		HESCOM	101.00	32
16		MESCOM	-	1
17		CHESCOM	0.03	11
18	Madhya Pradesh	Central	69.92	25
19		East	29.13	23
20		West	1.11	15
21	Maharashtra	MSEDCL	15.61	21
22	Punjab	PSPCL	-	1
23	Rajasthan	AVVNL	1.41	18
24		JVVNL	0.69	13
25		JDVVNL	0.98	14
26	Telangana	TSSPDCL	0.53	12
27		TSNPDCL	4.08	19
28	West Bengal	WBSEDCL	33.01	24
29	Uttar Pradesh	DVVNL	0.02	10
30		PVVNL	28.79	22
31		PuVVNL	10.02	20
32		KESCO	-	1

Observations:

The performance of KESCO and DVVNL are appreciable; however, the performance of the PuVVNLand PVVNL falls short of expectations. Prompt complaint redressal leads to customer satisfaction and helps in revenue maximization.

xii. Feeder Monitoring

Feeder monitoring is the number of feeders being monitored with appropriate infrastructure for both real time and standalone data acquisition. Feeder monitoring helps in isolating the losses and interruptions to feeder level, providing an opportunity for better services to the consumers and loss reduction.

Data Considerations:

Feeder monitoring is the count of the total number of feeders whose data is available with the National Power Portal (NPP) of the Ministry of Power, Government of India out of the total feeders recognized for the purpose. This measure is initiated as part of the R-APDRP program. Feeder monitoring parameter considered here is the ratio of number of feeders whose data is available in NPP to the total feeders metered as the part of R-APDRP. The data collected for the study is from the post "Go-Live" reports of R-APDRP. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. KESCO has metered 100% of its feeders but the details of monitoring on real time are unknown and thus considered zero feeders being monitored. Data as on September 2016 (compiled in October 2016) is considered for the parameter.

Current Positioning of PVVNL:

PVVNL with feeder monitoring percentage of 75% and stands in 22nd position out of 33 Discoms considered for the study. This list is topped by DGVCL with 100%.

Table 15: Details of Feeder Monitoring

S. No.	State	Discom	Total Feeders	No. of Feeders Data on NPP	% Feeder Monitoring	Rank
1	Andhra Pradesh	APEPDCL	564	561	99%	5
2		APSPDCL	922	920	100%	2
3	Bihar	NBPDCL	157	146	93%	15
4		SBPDCL	383	273	71%	23
5	Chhattisgarh	CSPDCL	749	741	99%	8
6	Gujarat	DGVCL	174	174	100%	1
7		MGVCL	332	330	99%	6

S. No.	State	Discom	Total Feeders	No. of Feeders Data on NPP	% Feeder Monitoring	Rank
8		PGVCL	780	778	100%	3
9		UGVCL	250	249	100%	4
10	Haryana	DHVBN	1,090	381	35%	31
11		UHVBN	586	211	36%	30
12	Jharkhand	JBVNL	352	190	54%	28
13	Karnataka	BESCOM	1,446	1,029	71%	24
14		GESCOM	177	140	79%	21
15		HESCOM	193	156	81%	20
16		MESCOM	284	279	98%	11
17		CHESCOM	194	191	98%	10
18	Madhya Pradesh	Central	696	331	48%	29
19		East	337	282	84%	19
20		West	663	556	84%	18
21	Maharashtra	MSEDCL	3,740	3,213	86%	17
22	Punjab	PSPCL	68	-	0%	32
23	Rajasthan	AVVNL	1,551	1,541	99%	7
24		JVVNL	781	747	96%	14
25		JDVVNL	1,441	1,287	89%	16
26	Telangana	TSSPDCL	1,459	1,442	99%	9
27		TSNPDCL	307	298	97%	12
28	West Bengal	WBSEDCL	601	386	64%	25
29	Uttar Pradesh	DVVNL	777	456	59%	27
30		MVVNL	1,452	923	64%	26
31		PVVNL	1,677	1,259	75%	22
32		PuVVNL	664	644	97%	13
33		KESCO	443	-	0%	32

Observations:

100% feeder monitoring is critical to analyse various aspects pertaining to reliability of the supply and loss measurement. The Discoms should ensure that it achieves 100% feeder monitoring within a period of 3 months in the R-APDRP towns and within 6 months for all other feeders.

xiii. Feeders with high SAIFI

Feeders with high SAIFI is the percentage of feeders with SAIFI more than 30 interruptions per month out of the feeders, who's DCUs are working and being monitored continuously.

Data Considerations

The data collected for the study is from the post "Go-Live" reports of R-APDRP. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. Data as on September 2016 (compiled in October 2016) is considered for the parameter.

Current Positioning of PVVNL:

PVVNL has 42.61% of feeders with SAIFI of more than 30 and stands in 30th position out of 33 Discoms. NBPDCL and JBVNL follows PVVNL with 47.26% and 55.29% feeders recorded more than 30% SAIFI.

Table 16: Feeders with high SAIFI

S. No.	State	Discom	Total Feeders having interruptions data	Feeders with SAIFI>=30	% Feeders with SAIFI>=30	Rank
1	Andhra Pradesh	APEPDCL	564	-	0.00%	1
2		APSPDCL	1,015	4	0.39%	14
3	Bihar	NBPDCL	146	69	47.26%	31
4		SBPDCL	273	59	21.61%	26
5	Chhattisgarh	CSPDCL	65	1	1.54%	18
6	Gujarat	DGVCL	174	-	0.00%	1
7		MGVCL	329	-	0.00%	1
8		PGVCL	772	-	0.00%	1
9		UGVCL	249	-	0.00%	1
10	Haryana	DHVBN	469	3	0.64%	15
11		UHVBN	344	8	2.33%	19
12	Jharkhand	JBVNL	85	47	55.29%	32
13	Karnataka	BESCOM	130	7	5.38%	24
14		GESCOM	129	-	0.00%	1
15		HESCOM	42	30	71.43%	33
16		MESCOM	292	69	23.63%	27
17		CHESCOM	194	47	24.23%	28
18	Madhya Pradesh	Central	693	34	4.91%	23
19		East	295	8	2.71%	21
20		West	548	25	4.56%	22
21	Maharashtra	MSEDCL	3,728	-	0.00%	1
22	Punjab	PSPCL	1,541	11	0.71%	16
23	Rajasthan	AVVNL	15	-	0.00%	1

S. No.	State	Discom	Total Feeders having interruptions data	Feeders with SAIFI>=30	% Feeders with SAIFI>=30	Rank
24		JVVNL	1,245	1	0.08%	13
25		JdVVNL	221	-	0.00%	1
26	Telangana	TSSPDCL	1,285	1	0.08%	12
27		TSNPDCL	296	-	0.00%	1
28	West Bengal	WBSEDCL	603	15	2.49%	20
29	Uttar Pradesh	DVVNL	161	41	25.47%	29
30		MVVNL	152	20	13.16%	25
31		PVVNL	115	49	42.61%	30
32		PuVVNL	619	9	1.45%	17
33		KESCO	443	-	0.00%	1

Observations:

This list need not represent the actual positioning of Discoms as these results are based on the sample data obtained through feeder monitoring units which are installed only in the selected towns. Progressive Discoms in the country are monitoring their system performance for entire population, whereas the aspiring discoms have just started monitoring the performance on a sample basis. It is most likely that only the main areas/circles of the discoms are monitored, which may not represent the profile of entire supply area. It is therefore suggested to the UP Discoms that, all the rural and urban areas need to be monitored for interruptions to provide reliable and quality services to the consumers, thereby increase the consumer satisfaction.

xiv. Feeders with high SAIDI

Feeders with high SAIDI is the percentage of feeders with SAIDI more than 30 hours per month out of the feeders, whose DCUs are working and being monitored continuously.

Data Considerations

The data collected for the study is from the post "Go-Live" reports of R-APDRP. However, KESCO which is not a part of R-APDRP program provided the data, which is regularly compiled for internal purpose. Data as on September 2016 (compiled in October 2016) is considered for the parameter.

Current Positioning of PVVNL:

PVVNL has 68.70% feeders with SAIDI of more than 30 hours in a month and stands in 32nd position out of 32 Discoms whose data is available. This list is topped by three Gujarat Discoms and one Karnataka Discom.

Table 17: Feeders with high SAIDI

S. No.	State	Discom	Total Feeders having interruptions data	Feeders with SAIDI>=30	% Feeders with SAIDI>=30	Rank
1	Andhra Pradesh	APEPDCL	564	4	0.71%	13
2		APSPDCL	1,015	12	1.18%	19
3	Bihar	NBPDCL	146	26	17.81%	26
4		SBPDCL	273	31	11.36%	25
5	Chhattisgarh	CSPDCL	65	3	4.62%	22
6	Gujarat	DGVCL	174	-	0.00%	1
7		MGVCL	329	-	0.00%	1
8		PGVCL	772	1	0.13%	9
9		UGVCL	249	-	0.00%	1
10	Haryana	DHVBN	469	246	52.45%	31
11		UHVBN	344	170	49.42%	30
12	Jharkhand	JBVNL	85	37	43.53%	29
13	Karnataka	BESCOM	130	1	0.77%	14
14		GESCOM	129	-	0.00%	1
15		HESCOM	42	24	57.14%	32
16		MESCOM	292	22	7.53%	23
17		CHESCOM	194	16	8.25%	24
18	Madhya Pradesh	Central	693	1	0.14%	10
19		East	295	3	1.02%	17
20		West	548	20	3.65%	21
21	Maharashtra	MSEDCL	3,728	12	0.32%	11
22	Punjab	PSPCL	1,541	32	2.08%	20
23	Rajasthan	AVVNL	15	-	0.00%	1
24		JVVNL	1,245	1	0.08%	8
25		JdVVNL	221	1	0.45%	12
26	Telangana	TSSPDCL	1,285	-	0.00%	1
27		TSNPDCL	296	3	1.01%	16
28	West Bengal	WBSEDCL	603	6	1.00%	15

S. No.	State	Discom	Total Feeders having interruptions data	Feeders with SAIDI>=30	% Feeders with SAIDI>=30	Rank
29	Uttar Pradesh	DVVNL	161	56	34.78%	27
30		MVVNL	152	66	43.42%	28
31		PVVNL	115	79	68.70%	33
32		PuVVNL	619	7	1.13%	18
33		KESCO	443	-	0.00%	1

Observations:

This list need not represent the actual positioning of Discoms as these results are based on the sample data obtained through feeders monitoring units which are installed only in the selected towns. Progressive Discoms in the country are monitoring their system performance for entire population, whereas the aspiring discoms have just started monitoring the performance on a sample basis. It is most likely that only the main areas/circles of the discoms are monitored, which may not represent the profile of entire supply area. It is therefore suggested to the UP Discoms that, all the rural and urban areas need to be monitored for interruptions to provide reliable and quality services to the consumers, thereby increase the consumer satisfaction.

xv. Peak Demand Supply Availability

Peak Demand Supply Availability is an index to explain if the Discom is able to cater to the peak demand of the system. It is an index which shows the readiness and planning of the Discom in assessing the load and making arrangements to cater it. However, it also depends on the purchasing capacity of the Discoms for peak power and the Discoms which are making Loss per unit sold generally tends to avoid such peak power purchase as it is comparatively costlier than the base and off-peak power.

Data Consideration:

The best source for the data is the LGBR Report published by CEA for FY 2015-16. The ranking of individual Discom is not done, instead ranking of the States is done with the available Data.

Current Positioning of Uttar Pradesh:

Current Position of Uttar Pradesh is 35 in the list of 37 entities, only ahead of Jammu & Kashmir and Andaman Nicobar Islands.

Recommendations:

UP is having one of the lower peak demand supply availability i.e the Discoms are unable to cater the demand of the customers. This may lead to poor customer satisfaction. However, the supply position has changed dramatically from October 2016, when the State has started supplying 24 hours power to cities and major towns and 18 hours power to the villages and tehsils. Significant generating capacity namely Lalitpur TPP – 1980 MW, Bara TPP – 1980 MW, Anpara D – 1000 MW, Srinagar Hydro – 290 MW, Case I – 2575 MW has been added in the last 2 years which has made the increase in hours of supply possible.

Table 18: Peak Demand Supply Gap

S. No	Region / State / System	Requirement (MUs)	Availability (MUs)	Surplus(+) / Deficit(-) (MUs/%)		Rank on Supply Availability
1	Chandigarh	1,607	1,607	-	-	1
2	Delhi	29,626	29,583	-43	-0.1	9
3	Haryana	47,506	47,437	-69	-0.1	9
4	Himachal Pradesh	8,821	8,758	-63	-0.7	20
5	Jammu & Kashmir	16,572	14,037	-2,536	-15.3	37
6	Punjab	49,687	49,675	-12	-	1
7	Rajasthan	67,417	67,205	-212	-0.3	13
8	Uttar Pradesh	106,350	93,033	-13,317	-12.5	36
9	Uttarakhand	12,889	12,675	-214	-1.7	25
10	Chhattisgarh	25,650	25,310	-340	-1.3	23
11	Gujarat	103,544	103,540	-4	-	1
12	Madhya Pradesh	62,375	62,375	-	-	1
13	Maharashtra	141,817	141,361	-456	-0.3	13
14	Daman & Diu	2,337	2,337	-	-	1
15	Dadra & Nagar Haveli	5,925	5,925	-	-	1
16	Goa	5,120	5,119	-1	-	1
17	Andhra Pradesh	50,437	50,366	-71	-0.1	9
18	Karnataka	64,302	60,971	-3,331	-5.2	32
19	Kerala	23,318	23,194	-124	-0.5	17
20	Tamil Nadu	97,277	96,586	-690	-0.7	20
21	Telangana	50,254	49,948	-307	-0.6	18
22	Puducherry	2,437	2,429	-8	-0.3	13
23	Lakshadweep	48	48	0	0	1
24	Bihar	23,960	23,658	-302	-1.3	23

S. No	Region / State / System	Requirement (MUs)	Availability (MUs)	Surplus(+) / Deficit(-) (MUs/%)		Rank on Supply Availability
25	Damodar Valley Corporation	18,437	18,234	-203	-1.1	22
26	Jharkhand	7,735	7,560	-174	-2.3	28
27	Odisha	26,763	26,600	-163	-0.6	18
28	West Bengal	47,359	47,194	-165	-0.3	13
29	Sikkim	399	399	0	0	9
30	Andaman & Nicobar	240	180	-60	-25	38
31	Arunachal Pradesh	625	591	-35	-6	33
32	Assam	8,762	8,271	-491	-5.6	34
33	Manipur	840	810	-30	-3.6	30
34	Meghalaya	1,832	1,724	-108	-5.9	35
35	Mizoram	471	455	-16	-3.3	29
36	Nagaland	755	738	-16	-2.2	27
37	Tripura	1,202	1,146	-57	-4.7	31
38	All India	1,114,408	1,090,851	-23,557	-2.1	26

B. Operations & Maintenance Expenses

i. O&M Expenses per unit of Energy Sales

Operation and Maintenance expenses or 'O&M expenses' refers to the expenditure incurred towards Employee expenses, Administrative & General expenses and Repair & Maintenance expenses. O&M expenses may also include certain incidental and one time expenses, which may be un-controllable, but the day to day expenses for normal functioning of the Discom is controllable in nature. Since the O&M expenses are controllable in nature, the lower the expenses are, the better the utility is, in terms of cost management. However, it is also pertinent to observe the correlation with the performance of the other operating parameters as there can be an instance where a certain Discom is under-staffed leading to lower employee cost and consequently lower O&M expenses. O&M expense per unit of energy sold is the ratio of the total O&M expenses incurred to the total units of energy sold in a year.

Data Consideration:

The best source of data of O&M expenses considered for this parameter is Audited Accounts of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the energy Sales are taken from the Audited Accounts. In case, the sales are not captured in the Audited Accounts, then True-up petitions are considered as the best source to capture Energy Sales of the relevant year.

Current Position of PVVNL:

Current Position of PVVNL is 2 out of 33 Discoms, with an expense of Rs. 0.31/kWh. This list is topped by DGVCL of Gujarat with Rs. 0.24/kWh.

Table 19: O&M Expenses per unit of Energy Sales

S.No.	State	Discom	O&M expense Per unit sales	Rank of O&M Per Unit Sales
1	Andhra Pradesh	APEPDCL	0.80	30
2		APSPDCL	0.80	28
3	Bihar	NBPDCL	0.43	8
4		SBPDCL	0.63	19
5	Chhattisgarh	CSPDCL	0.65	22
6	Gujarat	DGVCL	0.24	1
7		MGVCL	0.53	12

S.No.	State	Discom	O&M expense Per unit sales	Rank of O&M Per Unit Sales
8		PGVCL	0.40	6
9		UGVCL	0.31	3
10	Haryana	DHBVNL	0.54	13
11		UHBVNL	0.41	7
12	Jharkhand	JBVNL	0.32	4
13	Karnataka	BESCOM	0.39	5
14		GESCOM	0.61	17
15		HESCOM	0.63	18
16		MESCOM	0.77	26
17		CHESCOM	0.71	25
18	Madhya Pradesh	Central	0.55	14
19		East	0.83	31
20		West	0.55	15
21	Maharashtra	MSEDCL	0.65	21
22	Punjab	PSPCL	0.99	33
23	Rajasthan	AVVNL	0.91	32
24		JVVNL	0.79	27
25		JDVVNL	0.55	16
26	Telangana	TSSPDCL	0.47	10
27		TSNPDCL	0.80	29
28	West Bengal	WBSEDCL	0.70	24
29	Uttar Pradesh	DVVNL	0.44	9
30		MVVNL	0.68	23
31		PVVNL	0.31	2
32		PuVVNL	0.51	11
33		KESCO	0.64	20

Recommendations:

O&M expenses consists of Employee cost, Administrative & General expenses and Repair & Maintenance expenses for which specific provisions for determination of their norms have been prescribed under regulation 25.1, 25.2 and 25.3 of the UPERC MYDT Regulations, 2014. In terms of Regulation 25 (a) of the UPERC MYDT Regulations, 2014, the norms for Employee cost and A&G expenses have been prescribed for all the state owned Discoms considering them as a similar class. For R&M expenses, the norms have been prescribed distinctly for each specific Discom.

ii. O&M Expenses per unit of Energy Input

O&M expenses per unit of energy input is the ratio of the total O&M expenses incurred to the total units of energy wheeled into Discom Periphery at the distribution level.

Data Consideration:

The best source of data of O&M expenses considered for this parameter is Audited Accounts of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petitions filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the energy input are taken from the Audited Accounts. In case, the energy input is not captured in the Audited Accounts, then True-up petitions are considered as the best source to capture energy input of the relevant year.

Current Position of PVVNL:

Current Position of PVVNL is 3 with the expense of Rs. 0.25/kWh in the list of 33. The list is headed by DGVCL of Gujarat with Rs. 0.21/kWh.

Table 20: O&M Expenses per unit of Energy Input

S. No.	State	Discom	O&M per Input Energy	Rank of O&M per Input Energy
1	Andhra Pradesh	APEPDCL	0.74	32
2		APSPDCL	0.71	31
3	Bihar	NBPDCL	0.48	18
4		SBPDCL	0.35	9
5	Chhattisgarh	CSPDCL	0.51	21
6	Gujarat	DGVCL	0.21	1
7		MGVCL	0.46	16
8		PGVCL	0.30	6
9		UGVCL	0.28	4
10	Haryana	DHVBN	0.41	12
11		UHVBN	0.33	8
12	Jharkhand	JBVNL	0.24	2
13	Karnataka	BESCOM	0.33	7
14		GESCOM	0.49	19
15		HESCOM	0.53	22
16		MESCOM	0.69	29
17		CHESCOM	0.61	26

S. No.	State	Discom	O&M per Input Energy	Rank of O&M per Input Energy
18	Madhya Pradesh	Central	0.41	11
19		East	0.65	27
20		West	0.45	15
21	Maharashtra	MSEDCL	0.56	25
22	Punjab	PSPCL	0.84	33
23	Rajasthan	AVVNL	0.68	28
24		JVVNL	0.55	24
25		JdVVNL	0.42	13
26	Telangana	TSSPDCL	0.42	14
27		TSNPDCL	0.70	30
28	West Bengal	WBSEDCL	0.51	20
29	Uttar Pradesh	DVVNL	0.28	5
30		MVVNL	0.53	23
31		PVVNL	0.25	3
32		PuVVNL	0.39	10
33		KESCO	0.48	17

Recommendations:

O&M expenses per unit of energy input is a more reasonable parameter than O&M expenses per unit of energy sales as the latter does not reflect the inefficiency on the account of Distribution losses. However, as the determination of norms of the various constituents of the O&M expenses has been prescribed separately under regulation 25.1, 25.2 and 25.3 of the UPERC MYDT Regulations, 2014; the instant parameter of O&M expenses per unit of energy input is only being used for comparison and benchmarking purpose.

iii. Employees Cost per unit of Energy Sales

Employee Cost includes the expenses incurred on the account of salaries, wages, staff welfare expenses, gratuity, retirement benefits, provident fund etc. which are payable by Employer (Discom) to the Employees. Employee cost per unit of energy sales is the ratio of the total employee cost incurred to the total energy sales achieved by the Discom.

Clause 25.1 of the UPERC MYDT Regulations, 2014 deals with the provisions in respect of Employee costs and is reproduced below:

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:

EMPn= (EMPb * CPI inflation) + 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 (CPI) for immediately preceding three financial years.

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

Thus, the UPERC MYDT Regulations, 2014 provides for determination of the Employee cost norm, which would evidently be done pursuant to this benchmarking study. The Consumer Price Index (CPI) is published on monthly basis by the Labour Bureau, Govt. of India and the average increase in the CPI for the immediately preceding three financial years shall be applicable for computing the allowable Employee costs for each year of the control period. The 'Provision' shall be applicable for all un-controllable expenses such as terminal benefits pursuant to adoption of actuarial valuation, implications of pay commission, arrears, Interim Relief etc.

Data Consideration:

The best source of data of Employee costs considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the energy sales are taken from the Audited Accounts. In case, the sales are not captured in the Audited Accounts, then True-up petitions are considered as the source to capture energy sales of the relevant year. We have considered the net Employee costs after netting of the Employee costs which have been capitalized (charged to Gross Fixed Asset) in order to normalize the data-set across all sample Discoms.

Current Position of PVVNL:

Current Position of PVVNL is 1 with the expense Rs. 0.10/kWh in the list of 33. The list is followed by DVVNL with Rs. 0.13/kWh.

Table 21: Employee Cost per unit of Energy Sales

S. No.	State	Discom	Sales (MU)	Employee cost (Rs. Cr)	Employee Cost Per Unit Sales	Rank of Employee Cost per Unit Sales
1	Andhra Pradesh	APEPDCL	13,812	972	0.70	31
2		APSPDCL	26,361	1,813	0.69	30
3	Bihar	NBPDCL	6,480	172	0.27	7
4		SBPDCL	5,574	258	0.46	19
5	Chhattisgarh	CSPDCL	17,102	871	0.51	24
6	Gujarat	DGVCL	15,572	268	0.17	3
7		MGVCL	8,295	321	0.39	14
8		PGVCL	19,958	578	0.29	9
9		UGVCL	16,412	364	0.22	6
10	Haryana	DHVBN	18,496	891	0.48	21
11		UHVBN	15,626	513	0.33	10
12	Jharkhand	JBVNL	8,246	172	0.21	4
13	Karnataka	BESCOM	24,436	802	0.33	11
14		GESCOM	6,132	276	0.45	16
15		HESCOM	9,208	455	0.49	22
16		MESCOM	4,146	226	0.55	25
17		CHESCOM	5,240	294	0.56	26
18	Madhya Pradesh	Central	13,350	607	0.45	18
19		East	12,613	824	0.65	28
20		West	17,805	753	0.42	15
21	Maharashtra	MSEDCL	94,805	4,551	0.48	20
22	Punjab	PSPCL	40,403	3,570	0.88	33
23	Rajasthan	AVVNL	12,899	1,004	0.78	32
24		JVVNL	17,494	1,194	0.68	29
25		JDVVNL	15,845	720	0.45	17
26	Telangana	TSSPDCL	29,118	1,029	0.35	12
27		TSNPDCL	11,105	725	0.65	27
28	West Bengal	WBSEDCL	22,700	1,139	0.50	23
29	Uttar Pradesh	DVVNL	12,248	162	0.13	2
30		MVVNL	11,665	314	0.27	8
31		PVVNL	20,845	214	0.10	1
32		PuVVNL	13,893	290	0.21	5

S. No.	State	Discom	Sales (MU)	Employee cost (Rs. Cr)	Employee Cost Per Unit Sales	Rank of Employee Cost per Unit Sales
33		KESCO	2,582	98	0.38	13

Recommendations:

The ranks achieved by all the Uttar Pradesh Discoms including PVVNL are delusive as the lower Employee cost per unit of energy sales is contrasted by lower efficiency scores in respect of operational performance, commercial performance, financial performance and customer service. In view thereof, the lower Employee cost per unit of energy sale reflects under-staffing. This is further corroborated by the submissions of the PVVNL in the MYT Tariff Petition wherein it has furnished the details of the working strength of the employees versus the sanctioned strength of the employees at Tariff Form F32. The submissions of PVVNL in Form F32 depict that the actual deployment of staff is hardly 59% against the sanctioned employee strength, there by depicting that it is acutely under-staffed. The shortage is even more pronounced in respect of technical staff as compared to non-technical staff, which is reflective of both lower Employee cost per unit of energy sales as well as lower efficiency scores.

In view of the above, it is proposed to consider the value of statistical mean/median for determination of the Employee cost norm. Statistical mean[5] of the Employee costs per unit of energy sales of the sample Discoms for FY 2014-15 computes to be Rs.0.44/kWh and the Statistical median[6] of the Employee costs per unit of energy sales computes to be Rs. 0.45/kWh. The lower of the above two statistical averages i.e. Rs. 0.44/kWh is considered as the optimal Employee cost norm for FY 2014-15. Further to arrive at the employee cost for the 'n' year i.e. FY 2016-17, the Employee cost norm for FY 2014-15 is escalated by the average increase in the CPI for the immediately preceding three financial years. The Employee cost norm for FY 2016-17 is computed to be Rs. 0.51/kWh of energy sales as depicted in the table below:

Table 22: Employee Cost norm for FY 2016-17

Year	CPI*	Employee Cost per unit Sales (Rs./kWh)
2014-15		0.44
2015-16	5.6%	0.46

[5] Statistical mean being a measure of central tendency is reflective of the number where the data seem to cluster around.

[6] A median is the middle score for a set of data that has been arranged in order of magnitude. The median is used to attenuate the influence of the outliers and skewed data.

Year	CPI*	Employee Cost per unit Sales (Rs./kWh)
2016-17	4.1%	0.48

*Inflation index considered based on the UPERC letter UPERC/Secy/D(Tariff)/17-288 dated 15th May

iv. Employee Cost per 1000 consumers

Employee Cost 1000 consumers are the expense interpretations, which are computed for determination of norms as per the UPERC MYDT Regulations 2014. It is referred as the ratio of total Employee Cost to the number of consumers (in the multiples of 1000)

Data Consideration:

The data pertaining to UP Discoms are taken from the Audited Accounts of FY 2014-15 for determination of norms for each UP state owned Discom.

Norm Setting:

Table 23: Employee Cost norm for PVVNL

Discom	Year	CPI	Employee Cost per unit Sales (Rs./kWh)	Employee Cost per 1000 consumers (Rs. Crs)	Employees/1000 Consumers
PVVNL	2014-15		0.44	0.21	1.35
	2015-16	5.6%	0.46	0.22	
	2016-17	4.1%	0.48	0.23	

v. A&G Expenses per Unit of Energy Sales

Administrative and General (A&G) expenses refers to expenditures related to the day-to-day operations of a business. These expenses include particulars like office expenses, utility charges, security, travel and communication, legal, insurance, audit expenses and expenses for day to day administration of the Discom. A&G expenses are considered as controllable in nature.

Clause 25.3 of the UPERC MYDT Regulations, 2014 deals with the provisions in respect of A&G expenses and is reproduced below:

> A&G expense shall be computed as per the norm escalated by wholesale price index (WPI) and adjusted by provisions for confirmed initiatives (IT etc. initiatives as proposed by the Distribution Licensee and validated by the Commission) or other expected one-time expenses, and shall be governed by following formula:
>
> $A\&G_n = (A\&G_b * WPI\ inflation) + Provision$
>
> Where:
>
> $A\&G_n$: A&G expense for the year n
>
> $A\&G_b$: A&G expense as per the norm
>
> WPI inflation: is the average increase in the Wholesale Price Index (WPI) for immediately preceding three financial years
>
> Provision: Cost for initiatives or other one-time expenses as proposed by the Distribution Licensee and validated by the Commission.

Thus, the UPERC MYDT Regulations, 2014 provides for determination of the A&G expenses norm, which would evidently be done pursuant to this benchmarking study. The Wholesale Price Index (WPI) is published on weekly basis by the Office of Economic Advisor, Govt. of India and the average increase in the WPI for the immediately preceding three financial years shall be applicable for computing the allowable A&G expense for each year of the control period. The 'Provision' shall be applicable for initiative and one-time expenses as validated and approved by the Hon'ble Commission etc.

Data Consideration:

The best source of data of A&G expenses considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the energy sales are taken from the Audited Accounts. In case, the sales are not captured in the Audited Accounts, then True-up petitions are considered as the best source to capture energy sales of the year. We have considered the net A&G expenses after netting of the A&G

expenses which have been capitalized (charged to Gross Fixed Asset) in order to normalize the data-set across all sample Discoms.

Current Positioning of PVVNL:

Current position of PVVNL is 18 with the expense of Rs. 0.06/kWh in the list of 33. TSSPDCL stands in first position with Rs. 0.03/kWh of A&G Expenses.

Table 24: A&G Expenses per unit of Energy Sales

S. No.	State	Discom	Sales (MU)	A&G Expenses (Rs. Cr)	A&G Expenses per Unit Sales	Rank of A&G Expenses per Unit Sales
1	Andhra Pradesh	APEPDCL	13,812	71	0.05	14
2		APSPDCL	26,361	110	0.04	7
3	Bihar	NBPDCL	6,480	49	0.08	24
4		SBPDCL	5,574	47	0.09	28
5	Chhattisgarh	CSPDCL	17,102	121	0.07	22
6	Gujarat	DGVCL	15,572	61	0.04	5
7		MGVCL	8,295	65	0.08	26
8		PGVCL	19,958	107	0.05	15
9		UGVCL	16,412	65	0.04	6
10	Haryana	DHBVNL	18,496	72	0.04	4
11		UHBVNL	15,626	77	0.05	12
12	Jharkhand	JSEB/JBVNL	8,246	38	0.05	9
13	Karnataka	BESCOM	24,436	86	0.04	3
14		GESCOM	6,132	63	0.10	30
15		HESCOM	9,208	77	0.08	27
16		MESCOM	4,146	60	0.14	32
17		CHESCOM	5,240	40	0.08	25
18	Madhya Pradesh	Central	13,350	90	0.07	19
19		East	12,613	152	0.12	31
20		West	17,805	124	0.07	21
21	Maharashtra	MSEDCL	94,805	703	0.07	23
22	Punjab	PSPCL	40,403	176	0.04	8
23	Rajasthan	AVVNL	12,899	73	0.06	17
24		JVVNL	17,494	87	0.05	13
25		JDVVNL	15,845	55	0.03	2
26	Telangana	TSSPDCL	29,118	88	0.03	1

S. No.	State	Discom	Sales (MU)	A&G Expenses (Rs. Cr)	A&G Expenses per Unit Sales	Rank of A&G Expenses per Unit Sales
27		TSNPDCL	11,105	52	0.05	10
28	West Bengal	WBSEDCL	22,700	158	0.07	20
29	Uttar Pradesh	DVVNL	12,248	60	0.05	11
30		MVVNL	11,665	201	0.17	33
31		PVVNL	20,845	119	0.06	18
32		PuVVNL	13,893	77	0.06	16
33		KESCO	2,582	22	0.09	29

Recommendations:

It is proposed to consider the value of statistical mean/median of the A&G expenses of the sample Discoms for determination of the A&G expenses norm. Statistical mean of the A&G expenses per unit of energy sales of the sample Discoms for FY 2014-15 computes to be Rs.0.07/kWh and the Statistical median of the A&G expenses per unit of energy sales computes to be Rs. 0.06/kWh. PVVNL's A&G expenses are near to the statistical median of A&G expenses of sample Discoms in the country. The lower of the above two statistical averages i.e. Rs. 0.06/kWh is considered as the optimal A&G expenses norm for FY 2014-15. Further, to arrive at the A&G expense for the 'n' year i.e. FY 2016-17, the A&G expenses norm for FY 2014-15 is escalated by the average increase in the WPI for the immediately preceding three financial years. The A&G expenses norm for FY 2016-17 is computed to be Rs. 0.06/kWh of energy sales as depicted in the table below:

Table 25: A&G Expenses norm for FY 2016-17

Year	WPI*	A&G Expenses per unit Sales (Rs./kWh)
2014-15		0.06
2015-16	-3.65%	0.06
2016-17	1.75%	0.06

*Inflation index considered based on the UPERC letter UPERC/Secy/D(Tariff)/17-288 dated 15th May

vi. A&G Expenses per Personnel and 1000 consumer

A&G expense per personnel and 1000 consumers are the expense interpretations, which are computed for determination of norms as per the UPERC MYDT Regulations 2014. It is referred as the ratio of total A&G expenses to the total number of employees and other is the ratio of total A&G expenses to number of consumers (in the multiples of 1000).

Data Consideration:

The data pertaining to UP Discoms are taken from the Audited Accounts of FY 2014-15 for determination of norms for each UP state owned Discom.

Norm Setting:

Table 26: A&G Expense norm for PVVNL

Discom	Year	WPI	A&G Expenses per unit Sales (Rs./kWh)	A&G Cost per Employee/personnel (Rs. Cr)	A&G Cost per ('000) Consumers
PVVNL	2014-15		0.06	0.02	0.03
	2015-16	-3.65%	0.06	0.02	0.03
	2016-17	1.75%	0.06	0.02	0.03

vii. R&M Expenses per Unit of Energy Sales

Repair and Maintenance expense (R&M) shall include expenses like repair and maintenance of substations, transformers, conductors etc. of the Discom.

Data Consideration:

The best source of data of R&M expenses considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the energy sales are taken from the Audited Accounts. In case, the energy sales are not captured in the Audited Accounts, then True-up petitions are considered as the best source to capture energy sales of the year.

Current Positioning of PVVNL:

Current position of PVVNL is 29 with the expense of Rs. 0.15/kWh in the list of 33. The list is headed by DHBVNL (Haryana) with expense of only Rs. 0.02/kWh.

Table 27: R&M Expenses per unit of Energy Sales

S. No.	State	Discom	Sales (MU)	R&M Expenses (Rs. Cr)	R&M expenses per Unit Sales	Rank of R&M Expenses per unit Sales
1	Andhra Pradesh	APEPDCL	13,812.37	66.82	0.05	6
2		APSPDCL	26,361.00	178.84	0.07	18
3	Bihar	NBPDCL	6,479.82	59.85	0.09	25
4		SBPDCL	5,574.06	47.12	0.08	23
5	Chhattisgarh	CSPDCL	17,102.00	123.65	0.07	20
6	Gujarat	DGVCL	15,572.00	39.11	0.03	3
7		MGVCL	8,295.00	51.53	0.06	15
8		PGVCL	19,958.00	106.06	0.05	10
9		UGVCL	16,411.75	82.01	0.05	7
10	Haryana	DHBVNL	18,496.05	39.44	0.02	1
11		UHBVNL	15,626.00	55.69	0.04	5
12	Jharkhand	JBVNL	8,245.68	53.68	0.07	17
13	Karnataka	BESCOM	24,436.08	54.94	0.02	2
14		GESCOM	6,131.71	34.43	0.06	12
15		HESCOM	9,208.31	48.86	0.05	9
16		MESCOM	4,146.37	34.94	0.08	22
17		CHESCOM	5,240.07	37.56	0.07	19
18	Madhya Pradesh	Central	13,350.00	33.59	0.03	4
19		East	12,613.00	65.99	0.05	8
20		West	17,805.00	99.24	0.06	11
21	Maharashtra	MSEDCL	94,805.00	903.39	0.10	26
22	Punjab	PSPCL	40,403.00	246.34	0.06	14
23	Rajasthan	AVVNL	12,899.39	101.43	0.08	21
24		JVVNL	17,493.84	100.10	0.06	13
25		JDVVNL	15,844.61	101.25	0.06	16
26	Telangana	TSSPDCL	29,118.33	258.81	0.09	24
27		TSNPDCL	11,104.79	113.68	0.10	27
28	West Bengal	WBSEDCL	22,700.32	289.83	0.13	28
29	Uttar Pradesh	DVVNL	12,248.48	59.53	0.26	33
30		MVVNL	11,665.40	284.02	0.24	31
31		PVVNL	20,845.35	306.96	0.15	29
32		PuVVNL	13,893.33	343.30	0.25	32
33		KESCO	2,582.04	46.00	0.18	30

Recommendations:

The high R&M expense per unit of sales is reflective of the poor quality of the distribution network. R&M expenses, being controllable in nature, can be reduced by regular and proper maintenance of the distribution infrastructure. Discom may design a strategy for improvement of electrical infrastructure by adopting a two-pronged approach (i) preventive maintenance (ii) replacement of old and ineffective physical assets with new infrastructure. Such an approach would not only reduce the R&M expenses, but will also reduce technical losses.

viii. R&M Expenses as % of Gross Fixed Asset (GFA)

R&M expenses as a percentage of GFA is calculated by dividing the total R&M expenses with GFA balance of the relevant year.

Clause 25.2 of the UPERC MYDT Regulations, 2014 deals with the provisions in respect of R&M expenses and is reproduced below:

> Repairs and Maintenance expense shall be calculated as percentage (as per the norm defined) of Average Gross Fixed Assets for the year governed by following formula:
>
> $R\&M_n = K_b * GFA_n$
>
> Where:
>
> $R\&M_n$: Repairs & Maintenance expense for n^{th} year
>
> GFA_n: Average Gross Fixed Assets for n^{th} year
>
> K_b: Percentage point as per the norm.

Thus, the UPERC MYDT Regulations, 2014 provides for determination of the R&M expenses norm, which would evidently be done pursuant to this benchmarking study. It is pointed out that the regulation 25.2 of the UPERC MYDT Regulations, 2014 has inadvertently missed out to provide for the annual escalation factor even though the regulation 25 (g) of the UPERC MYDT Regulations, 2014 provided for the annual escalation of O&M expenses on the account of Inflation as below:

> 25 Operation and Maintenance Expenses
>
> (g) The norms shall be determined at constant prices of base year and escalation on account of inflation shall be over and above the baseline.

Data Consideration:

The best source of data of R&M expenses considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the GFA balance are taken from the Audited Accounts and True-up Petitions filed by the Discoms with the respective State Electricity Regulatory Commissions. Closing GFA of all the Discoms for FY 2014-15 is considered, for consistency.

Current Positioning of PVVNL:

Current position of PVVNL is 29 with the expense 4% of GFA in the list of 33. The list is headed Central Discom of Madhya Pradesh with only 0.5%.

Table 28: R&M Expenses as % of GFA

S. No.	State	Discom	Gross Fixed Asset (Rs. Cr)	R&M Expenses (Rs. Cr)	R&M Expenses as % GFA	Rank of R&M Expenses as % of GFA
1	Andhra Pradesh	APEPDCL	4,352	67	1.5%	19
2		APSPDCL	9,582	179	1.9%	22
3	Bihar	NBPDCL	4,299	60	1.4%	15
4		SBPDCL	4,282	47	1.1%	9
5	Chhattisgarh	CSPDCL	5,229	124	2.4%	26
6	Gujarat	DGVCL	3,992	39	1.0%	6
7		MGVCL	3,681	52	1.4%	17
8		PGVCL	10,311	106	1.0%	7
9		UGVCL	4,578	82	1.8%	20
10	Haryana	DHBVNL	6,233	39	0.6%	2
11		UHBVNL	5,920	56	0.9%	5
12	Jharkhand	JBVNL	4,235	54	1.3%	12
13	Karnataka	BESCOM	7,079	55	0.8%	4
14		GESCOM	2,611	34	1.3%	14
15		HESCOM	3,362	49	1.5%	18
16		MESCOM	1,871	35	1.9%	23
17		CHESCOM	2,018	38	1.9%	21
18	Madhya Pradesh	Central	6,569	34	0.5%	1
19		East	6,059	66	1.1%	8
20		West	4,881	99	2.0%	24
21	Maharashtra	MSEDCL	41,927	903	2.2%	25

S. No.	State	Discom	Gross Fixed Asset (Rs. Cr)	R&M Expenses (Rs. Cr)	R&M Expenses as % GFA	Rank of R&M Expenses as % of GFA
22	Punjab	PSPCL	19,285	246	1.3%	13
23	Rajasthan	AVVNL	9,122	101	1.1%	10
24		JVVNL	13,196	100	0.8%	3
25		JDVVNL	8,975	101	1.1%	11
26	Telangana	TSSPDCL	7,806	259	3.3%	28
27		TSNPDCL	4,275	114	2.7%	27
28	West Bengal	WBSEDCL	20,739	290	1.4%	16
29	Uttar Pradesh	DVVNL	6,006	60	5.3%	30
30		MVVNL	5,053	284	5.6%	32
31		PVVNL	7,620	307	4.0%	29
32		PuVVNL	6,459	343	5.3%	31
33		KESCO	636	46	7.2%	33

Recommendations:

The high R&M expense per % of GFA is reflective of the cost inefficiency of the distribution network. R&M expenses, being controllable in nature, can be reduced by regular and proper maintenance of the distribution infrastructure. Discom may design a strategy for improvement of electrical infrastructure by adopting a two-pronged approach (i) preventive maintenance (ii) replacement of old and ineffective physical assets with new infrastructure. Such an approach would not only reduce the R&M expenses, but will also reduce technical losses.

Curtailment of normative R&M expenses would have a crippling effect on quality of supply and consumer service. In view of the same, the R&M expense norm as % of GFA i.e. K_b may be determined as 4.24% (as per the norms determined by the Hon'ble Commission in UPERC MYDT Regulations as the 'average GFA').

The annual escalation owing to inflation has been provided in respect of Employee cost and A&G expense in terms of regulation 25.1 and 25.3 of the UPERC MYDT Regulations, 2014. The CPI inflation is applicable in case of Employee cost and WPI inflation is applicable in case of A&G expense. However, the provision for annual inflation in respect of R&M expense is inadvertently left-out in the regulation 25.2. In view of the same, it is proposed that the average increase in the WPI and CPI inflation in the ratio of 60:40 for the immediately preceding three financial years may be considered for computing the R&M expense for any relevant year.

Table 29: R&M Norms for PVVNL

Year	WPI	CPI	Ka	PVVNL
2014-15	0.00%	0.00%	0.00%	4.24%
2015-16	-3.65%	5.65%	0.07%	4.24%
2016-17	1.75%	4.12%	2.70%	4.36%

C. Financial Performance

i. Average Cost of Supply (ACS)

Average cost of supply is the aggregate value of all the costs incurred per unit of energy sales. It is determined by dividing the Aggregate Revenue Requirement with the total number of energy sales.

Data Consideration:

The best source of data for this parameter is the Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016.

Current Positioning of PVVNL:

Current Position of PVVNL is 20 with ACS of Rs. 5.19/kWh in the list of 33. This list is headed by PGVCL of Gujarat with ACS of Rs. 3.78/kWh.

Table 30: Average Cost of Supply

S. No.	State	Utility	ACS (Rs./kWh)	Rank
1	Andhra Pradesh	APEPDCL	5.66	27
2		APSPDCL	5.49	24
3	Bihar	NBPDCL	5.11	17
4		SBPDCL	4.79	11
5	Chhattisgarh	CSPDCL	4.15	4
6	Gujarat	DGVCL	5.20	21
7		MGVCL	4.90	13
8		PGVCL	3.78	1
9		UGVCL	4.06	2
10	Haryana	DHBVNL	4.90	13
11		UHBVNL	5.41	23
12	Jharkhand	JBVNL	4.68	9
13	Karnataka	BESCOM	4.60	8
14		GESCOM	4.33	5
15		HESCOM	4.38	7
16		MESCOM	4.73	10
17		CHESCOM	4.14	3
18	Madhya Pradesh	Central	5.03	16
19		East	5.13	18
20		West	4.34	6

S. No.	State	Utility	ACS (Rs./kWh)	Rank
21	Maharashtra	MSEDCL	5.15	19
22	Punjab	PSPCL	4.89	12
23	Rajasthan	AWNL	6.41	33
24		JWNL	5.84	29
25		JDWNL	5.93	30
26	Telangana	TSSPDCL	5.23	22
27		TSNPDCL	5.58	26
28	West Bengal	WBSEDCL	4.92	15
29	Uttar Pradesh	DVVNL	6.13	32
30		MVVNL	5.49	24
31		PVVNL	5.19	20
32		PVVNL	5.82	28
33		KESCO	6.03	31

Observations:

The lowest ACS among the UP Discoms is that of PVVNL and the highest is that of DVVNL.

Power purchase cost accounts for around 80% of the ARR of a Discom. States like Uttar Pradesh, which are situated in the hinterland, incur a significant cost in respect of transportation of coal which has an impact on the power generation cost of the state Genco plants as well as IPPs situated in the State. Thus, ACS of States like Uttar Pradesh would naturally be higher as compared to coal producing states like Chhattisgarh, Odisha, Jharkhand and Coastal states such as Gujarat, which has a lot of imported coal based plants. However, the Discoms can rationalize their power purchase cost by procurement of power through competitive bid route instead of MoU route, appropriate thermal – hydro mix (Hydro and Gas based plants can provide peaking power), power purchase optimization through exchange and banking etc.

High distribution losses of UP Discoms which are in the range of 20% - 32% is a major inefficiency being loaded on the ACS. The ACS of UP Discoms can be optimized by reduction in the T&D losses. The other aspects of ARR such as depreciation, returns, O&M expenses, interest on loan are mostly uncontrollable in nature and provide little scope for rationalization.

ii. Average Power Purchase Cost (APPC)

Average Power Purchase Cost (APPC) is the average price at which the distribution licensee has purchased electricity in the relevant year from all the sources of power. The power purchase from traders, short-term purchases and purchases from renewable sources are also considered while

determining Average Power Purchase Cost. APPC is the ratio of the total power purchase costs to the total number of units purchased.

Data Consideration:

The best source of data for power purchase cost considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the quantum of energy purchased are taken from the Audited Accounts.

Current Positioning of PVVNL:

Current Position of PVVNL is 30 with APPC of Rs. 4.65/kWh in the list of 33. The list is headed by GESCOM of Karnataka with APPC of Rs. 3.24/kWh.

Table 31: Average Power Purchase Cost

S. No.	State	Discoms	Power Purchase (MU)	Power Purchase Cost (Rs. Cr)	APPC (Rs./APPC)	Rank
1	Andhra Pradesh	APEPDCL	15,341	6,835	4.46	25
2		APSPDCL	29,666	12,995	4.38	23
3	Bihar	NBPDCL	7,553	3,491	4.62	27
4		SBPDCL	11,178	4,707	4.21	18
5	Chhattisgarh	CSPDCL	24,006	7,806	3.25	2
6	Gujarat	DGVCL	20,559	10,078	4.90	33
7		MGVCL	10,135	4,246	4.19	17
8		PGVCL	30,647	10,101	3.30	4
9		UGVCL	19,142	7,292	3.81	9
10	Haryana	DHVBN	28,619	12,358	4.32	20
11		UHVBN	22,489	9,832	4.37	22
12	Jharkhand	JBVNL	11,105	4,776	4.30	19
13	Karnataka	BESCOM	29,423	11,685	3.97	11
14		GESCOM	7,564	2,452	3.24	1
15		HESCOM	11,513	3,786	3.29	3
16		MESCOM	4,839	1,658	3.43	5
17		CHESCOM	6,299	2,163	3.43	6
18	Madhya Pradesh	Central	18,426	6,874	3.73	7
19		East	16,106	6,638	4.12	16

S. No.	State	Discoms	Power Purchase (MU)	Power Purchase Cost (Rs. Cr)	APPC (Rs./APPC)	Rank
20		West	21,626	8,093	3.74	8
21	Maharashtra	MSEDCL	112,565	49,088	4.36	21
22	Punjab	PSPCL	47,640	18,814	3.95	10
23	Rajasthan	AVVNL	18,518	7,606	4.11	15
24		JVVNL	26,879	10,756	4.00	12
25		JdVVNL	22,355	9,023	4.04	13
26	Telangana	TSSPDCL	33,885	14,925	4.40	24
27		TSNPDCL	13,304	5,984	4.50	26
28	West Bengal	WBSEDCL	37,813	15,529	4.11	14
29	Uttar Pradesh	DVVNL	19,129	8,907	4.66	31
30		MVVNL	15,126	7,027	4.65	28
31		PVVNL	25,945	12,065	4.65	30
32		PuVVNL	18,224	8,607	4.72	32
33		KESCO	3,501	1,628	4.65	29

Observations:

Uttar Pradesh, being situated in the hinterland, incurs a significant cost in respect of transportation of coal which has an impact on the power generation cost of the state Genco plants as well as the IPPs situated in the State. Thus, APPC of States like Uttar Pradesh would naturally be higher as compared to coal producing states like Chhattisgarh, Odisha, Jharkhand and Coastal states such as Gujarat, which has a lot of imported coal based plants. However, the Discoms can rationalize their power purchase cost by procurement of power through competitive bid route instead of MoU route, appropriate thermal–hydro mix (Hydro and Gas based plants can provide peaking power), power purchase optimization through exchange and banking etc.

UP had made two attempts for procurement of power under Case-I route in the year 2007 and 2009 respectively. However, due to various reasons, it couldn't tie up any power under the said bid process and had to annul the bid. Finally, in the year 2012, UP went for another Case-I bid for procurement of 6000MW of power. However, it could tie-up only 2575 MW of power against the requisitioned capacity of 6000 MW. Additionally, it is also noteworthy to mention that UP lost most of its hydro power plants totaling a capacity of 966.45 MW (plus 724 MW of projects under construction) to Uttarakhand pursuant to the State reorganization in the year 2001.

It is suggested that UP Discoms may implement an Energy/Load Management and Cost Optimization system and build a time block wise demand-supply model to strategize on the power procurement at

competitive prices. UP Discoms should also develop standard operating procedures for load management, bidding for bilateral contracts and determination of quantum and rate of bid to be filed in the power exchanges.

iii. Average Cost of Supply (ACS) – Average Revenue Realized (ARR) Gap

Average Revenue Realized is the revenue generated by the sale of each unit of electricity, which is computed by dividing the total revenue earned by the Discom with total sales billed. The parameter of ACS and ARR gap will give the positioning of Discom in terms of likely profitability for every unit sold. This Gap is a function of commercial performance of the Discom

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016 and the True-up Petitions filed by the Discoms with the respective State Electricity Regulatory Commissions for FY 2014-15.

Current Positioning of PVVNL:

Current Position of PVVNL is 19 with loss of Rs. 0.73/kWh in the list of 33. The list is headed by MGVCL of Gujarat with a profit of Rs. 0.19 per unit sold.

Table 32: Details of ACS - ARR Gap

S.No.	State	Utility	Gap (Rs./kWh)	Rank
1	Andhra Pradesh	APEPDCL	0.60	16
2		APSPDCL	0.84	22
3	Bihar	NBPDCL	0.88	24
4		SBPDCL	0.68	18
5	Chhattisgarh	CSPDCL	0.88	24
6	Gujarat	DGVCL	(0.05)	3
7		MGVCL	(0.19)	1
8		PGVCL	(0.01)	4
9		UGVCL	(0.13)	2
10	Haryana	DHBVNL	0.34	14
11		UHBVNL	0.77	20
12	Jharkhand	JBVNL	0.66	17
13	Karnataka	BESCOM	0.11	7
14		GESCOM	0.26	11
15		HESCOM	0.12	8
16		MESCOM	0.17	10

S.No.	State	Utility	Gap (Rs./kWh)	Rank
17		CHESCOM	0.04	5
18	Madhya Pradesh	Central	1.54	27
19		East	0.85	23
20		West	0.59	15
21	Maharashtra	MSEDCL	0.30	12
22	Punjab	PSPCL	0.32	13
23	Rajasthan	AVVNL	2.04	33
24		JVVNL	1.83	30
25		JDVVNL	1.98	32
26	Telangana	TSSPDCL	0.09	6
27		TSNPDCL	1.40	26
28	West Bengal	WBSEDCL	0.12	8
29	Uttar Pradesh	DVVNL	1.93	31
30		MVVNL	1.80	29
31		PVVNL	0.73	19
32		PuVVNL	1.79	28
33		KESCO	0.82	21

Recommendations:

PuVVNL is having one of the highest ACS-ARR gap in the country and requires urgent intervention. ACS-ARR Gap being the controllable parameter can be reduced by monitoring and controlling the theft of electricity, timely filing of tariff petitions & tariff revision, reducing the costs, increasing the revenue realization. Discoms need to act swiftly and effectively in maximizing the revenue for the electricity billed by adopting practices like measures for pass through of fluctuating power purchase cost by adopting FPPCA and FAC pass through practice, customer awareness, strict enforcement of law to recover the revenue, increasing the customer satisfaction etc. Discom may also design strategies to provide electricity to the low paying consumers and agricultural consumers at lower costs. DDGs and Solar Pump-sets are proved efficient to fulfil the universal service obligation and at the same time reduce the costs of service.

iv. APPC to ACS Ratio

The ratio of APPC to ACS of a Discom will help in identifying the quantum (share) of un-controllable costs of a Discom in terms of power purchase cost.

Data Consideration:

The source of data for this ACS is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY 2014-15 published in June 2016. The best source of data of Power Purchase Cost considered for this parameter is Audited Accounts of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions. Details of the quantum of energy purchase are taken from the Audited Accounts.

Current Positioning of PVVNL:

Current Position of PVVNL is 5 with the ratio of 90% in the list of 33. The list is headed by DGVCL with 94%.

Table 33: Ratio of APPC to ACS

S. No.	State	Utility	ACS (Rs./kWh)	APPC (Rs./kWh)	Ratio of APPC to ACS	Rank
1	Andhra Pradesh	APEPDCL	5.66	4.46	79%	23
2		APSPDCL	5.49	4.38	80%	22
3	Bihar	NBPDCL	5.11	4.62	90%	4
4		SBPDCL	4.79	4.21	88%	7
5	Chhattisgarh	CSPDCL	4.15	3.25	78%	24
6	Gujarat	DGVCL	5.20	4.90	94%	1
7		MGVCL	4.90	4.19	86%	11
8		PGVCL	3.78	3.30	87%	8
9		UGVCL	4.06	3.81	94%	2
10	Haryana	DHBVNL	4.90	4.32	88%	6
11		UHBVNL	5.41	4.37	81%	18
12	Jharkhand	JBVNL	4.68	4.30	92%	3
13	Karnataka	BESCOM	4.60	3.97	86%	9
14		GESCOM	4.33	3.24	75%	28
15		HESCOM	4.38	3.29	75%	27
16		MESCOM	4.73	3.43	72%	30
17		CHESCOM	4.14	3.43	83%	16
18	Madhya Pradesh	Central	5.03	3.73	74%	29
19		East	5.13	4.12	80%	21
20		West	4.34	3.74	86%	10
21	Maharashtra	MSEDCL	5.15	4.36	85%	12
22	Punjab	PSPCL	4.89	3.95	81%	19
23	Rajasthan	AVVNL	6.41	4.11	64%	33

S. No.	State	Utility	ACS (Rs./kWh)	APPC (Rs./kWh)	Ratio of APPC to ACS	Rank
24		JVVNL	5.84	4.00	69%	31
25		JDVVNL	5.93	4.04	68%	32
26	Telangana	TSSPDCL	5.23	4.40	84%	14
27		TSNPDCL	5.58	4.50	81%	20
28	West Bengal	WBSEDCL	4.92	4.11	83%	15
29	Uttar Pradesh	DVVNL	6.13	4.66	76%	26
30		MVVNL	5.49	4.65	85%	13
31		PVVNL	5.19	4.65	90%	5
32		PuVVNL	5.82	4.72	81%	17
33		KESCO	6.03	4.65	77%	25

Observations:

PVVNL is having one of the efficient APPC to ACS ratio in the country. However, excessive reliance on this ratio may be misleading as higher proportion of power purchase cost in the ACS reflects inability of the Discom to optimize the ACS and conversely lower proportion of the power purchase cost is reflective of higher T&D losses like in the case of DVVNL and KESCO.

v. Age of Debtors

Age of debtors is the total revenue due to be received by the Discom in terms in the number of days. High age of debtors increases the working capital requirement. It also adds to a risk of turning into bad debts without reasonable efforts. Age of Debtors in Days is computed by equating the pending receivables to total revenue assessment in a year.

$$\boldsymbol{Age\ of\ Debtors\ (Number\ of\ Days) = \frac{Debtors\ for\ sale\ of\ power}{Revenue\ for\ sale\ of\ power} X\ 365}$$

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016. For the Discoms whose data is not available in the PFC report is taken from the Discom's Audited Accounts of FY 2014-15.

Current Positioning of PVVNL:

Current Position of PVVNL is that, the Discom stands in 21st position out of 33 Discoms with Debtor days of 113. This list is topped by PGVCL with 14 days.

Table 34: Details of Age of Debtors

S.No	State	Discom	Revenue from Sale of Power (Acc)	Debtor for sale of Power (Rs. Crores)	Debtor for sale of Power (Days)	Rank
1	Andhra Pradesh	APEPDCL	6742	987	53	11
2		APSPDCL	10924	1341	45	7
3	Bihar	NBPDCL	2095	946	159	25
4		SBPDCL	2540	717	98	17
5	Chhattisgarh	CSPDCL	8370	1802	83	14
6	Gujarat	DGVCL	10553	508	18	2
7		MGVCL	4804	374	28	3
8		PGVCL	10880	414	14	1
9		UGVCL	7617	592	28	3
10	Jharkhand	JBVNL	11170	1046	126	23
11	Haryana	DHBVNL	7335	2141	70	12
12		UHBVNL	2787	1515	75	13
13	Karnataka	BESCOM	13480	4424	120	22
14		GESCOM	3125	1612	188	28
15		HESCOM	4852	1829	140	24
16		MESCOM	2111	574	99	19
17		CHESCOM	2555	2177	497	32
18	Madhya Pradesh	MKVVCL	5228	2629	184	27
19		PoKVVCL	5812	2649	166	26
20		PKVVCL	8268	1635	87	15
21	Maharashtra	MSEDCL	55535	16915	111	20
22	Punjab	PSPCL	16748	2234	49	9
23	Rajasthan	AVVNL	7130	602	30	5
24		JVVNL	9585	1287	47	8
25		JDVVNL	8029	1122	51	10
26	Telangana	TSSPDCL	15497	1737	42	6
27		TSNPDCL	3506	943	98	17
28	Bengal	WBSEDCL	16907	4638	97	16
29	Uttar Pradesh	DVVNL	6115	5333	374	30
30		MVVNL	5950	3878	294	29
31		PVVNL	10231	3037	113	21
32		PuVVNL	6380	8102	553	33
33		KESCO	1679	1794	388	31

Recommendations:

The UP Discoms fare very poorly on the collection efficiency front, with PVVNL being an outlier with 97% of collection efficiency in FY 2014-15. However, owing to the previous year's receivable accumulation, PVVNL has debtor days of 113 days. The debtor days can be reduced by (i) dunning and recovery process (ii) disconnection/ reconnection, (iii) naming and shaming of defaulters, (iv) pre-paid billing using smart meters, (v) credit rating based recovery actions ranging from SMS reminders, call centre reminder, door-step collection, disconnection, legal action.

vi. Age of Creditors

Age of creditors is the total payment due to be paid by the Discom to power producers in terms in the number of days.

$$Age\ of\ Creditors\ (Number\ of\ Days) = \frac{Creditors\ for\ purchas\ of\ power}{Expense\ for\ purchase\ of\ power} X\ 365$$

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016. For the Discoms whose data is not available in the PFC report is taken from the Discom's Audited Accounts of FY 2014-15

Current Positioning of PVVNL:

Current Position of PVVNL is that, the Discom stands in 16th position of 33 Discoms with Creditor days of 90. Gujarat Utilities top the list with almost negligible Creditor days.

Table 35: Details of Age of creditors

S. No	State	Discom	Power Purchase Bill (Rs. Crores)	Creditor for purchase of Power (Rs. Crores)	Creditor for Purchase of Power (Days)	Rank
1	Andhra Pradesh	APEPDCL	6835	1520	81	11
2		APSPDCL	12995	2403	67	10
3	Bihar	NBPDCL	3491	769	88	15
4		SBPDCL	4707	1118	87	14
5	Chhattisgarh	CSPDCL	7806	2982	139	24
6	Gujarat	DGVCL	10078	1	1	1
7		MGVCL	4246	417	36	4
8		PGVCL	10101	4	1	1

S. No	State	Discom	Power Purchase Bill (Rs. Crores)	Creditor for purchase of Power (Rs. Crores)	Creditor for Purchase of Power (Days)	Rank
9		UGVCL	7292	15	1	1
10	Jharkhand	JBVNL	12358	7104	540	33
11	Haryana	DHBVNL	9832	3041	90	16
12		UHBVNL	4776	3156	117	20
13	Karnataka	BESCOM	11685	3231	101	18
14		GESCOM	2452	2326	346	30
15		HESCOM	3786	2263	218	27
16		MESCOM	1658	1391	306	29
17		CHESCOM	2163	2308	389	31
18	Madhya Pradesh	MKVVCL	6874	2950	157	25
19		PoKVVCL	6638	1527	84	13
20		PKVVCL	8093	1326	60	9
21	Maharashtra	MSEDCL	49088	17952	133	22
22	Punjab	PSPCL	18814	1521	45	6
23	Rajasthan	AVVNL	7606	1116	54	8
24		JVVNL	10756	1095	37	5
25		JDVVNL	9023	1259	51	7
26	Telangana	TSSPDCL	14925	5629	138	23
27		TSNPDCL	5984	1841	112	19
28	Bengal	WBSEDCL	15529	5618	132	21
29	Uttar Pradesh	DVVNL	8907	5184	217	26
30		MVVNL	7027	3993	242	28
31		PVVNL	12065	2921	90	16
32		PuVVNL	8607	8851	389	31
33		KESCO	1628	362	83	12

Observations:

The high age of creditors reflects strained financial condition of the UP Discoms, owing to high AT&C losses. The power producers provide a rebate of 2% on timely payment of energy bills, which the UP Discoms are not able to avail. Power producers impose a late payment surcharge incase the energy bills are outstanding for a period of more than 90 days. Thus, payable management also has an impact on optimizing the power procurement cost. The UP Discoms may not be in a position to improve the age of creditors unless it attains the overall efficiency on all key parameters such as T&D

losses, collection efficiency etc. Lower creditor days improves the credit rating of Discoms which has an impact on the cost of lending as well as loading of lower risk premium by various generators when bidding in power procurement tenders in UP.

vii. Average Wheeling Cost

Average wheeling cost per unit is the share of non-power purchase expenses in the total cost of supply per unit. Share of wheeling cost of a Discom will help in identifying the distribution cost associated in delivering the electricity. These costs can be reduced by optimal utilization of resources and minimizing the losses.

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016 and Audited Accounts of Discoms of FY 2014-15. In case Audited Accounts are not available in the public domain, True-up Petition of the Discom filed with the respective State Electricity Regulatory Commissions is considered.

Current Positioning of PVVNL:

Current Position of PVVNL is 6 with the expense of Rs. 0.54/kWh in the list of 33. The list is headed by UGVCL of Gujarat with an expense of Rs. 0.25/kWh.

Table 36: Details of Average Wheeling Cost

S. No.	State	Utility	ACS (Rs./kWh)	Wheeling Cost (Rs./kWh)	Rank
1	Andhra Pradesh	APEPDCL	5.66	1.20	26
2		APSPDCL	5.49	1.11	25
3	Bihar	NBPDCL	5.11	0.49	5
4		SBPDCL	4.79	0.58	7
5	Chhattisgarh	CSPDCL	4.15	0.90	17
6	Gujarat	DGVCL	5.20	0.30	2
7		MGVCL	4.90	0.71	12
8		PGVCL	3.78	0.48	4
9		UGVCL	4.06	0.25	1
10	Haryana	DHBVNL	4.90	0.58	8
11		UHBVNL	5.41	1.04	20
12	Jharkhand	JBVNL	4.68	0.38	3
13	Karnataka	BESCOM	4.60	0.63	10

S. No.	State	Utility	ACS (Rs./kWh)	Wheeling Cost (Rs./kWh)	Rank
14		GESCOM	4.33	1.09	22
15		HESCOM	4.38	1.09	23
16		MESCOM	4.73	1.30	28
17		CHESCOM	4.14	0.71	11
18	Madhya Pradesh	Central	5.03	1.30	27
19		East	5.13	1.01	19
20		West	4.34	0.60	9
21	Maharashtra	MSEDCL	5.15	0.79	13
22	Punjab	PSPCL	4.89	0.94	18
23	Rajasthan	AVVNL	6.41	2.30	33
24		JVVNL	5.84	1.84	31
25		JDVVNL	5.93	1.89	32
26	Telangana	TSSPDCL	5.23	0.83	15
27		TSNPDCL	5.58	1.08	21
28	West Bengal	WBSEDCL	4.92	0.81	14
29	Uttar Pradesh	DVVNL	6.13	1.47	30
30		MVVNL	5.49	0.84	16
31		PVVNL	5.19	0.54	6
32		PuVVNL	5.82	1.10	24
33		KESCO	6.03	1.38	29

Observations:

Lower wheeling cost reflects optimal deployment of capital expenditure, resources and manageable T&D losses. All the UP Discoms except PVVNL fare poorly on the ranking of wheeling costs. It is imperative that the Discoms strategically plan and rationalize capital expenditure after due adherence to safety and statutory requirement and after assessing quantitative and qualitative benefits to consumers.

viii. Profit after Tax (PAT) as a % of Expenditure

Profit after Tax as a % of expenditure is the best way of assessing the financial positioning of the Discom, as it adjusts to the geographical size, consumer base and sales quantum of the Discom and thereby helps in establishing the actual financial position of the Discom.

Data Consideration:

Data for Profit after Tax (PAT) is taken from the Audited Accounts of FY 2014-15 for each Discom and from the Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY 2014-15 published in June 2016, for the Discoms whose Audited Accounts are available in the public domain.

Current Positioning of PVVNL:

Current Position of PVVNL is that, the Discom stands in 23rd position of 33 Discoms with a loss of 14%. CHESCOM of Karnataka tops the list with 2% profit.

Table 37: Profit After Tax as % of Expenditure

S. No.	State	Utility	Total Expenditure (Rs. Crs)	Profit after Tax (Rs./kWh)	% PAT over Total Expenditure	Rank
1	Andhra Pradesh	APEPDCL	8,683	(722)	-8%	16
2		APSPDCL	16,293	(1,675)	-10%	18
3	Bihar	NBPDCL	3,857	(297)	-8%	15
4		SBPDCL	5,358	(748)	-14%	24
5	Chhattisgarh	CSPDCL	9,965	(1,554)	-16%	27
6	Gujarat	DGVCL	10,700	51	0%	7
7		MGVCL	4,970	29	1%	5
8		PGVCL	11,595	11	0%	10
9		UGVCL	8,266	17	0%	8
10	Haryana	DHBVNL	14,035	(636)	-5%	13
11		UHBVNL	12,158	(1,481)	-12%	21
12	Jharkhand	JBVNL	5,315	(474)	-9%	17
13	Karnataka	BESCOM	13,546	113	1%	2
14		GESCOM	3,276	(110)	-3%	12
15		HESCOM	4,848	30	1%	4
16		MESCOM	2,216	14	1%	3
17		CHESCOM	2,607	40	2%	1
18	Madhya Pradesh	Central	9,264	(2,728)	-29%	30
19		East	8,261	(1,162)	-14%	25
20		West	9,388	(1,061)	-11%	20
21	Maharashtra	MSEDCL	57,954	(366)	-1%	11
22	Punjab	PSPCL	23,525	133	1%	6
23	Rajasthan	AVVNL	11,873	(3,593)	-30%	32
24		JVVNL	15,689	(4,735)	-30%	31

S. No.	State	Utility	Total Expenditure (Rs. Crs)	Profit after Tax (Rs./kWh)	% PAT over Total Expenditure	Rank
25		JDWNL	13,247	(4,146)	-31%	33
26	Telangana	TSSPDCL	17,731	(1,171)	-7%	14
27		TSNPDCL	7,429	(1,343)	-18%	29
28	West Bengal	WBSEDCL	19,553	20	0%	9
29	Uttar Pradesh	DVVNL	11,390	(2,036)	-18%	28
30		MVVNL	8,904	(965)	-11%	19
31		PVVNL	14,258	(1,967)	-14%	23
32		PuVVNL	10,616	(1,318)	-12%	22
33		KESCO	2,135	(317)	-15%	26

Observations:

UP Discoms are ranked between 19 and 28 out of the sample size of 33 Discoms; thereby reflecting the precarious financial position. The input parameters such as T&D losses and collection efficiency need to be improved to achieve success on this parameter.

D. Capital Cost

Capital Cost of the major infrastructure pertaining to electricity distribution function depends on the factors like inflation, external & local risks and credit worthiness of the Discom etc. which, most of the times are un-controllable in nature. Capital Cost includes the cost of material & equipment, sundry charges, labour charges, civil costs and contingencies.

Data Considerations:

The capital cost of works is captured from the Cost Data Books and Schedule of Rates of the Discoms, whose data is available. TSSPDCL and TSNPDCL costs are taken from Cost Data Book of 2014-15 of APEPDCL as the State was formed in FY 2014-15 as per the Andhra Pradesh State Reorganization Act 2014 on June 2, 2014 and no separate Cost Data Book of the Discoms is available after FY 2014-15. The capital cost of works of PVVNL, PuVVNL, DVVNL, MVVNL and KESCO is captured from the RESSPO's Schedule of Rates 2016-17. The cost of other state discoms are taken from the respective state discoms/holding company's Schedule of Rates of FY 2015-16

i. Cost of 33KV overhead line in Rs. per Ckt. kms

The cost of construction of 33KV line in Jharkhand is costlier because of higher local risks linked to Maoists & labour risks. UP Discoms capex Benchmark is among the lowest of the considered State Discoms.

Table 38: Details of Capital cost of 33KV Overhead line

S.No	State	33KV Line (60-80Mtr span) (Dog) (Rs.)
1	PVVNL	519,202
2	MVVNL	519,202
3	KESCO	519,202
4	DVVNL	519,202
5	PuVVNL	519,202
6	JBVNL	1,330,988
7	UHBVNL	550,000
8	DHBVNL	550,000
9	CSPDCL	556,459
10	APEPDCL	650,046
11	APSPDCL	650,046
12	TSNPDCL	650,046
13	TSSPDCL	650,046

S.No	State	33KV Line (60-80Mtr span) (Dog) (Rs.)
14	MPMKVVCL	747,011
15	MPPKVVCL	747,011
16	MPPuKVVCL	747,011

ii. Cost of 11KV overhead line in Rs. per Ckt. kms

The cost of construction of 11KV line in Jharkhand is costlier because of higher local risks linked to Maoists & labour risks. UP Discoms capex Benchmark is among the lowest of the considered State Discoms.

Table 39: Details of Capital Cost for 11KV Overhead line

S.No	State	11KV Line (Rabbit) (Rs.)
1	PVVNL	371,460
2	MVVNL	371,460
3	KESCO	371,460
4	DVVNL	371,460
5	PuVVNL	371,460
6	JBVNL	580,042
7	UHBVNL	420,000
8	DHBVNL	420,000
9	CSPDCL	457,620
10	APEPDCL	434,306
11	APSPDCL	434,306
12	TSNPDCL	434,306
13	TSSPDCL	434,306
14	MPMKVVCL	407,787
15	MPPKVVCL	407,787
16	MPPuKVVCL	407,787

iii. Receiving Station (33/11 kV) Sub-Station cost with 10 MVA Transformer capacity

The cost of construction of 33/11 kV substation in all the States is similar to that of UP Discoms and the capex Benchmark of the UP Discoms is only higher than the Discoms of Jharkhand and Chhattisgarh of the sample Discoms.

Table 40: Details of Capital Cost of 33/11 kV Transformer with 10MVA capacity

S.No	State	10MVA 33/11KV (Rs.)
1	PVVNL	17,797,900
2	MVVNL	17,797,900
3	KESCO	17,797,900
4	DVVNL	17,797,900
5	PuVVNL	17,797,900
6	JBVNL	17,054,541
7	UHBVNL	16,083,409
8	DHBVNL	16,083,409
9	CSPDCL	17,306,929
10	APEPDCL	17,672,762
11	APSPDCL	17,672,762
12	TSNPDCL	17,672,762
13	TSSPDCL	17,672,762
14	MPMKVVCL	19,631,779
15	MPPKVVCL	19,631,779
16	MPPuKVVCL	19,631,779

iv. Distribution (11/.4 kV) Transformer with 100 KVA Transformer capacity

The cost of construction of 11/.4 kV line in all the States is similar to that of UP Discoms and the capex Benchmark of UP Discoms is only higher than the Discoms of Andhra Pradesh, Madhya Pradesh and Jharkhand of the sample Discoms.

Table 41: Details of Capital Cost of 11/0.4 KV Substation with 100KVA Capacity

S.No	State	100KVA 11/.433 SS (Rs.)
1	PVVNL	310,390
2	DVVNL	310,390

S.No	State	100KVA 11/.433 SS (Rs.)
3	KESCO	310,390
4	MVVNL	310,390
5	PuVVNL	310,390
6	JBVNL	310,549
7	UHBVNL	348,876
8	DHBVNL	348,876
9	CSPDCL	269,627
10	APEPDCL	250,720
11	APSPDCL	250,720
12	TSNPDCL	250,720
13	TSSPDCL	250,720
14	MPMKVVCL	242,683
15	MPPKVVCL	242,683
16	MPPuKVVCL	242,683

v. LT Overhead Network

The cost of construction of LT line in Jharkhand is costlier because of higher local risks linked to Maoists and labour risks. UP Discom's capex Benchmark is slightly higher in the sample Discoms, only lesser than Haryana Discoms.

Table 42: Details of Capital Cost of 3Ph and 1Ph LT line

S.No	State	3 Phase LT 5 wire Line (Rabbit) (Rs.)	1 Phase LT Line (Weasel) (Rs.)
1	PVVNL	353,350	239,920
2	MVVNL	353,350	239,920
3	KESCO	353,350	239,920
4	DVVNL	353,350	239,920
5	PuVVNL	353,350	239,920
6	JBVNL	616,816	569,989
7	UHBVNL	357,797	214,805
8	DHBVNL	357,797	214,805
9	CSPDCL	394,195	293,047
10	APEPDCL	334,290	203,880

S.No	State	3 Phase LT 5 wire Line (Rabbit) (Rs.)	1 Phase LT Line (Weasel) (Rs.)
11	APSPDCL	334,290	203,880
12	TSNPDCL	334,290	203,880
13	TSSPDCL	334,290	203,880
14	MPMKVVCL	345,000	220,000
15	MPPKVVCL	345,000	220,000
16	MPPuKVVCL	345,000	220,000

Observations:

The Benchmarks in respect of the capital cost pertaining to construction of line, sub-stations, distribution transformers and metering equipment is prescribed by the Hon'ble UPERC in the Cost Data Book, which is updated annually. It is suggested that the capital costs Benchmarks should not be established merely on the basis of financial considerations but due importance should be accorded to quality as well. A lot of innovation and technological advancements are happening in the electrical equipment space and a combination of quality and cost based selection should be accorded preference over a mere cost based selection.

VI. BENCHMARKING WITH PRIVATE UTILITIES

This instant additional chapter of the benchmarking study has been inserted on the specific request of the Hon'ble Commission and is intended to focus on the functional areas and parameters which can be quantified, as the Discoms are expected to work on these parameters in the near to mid-term future, in or beyond the control period. These metrics are developed and identified in-line with the main study, considering the availability of data and the exhaustiveness for conducting the Benchmarking study of the Discoms with respect to private Discoms.

However, in order to establish the 'desired position' but retaining the spirit prescribed in the revised Tariff Policy 2016, UP Discoms are benchmarked with three private Discoms of Delhi and one from Maharashtra in order to establish the position, to understand the positions which UP Discoms can achieve in or beyond the control period.

A. Operational Performance

i. Aggregate Technical and Commercial Losses

The AT&C losses in the distribution system comprise two major components i.e. technical loss and commercial loss. The technical loss refers to the distribution network loss that is inherent in the delivery of the electrical energy. It includes losses in the conductors, transformers, switchgears and loss in the measurement system. The commercial loss is energy loss that is caused by external factors to the distribution system and is caused by direct energy theft, and deficiencies in the energy metering, billing and collection systems etc.

In the context of operational performance, parameter of AT&C losses plays an important role in determining the operational efficiency of any Discom. The technical loss in the distribution system is an engineering issue. The technical loss beyond limit represents shortcomings in the distribution system planning and infrastructure. The commercial loss, on the other hand is an avoidable financial loss for the Discom.

Data Consideration:

The data for all the Discoms is computed from the Audited Accounts of FY 2014-15 and from Petitions filed the by the Discoms with respective State Electricity Regulatory Commissions, whose Audited Accounts are not available.

Current Positioning:

This list is topped by TPL-Surat of Gujarat with AT&C losses of 4%. The performance of UP Discoms needs to be improved significantly to compete in a league with private Discoms.

Table 43: Aggregate Technical and Commercial Loss

S. No.	State	Discom	AT&C Losses (%)	Rank of AT&C Losses
1	Delhi	BRPL	16%	4
2	Delhi	BYPL	17%	5
3	Delhi	TPDDL	14%	3
4	Maharashtra	R Infra D	10%	2
5	Uttar Pradesh	DVVNL	50%	10
6	Uttar Pradesh	MVVNL	48%	9
7	Uttar Pradesh	PVVNL	22%	6
8	Uttar Pradesh	PuVVNL	40%	8
9	Uttar Pradesh	KESCO	36%	7
10	Gujarat	TPL-Surat	4%	1

ii. Distribution Loss

Distribution Loss consists of both technical loss as well as commercial loss. The technical losses are due to energy dissipated in the conductors and equipment used for distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The commercial losses are caused by pilferage, unauthorized use, defective meters, and errors in meter reading and in estimating unmetered supply of energy.

The Distribution Loss levels along with the collection efficiency are the most important parameters for gauging the efficiency quotient of any Discom.

Data Consideration:

The Distribution Losses of all Discoms except UP Discoms are taken from the PFC report "Performance of State Power Utilities" published in June 2016 and for UP Discoms from Audited Accounts of FY 2014-15 have been referred.

Current Position:

This list is topped by TPL-Surat of Gujarat with Distribution losses of 4%.

Table 44: Distribution Loss

S. No.	State	Discom	Distribution Losses (%)	Rank of Distribution Losses
1	Delhi	BRPL	17%	5
2	Delhi	BYPL	16%	4
3	Delhi	TPDDL	14%	3
4	Maharashtra	R Infra D	10%	2
5	Uttar Pradesh	DVVNL	36%	10
6	Uttar Pradesh	MVVNL	23%	7
7	Uttar Pradesh	PVVNL	20%	6
8	Uttar Pradesh	PuVVNL	24%	8
9	Uttar Pradesh	KESCO	26%	9
10	Gujarat	TPL-Surat	4%	1

iii. Collection Efficiency

Collection efficiency is the ratio of the total revenue realized to the total revenue billed to the consumers for the relevant year.

Data Consideration:

The Collection Efficiency of the Discoms is taken from the PFC report "Performance of State Power Utilities" published in June 2016 and the Audited Accounts of FY 2014-15. And for the Discoms whose Audited Accounts are not available, data is compiled from Petitions filed the by the Discoms with respective State Electricity Regulatory Commissions.

Current Position:

This list is topped by BRPL of Delhi with AT&C losses of 101% (including collection of arrears).

Table 45: Collection Efficiency

S. No.	State	Discom	Collection Efficiency (%)	Rank of Collection Efficiency
1	Delhi	BRPL	101%	1
2	Delhi	BYPL	98%	5
3	Delhi	TPDDL	100%	3

S. No.	State	Discom	Collection Efficiency (%)	Rank of Collection Efficiency
4	Maharashtra	R Infra D	100%	2
5	Uttar Pradesh	DVVNL	78%	9
6	Uttar Pradesh	MVVNL	67%	10
7	Uttar Pradesh	PVVNL	97%	6
8	Uttar Pradesh	PuVVNL	78%	8
9	Uttar Pradesh	KESCO	86%	7
10	Gujarat	TPL-Surat	100%	4

iv. Reliability Indices

Reliability can be defined as the ability of the Discom to deliver electricity to all points of consumption, in the quantity demanded & with the quality expected by the consumer. Reliability is often measured by the outage indices defined in one international standard called IEEE 1366. (IEEE is the Institution of Electrical & Electronics Engineers, the biggest professional body of Electrical & Electronics Engineers. IEEE has its head office in the USA & has presence in most countries). These outage indices are based on the duration of each power supply interruption and the frequency of interruption.

SAIFI and SAIDI are some of the indices used to measure distribution system reliability. A power supply outage is an unplanned event and can be described in terms of the frequency, duration and duration per interruptions.

Data Considerations

The data which is generally captured by the Discoms is not uniform across the country. Few Discoms carefully capture the data and others just capture the data on a sample basis, which is a serious concern while considering the data for the study. Functioning of PTs, CTs and information capturing devices is another constraint in authenticity of the data recorded. The data collected for the study is from the post "Go-Live" reports of R-APDRP towns. However, for the private Discoms, which are not parts of R-APDRP program, data is taken from the CEA report for FY 2015-16 and KESCO has provided data upon request.

a. SAIFI

SAIFI (System Average Interruption Frequency Index): This measures the average number of sustained interruptions (outages) that a customer experiences in a year. It is a ratio of the number of customer-interruptions in a year to the total number of customers. Customer interruptions are determined from estimates of the number of customers affected by each interruption.

Current Positioning:

This list is topped by TPL-Surat of Gujarat with SAIFI of 0.30.

Table 46: System Average Interruption Frequency Index

S. No.	State	Discom	SAIFI	Rank of SAIFI
1	Delhi	BRPL	9.33	5
2	Delhi	BYPL	6.58	4
3	Delhi	TPDDL	3.05	3
4	Maharashtra	R Infra D	1.39	2
5	Uttar Pradesh	DVVNL	566.37	10
6	Uttar Pradesh	MVVNL	370.11	8
7	Uttar Pradesh	PVVNL	525.96	9
8	Uttar Pradesh	PuVVNL	165.92	6
9	Uttar Pradesh	KESCO	339.15	7
10	Gujarat	TPL-Surat	0.30	1

a. SAIDI

SAIDI (System Average Interruption Duration Index): SAIDI is the average duration of interruptions per consumer during the year. It is the ratio of the annual duration of interruptions (sustained) to the number of consumers. If duration is specified in minutes, SAIDI is given as consumer minutes.

Current Positioning:

This list is topped by TPL-Surat of Gujarat with an index of 14:00 minutes in a year.

Table 47: System Average Interruption Duration Index

S. No.	State	Discom	SAIDI	Rank of SAIDI
1	Delhi	BRPL	4:38:45	4
2	Delhi	BYPL	3:09:57	3
3	Delhi	TPDDL	16:27:18	5
4	Mumbai	R Infra D	0:46:40	2
5	Uttar Pradesh	DVVNL	1280:54:53	8
6	Uttar Pradesh	MVVNL	2342:18:03	9
7	Uttar Pradesh	PVVNL	2527:07:14	10

S. No.	State	Discom	SAIDI	Rank of SAIDI
8	Uttar Pradesh	PuVVNL	139:01:20	7
9	Uttar Pradesh	KESCO	38:44:34	6
10	Gujarat	TPL-Surat	0:14:00	1

B. O&M Expenses

i. O&M Expenses per unit of Energy Sales

Operations and Maintenance expenses or 'O&M expenses' refers the expenditure incurred towards Employee expenses, Administrative & General expenses and Repair & Maintenance expenses. O&M expense per unit of energy sold is the ratio of the total O&M expenses incurred to the total units of energy sold in a year.

Data Consideration:

The best source of data of O&M expenses considered for this parameter is Audited Accounts of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions.

Current Positioning:

This list is topped by PVVNL of Uttar Pradesh with Rs. 0.31/kWh. Except for KESCO, the O&M expenses of Uttar Pradesh Discoms are well competitive compared to private Discoms.

Table 48: O&M Expenses per unit of Energy Sales

S. No.	State	Discom	Employee cost (Rs. /kWh)	R&M Expenses (Rs. /kWh)	A&G Expenses (Rs. /kWh)	O&M expense (Rs. /kWh)	Rank of O&M Expenses
1	Delhi	BRPL	0.30	0.14	0.15	0.60	5
2	Delhi	BYPL	0.35	0.16	0.23	0.77	9
3	Delhi	TPDDL	0.39	0.14	0.07	0.61	6
4	Maharashtra	R Infra D	0.85	0.27	0.24	1.38	10
5	Uttar Pradesh	DVVNL	0.13	0.26	0.05	0.45	3
6	Uttar Pradesh	MVVNL	0.27	0.24	0.17	0.70	7
7	Uttar Pradesh	PVVNL	0.10	0.15	0.06	0.31	1
8	Uttar Pradesh	PuVVNL	0.21	0.25	0.06	0.52	4
9	Uttar Pradesh	KESCO	0.38	0.18	0.09	0.73	8

S. No.	State	Discom	Employee cost (Rs. /kWh)	R&M Expenses (Rs. /kWh)	A&G Expenses (Rs. /kWh)	O&M expense (Rs. /kWh)	Rank of O&M Expenses
10	Gujarat	TPL-Surat	0.15	0.09	0.10	0.35	2

ii. R&M Expenses as % of Gross Fixed Asset (GFA)

R&M expenses as a percentage of GFA is calculated by dividing the total R&M expenses with GFA balance of the relevant year.

Data Consideration:

The best source of data of R&M expenses considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions.

Current Positioning:

The list is headed TPL-Surat of Gujarat with R&M Expenses only 2.0% of GFA. R&M expenses as % of Gross Fixed Asset of Uttar Pradesh Discoms is slightly higher compared to Private Discoms.

Table 49: R&M Expenses as % of GFA

S. No.	State	Discom	Gross Fixed Asset (Rs. Cr)	R&M Expenses (Rs. Cr)	R&M Expenses (% GFA)	Rank of R&M Expenses as % GFA
1	Delhi	BRPL	5269	161	3.1%	3
2	Delhi	BYPL	2640	111	4.2%	6
3	Delhi	TPDDL	5062	106	2.1%	2
4	Maharashtra	R Infra D	4897	199	4.1%	5
5	Uttar Pradesh	DVVNL	6006	316	5.3%	7
6	Uttar Pradesh	MVVNL	5053	284	5.6%	9
7	Uttar Pradesh	PVVNL	7620	307	4.0%	4
8	Uttar Pradesh	PuVVNL	6459	343	5.3%	8
9	Uttar Pradesh	KESCO	636	46	7.2%	10
10	Gujarat	TPL-Surat	1429	29.07	2.0%	1

C. Financial Performance

i. Average Power Purchase Cost (APPC)

Average Power Purchase Cost (APPC) is the average price at which the distribution licensee has purchased electricity in the relevant year from all the sources of power. The power purchase from traders, short-term purchases and purchases from renewable sources are also considered while determining Average Power Purchase Cost. APPC is the ratio of the total power purchase costs to the total number of units purchased.

Data Consideration:

The best source of data for power purchase cost considered for this parameter is Audited Account of FY 2014-15 for each Discom. For the Discoms whose Audited Accounts are not available in public domain, data is taken from the True-up Petition filed by the Discoms with the respective State Electricity Regulatory Commissions.

Current Positioning:

The list is headed by TPDDL of Delhi with APPC of Rs. 4.56/kWh. Average Power Purchase Cost of all the UP Discoms is marginally higher than the league leader, with all the UP Discoms occupying place after the pole position.

Table 50: Average Power Purchase Cost

S. No.	State	Discom	APPC (Rs./kWh)	Rank of APPC
1	Delhi	BRPL	5.95	9
2	Delhi	BYPL	6.38	10
3	Delhi	TPDDL	4.56	1
4	Maharashtra	R Infra D	5.20	7
5	Uttar Pradesh	DVVNL	4.66	5
6	Uttar Pradesh	MVVNL	4.65	2
7	Uttar Pradesh	PVVNL	4.65	4
8	Uttar Pradesh	PuVVNL	4.72	6
9	Uttar Pradesh	KESCO	4.65	3
10	Gujarat	TPL-Surat	5.71	8

ii. Average Cost of Supply (ACS) – Average Revenue Realized (ARR) Gap

Average Revenue Realized is the revenue generated by the sale of each unit of electricity, which is computed by dividing the total revenue earned by the Discom with total sales billed.

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016 and the True-up Petitions filed by the Discoms with the respective State Electricity Regulatory Commissions for FY 2014-15.

Current Positioning:

The list is headed by TPDDL of Delhi with a profit of Rs. (0.42) per unit sold.

Table 51: Details of ACS - ARR Gap

S. No.	State	Discom	ACS-ARR Gap (Rs./kWh)	Rank of ACS-ARR Gap
1	Delhi	BRPL	(0.07)	4
2	Delhi	BYPL	(0.05)	5
3	Delhi	TPDDL	(0.42)	1
4	Maharashtra	R Infra D	(0.10)	3
5	Uttar Pradesh	DVVNL	1.93	10
6	Uttar Pradesh	MVVNL	1.80	9
7	Uttar Pradesh	PVVNL	0.73	6
8	Uttar Pradesh	PuVVNL	1.79	8
9	Uttar Pradesh	KESCO	0.82	7
10	Gujarat	TPL-Surat	(0.15)	2

iii. Age of Debtors

Age of debtors is the total revenue due to be received by the Discom in terms in the number of days. High age of debtors increases the working capital requirement. It also adds to a risk of turning into bad debts without reasonable efforts. Age of Debtors in Days is computed by equating the pending receivables to total revenue assessment in a year.

$$\boldsymbol{Age\ of\ Debtors\ (Number\ of\ Days) = \frac{Debtors\ for\ sale\ of\ power}{Revenue\ for\ sale\ of\ power} X\ 365}$$

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016. For the Discoms whose data is not available in the PFC report is taken from the Discom's Audited Accounts of FY 2014-15.

Current Positioning:

The list is headed by TPDDL of Delhi with debtor days of 8 days.

Table 52: Details of Age of Debtors

S. No.	State	Discom	Debtor for sale of power (Days)	Rank of Debtor Days
1	Delhi	BRPL	15	2
2	Delhi	BYPL	25	3
3	Delhi	TPDDL	8	1
4	Uttar Pradesh	DVVNL	374	7
5	Uttar Pradesh	MVVNL	294	6
6	Uttar Pradesh	PVVNL	113	5
7	Uttar Pradesh	PuVVNL	553	9
8	Uttar Pradesh	KESCO	388	8
9	Gujarat	TPL-Surat	29	4

iv. Age of Creditors

Age of creditors is the total payment due to be paid by the Discom to power producers in terms in the number of days.

$$Age\ of\ Creditors\ (Number\ of\ Days) = \frac{Creditors\ for\ purchas\ of\ power}{Expense\ for\ purchase\ of\ power} X\ 365$$

Data Consideration:

The best source of data for this parameter is Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY2014-15 published in June 2016. For the Discoms whose data is not available in the PFC report is taken from the Discom's Audited Accounts of FY 2014-15.

Current Positioning:

The list is headed by TPDDL of Delhi with 0 creditor days. The performance of UP Discoms needs to be improved significantly in order to reap the benefits of having lower number of creditor days.

Table 53: Details of Age of creditors

S. No.	State	Discom	Creditor for purchase of power (Days)	Rank of Creditor Days

S. No.	State	Discom	Creditor for purchase of power (Days)	Rank of Creditor Days
1	Delhi	BRPL	265	7
2	Delhi	BYPL	366	8
3	Delhi	TPDDL	0	1
4	Uttar Pradesh	DVVNL	217	5
5	Uttar Pradesh	MVVNL	242	6
6	Uttar Pradesh	PVVNL	90	3
7	Uttar Pradesh	PuVVNL	389	9
8	Uttar Pradesh	KESCO	83	2
9	Gujarat	TPL-Surat	108	4

v. Profit after Tax (PAT) as a % of Expenditure

Profit after Tax as a % of expenditure is the best way of assessing the financial positioning of the Discom, as it adjusts to the geographical size, consumer base and sales quantum of the Discom and thereby helps in establishing the actual financial position of the Discom.

Data Consideration:

Data for Profit after Tax (PAT) is taken from the Audited Accounts of FY 2014-15 for each Discom and from the Power Finance Corporation Limited's (PFC) "Performance of State Power Utilities" for year FY 2014-15 published in June 2016, for the Discoms whose Audited Accounts are available in the public domain.

Current Positioning:

The list is headed by TPDDL of Delhi with PAT of 5.5% of expenditure.

Table 54: Profit After Tax as % of Expenditure

S. No.	State	Discom	PAT as % of expenditure	Rank of PAT as % of Expenditure
1	Delhi	BRPL	0.6%	2
2	Delhi	BYPL	0.3%	3
3	Delhi	TPDDL	5.5%	1
4	Uttar Pradesh	DVVNL	-18%	9
5	Uttar Pradesh	MVVNL	-11%	5
6	Uttar Pradesh	PVVNL	-14%	7
7	Uttar Pradesh	PuVVNL	-12%	6

S. No.	State	Discom	PAT as % of expenditure	Rank of PAT as % of Expenditure
8	Uttar Pradesh	KESCO	-15%	8
9	Gujarat	TPL-Surat	1.3%	2

Inference:

From the above study involving Benchmarking of Operational and Financial parameters with private Discoms, the following are the key takeaways:

1. The Operational Performance of the private utilities is far superior to UP Discoms in respect of aspects such as AT&C Losses, Distribution Losses, Collection Efficiency, Reliability Indices and consequent financial parameters such as Age of Debtors, Age of Creditors and PAT as % of Expenditure. The superior performance of private utilities can be attributed to management structure, strict monitoring of key performance indicators, adoption of technology and best practices in respect of smart meters, pre-paid meters, prudent capital expenditure and man-power management.

2. The UP Discoms fare better in respect of APPC and ACS owing to the legacy PPAs in which case the fixed cost has been recovered in respect of many power stations.

3. The UP Discoms seem to fare better in respect of O&M Expenses per unit of Energy Sales and compete in respect of R&M Expenses as % of the GFA. However, such comparison is delusive as the lower employee cost per unit of energy sales is contrasted by lower efficiency scores in respect of operational and financial performance as well as customer services. The lower Employee cost per unit of Energy Sales is reflective of the under-staffing at UP Discoms. In respect of R&M Expenses as % of the GFA, the comparison with private Discoms may not be appropriate as the geographical outreach of the UP Discom network is far significant to the clustered network of private Discoms.

VII. SUMMARY OF RANKING

Of the 33 Discoms initially taken into consideration, the data for each of the aforementioned parameter was neither available in public domain nor available with the individual Discoms. In order to perform statistical operations such as the Principal Component Analysis and the Data Envelopment Analysis, it is only logical to maintain a consistent database. Therefore, the total number of utilities considered, have been narrowed down to 33. All the Discoms were allotted certain ranks and scores for each parameter by considering factors such as bandwidth and the Percentage of efficiency for each parameter.

Table 55: Summary of Ranking

S. No.	Parameters		Rank of Feeders with high SAIDI	Rank of Feeders with high SAIFI	Rank of Feeder Monitoring	Rank of HT to LT Ratio	Rank of Lead time for New Connections	Rank of Lead time for Complaint Redressal	Rank of R&M Expenses as % GFA	Rank of O&M Expense per unit of Energy Sales	Rank of Average Power Purchase Cost	Rank of ACS-ARR Gap	Rank of Age of Debtors (Days)	Rank of Age of Creditors (Days)	Rank of Collection Efficiency	Rank of E Payment	Rank of AT&C Losses	Rank of PAT as % of expenditure	Rank of Distribution Loss
			D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
1	Andhra Pradesh	APEPDCL	13	1	5	25	1	1	19	30	25	16	8	11	13	10	1	16	1
2	Andhra Pradesh	APSPDCL	19	14	2	25	5	1	22	28	23	22	14	19	6	15	5	18	4
3	Bihar	NBPDCL	26	31	15	16	23	27	15	8	27	24	20	15	28	21	29	15	31
4	Bihar	SBPDCL	25	26	23	19	19	30	9	19	18	18	16	14	3	18	30	24	33
5	Chhattisgarh	CSPDCL	22	18	8	30	13	16	26	22	2	24	15	24	24	9	20	27	17
6	Gujarat	DGVCL	1	1	1	12	1	1	6	1	33	3	1	1	7	19	3	7	2
7	Gujarat	MGVCL	1	1	6	14	9	1	17	12	17	1	2	4	1	4	4	5	6
8	Gujarat	PGVCL	9	1	3	6	4	1	7	6	4	4	5	1	5	28	16	10	22
9	Gujarat	UGVCL	1	1	4	5	11	1	20	3	9	2	3	1	2	17	2	8	3
10	Haryana	DHVBN	31	15	31	7	22	26	2	13	20	14	23	13	25	3	22	13	21
11	Haryana	UHVBN	30	19	30	8	21	28	5	7	22	20	12	20	22	2	26	21	29
12	Jharkhand	JBVNL	29	32	28	15	29	29	12	4	19	17	31	33	32	32	31	17	30
13	Karnataka	BESCOM	14	24	24	20	28	17	4	5	11	7	25	21	19	7	10	2	8
14	Karnataka	GESCOM	1	1	21	17	30	32	14	17	1	11	24	32	12	31	12	12	14
15	Karnataka	HESCOM	32	33	20	21	17	33	18	18	3	8	21	28	14	5	11	4	13
16	Karnataka	MESCOM	23	27	11	29	26	1	23	26	5	10	17	5	20	30	7	3	5
17	Karnataka	CHESCOM	24	28	10	23	16	11	21	25	6	5	28	31	26	29	13	1	9
18	Madhya Pradesh	Central	10	23	29	9	25	25	1	14	7	27	26	26	27	14	25	30	23
19	Madhya Pradesh	East	17	21	19	9	18	23	8	31	16	23	27	12	23	11	19	25	16

S. No.	Parameters		Rank of Feeders with high SAIDI	Rank of Feeders with high SAIFI	Rank of Feeder Monitoring	Rank of HT to LT Ratio	Rank of Lead time for New Connections	Rank of Lead time for Complaint Redressal	Rank of R&M Expenses as % GFA	Rank of O&M Expense per unit of Energy Sales	Rank of Average Power Purchase Cost	Rank of ACS-ARR Gap	Rank of Age of Debtors (Days)	Rank of Age of Creditors (Days)	Rank of Collection Efficiency	Rank of E Payment	Rank of AT&C Losses	Rank of PAT as % of expenditure	Rank of Distribution Loss
			D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
20	Madhya Pradesh	West	21	22	18	9	20	15	24	15	8	15	9	9	18	13	23	20	26
21	Maharashtra	MSEDCL	11	1	17	24	3	21	25	21	21	12	18	22	21	8	15	11	10
22	Punjab	PSPCL	20	16	32	4	24	1	13	33	10	13	6	6	10	1	9	6	12
23	Rajasthan	AVVNL	1	1	7	1	33	18	10	32	15	33	4	8	10	33	17	32	24
24	Rajasthan	JVVNL	8	13	14	1	14	13	3	27	12	30	9	10	8	16	24	31	28
25	Rajasthan	JdVVNL	12	1	16	1	15	14	11	16	13	32	7	7	16	22	18	33	20
26	Telangana	TSSPDCL	1	12	9	25	8	12	28	10	24	6	9	23	4	6	6	14	11
27	Telangana	TSNPDCL	16	1	12	25	12	19	27	29	26	26	19	18	17	27	8	29	7
28	West Bengal	WBSEDCL	15	20	25	22	27	24	16	24	14	8	13	16	15	20	21	9	27
29	Uttar Pradesh	DVVNL	27	29	27	18	31	10	30	9	31	31	30	27	31	23	33	28	32
30	Uttar Pradesh	MVVNL	28	25	26	32	32	31	32	23	28	29	29	29	33	24	32	19	18
31	Uttar Pradesh	PVVNL	33	30	22	31	10	22	29	2	30	19	22	17	9	12	14	23	15
32	Uttar Pradesh	PuVVNL	18	17	13	33	7	20	31	11	32	28	32	30	30	25	28	22	19
33	Uttar Pradesh	KESCO	1	1	32	13	6	1	33	20	29	21	33	25	29	26	27	26	25

VIII. BENCHMARKING

In the next step of Benchmarking study, Rank of PVVNL need to be determined to benchmark it with the best efficient Discom in the league. The factors which were considered for the study cover financial, operational and technical parameters which give the overall efficiency of the Discom. Ranking is based on the efficiency scores of the Discoms which are derived by performing some statistical techniques. Statistical techniques which are best suited for the purpose are Data Envelopment Analysis (DEA), Principal Component Analysis (PCA) and Factor Analysis. But all these statistical techniques have their own limitations and to get the desired output, it is intended to use PCA-DEA jointly along with Factor analysis in calculating Eigen Values[7] and variance as a part of PCA**.**

1. Data Envelopment Analysis

DEA is a non-parametric technique for evaluating the efficiencies of Discoms which consume common inputs to generate common outputs. A Discom is said to be 100% efficient if (i) None of the outputs can be increased without either increasing one or more inputs; or decreasing some of the other outputs; and (ii) None of the inputs can be decreased without either decreasing some of its outputs; or increasing some of its other inputs.

Based on this definition of efficiency, DEA is a mathematical optimization technique which determines the efficiency of each Decision Making Unit (DMU) by maximizing the ratio of a weighted sum of its outputs to a weighted sum of its inputs while ensuring that the efficiencies of other units do not exceed 100%. Besides determining relative efficiency measures for each DMU, DEA also identifies efficient peer DMUs for each inefficient DMU and quantifies the required increase in outputs or decrease in inputs required to transform an inefficient DMU into an efficient DMU.

From a mathematical point of view, DEA solves a sequence of simple linear programs. The post-optimal analysis of these linear programs provides us with the important information which quantifies inefficiencies.

[7]**Eigen Values:** Eigen values are a special set of scalars associated with a linear system of equations (i.e., a matrix equation) that are sometimes also known as characteristic values or latent roots. The determination of the Eigen values of a system is extremely important in determining the latent value after adjusting the vector direction, where it is equivalent to matrix diagonalization and arises in such common applications as stability analysis, the physics of rotating vectors etc. Each Eigen value is generally paired with a corresponding so-called Eigen vector (or, in general, a corresponding right Eigen vector and a corresponding left Eigen vector; there is no analogous distinction between left and right for Eigen values).

There is now an extensive literature discussing both theory and applications of DEA. While applications have been reported in the private sector (e.g. in retailing, banking, hotels and the airline industry), most of the applications of DEA have occurred in the public sector.

Initially, a model of DEA demonstrated how to change a fractional linear measure of efficiency into a linear programming (LP) format. As a result, DMUs could be assessed on the basis of multiple inputs and outputs, even if the production function was unknown. There is an extensive literature discussing both theory and applications of DEA.

The DEA ranking methods can be divided into six broad areas: (i) Cross Efficiency, (ii) Super Efficiency, (iii) Benchmarking, (iv) ranking using multivariate statistical techniques, (v) ranking inefficient units through proportional measures of inefficiency and (vi) combining multi-criteria decision methodology with DEA approach.

2. Principal Component Analysis

Principal component analysis (PCA) is a multivariate statistical method which is primarily used for: i) reducing the dimensionality of data set without losing the main information, and ii) to detect structure in the relationships between variables, in order to classify variables. The goal of PCA is to identify the most meaningful basis to re-express a data set by filtering out the noise and thus reveal hidden structure.

In particular, PCA allows identifying the principal directions in which the data varies. In computational terms, the principal components are found by calculating the Eigen vectors and Eigen values of the data covariance matrix. This process is equivalent to finding the axis system in which the co-variance matrix is diagonal. The Eigen vector with the largest Eigen value is the direction of greatest variation, the one with the second largest Eigen value is the (orthogonal) direction with the next highest variation and so on.

In the context of DMU's efficiency rating, PCA can be employed to improve the discriminatory power of the DEA without requiring additional preferential information. Joe Zhu (1998) suggested that PCA can be applied to 'output by input' ratios as complementary approach to DEA *(Source: European Journal of Operational Research 111(1998)50-61 Theory and Methodology Data envelopment analysis vs. principal component analysis: An illustrative study of economic performance of Chinese cities by Joe Zhu)*

3. Combining PCA and DEA

Joe Zhu (1998) combined PCA statistical method with base models of DEA and proposed a novel model for evaluating the efficiency of DMUs. He proposed a procedure for ranking of DMUs based on PCA and showed that the ranking is consistent with the DEA ranking for the data set considered in his

article. I. M. Premachandra (2001) *(Source: European Journal of Operational Research 132(2001)553-560 Theory and Methodology A note of DEA vs. principal component analysis: An improvement to Joe Zhu's approach by I.M. Premachandra)* further modified the combined methodology developed by Joe Zhu (1998) for ranking of DMUs by accounting for the overall and relative performance of the DMUs.

According to Joe Zhu, a particular DMU_j is expected to perform better with respect to the i^{th} input and r^{th} output if the ratio R_{ir}^j takes larger values.

R_{ir}^j is calculated as:

R_{ir}^j = ratio of the 'i^{th}' input and 'r^{th}' output of DMU 'j' = $\frac{y_{rj}}{x_{ij}}$

Where 'i' = 1,.....m; 'r'= 1,.....s.

Zhu considered the following matrix D of ratios in the PCA.

Let the column vector $V^{(k)} = [R_{ir}^1, R_{ir}^2, \ldots\ldots\ldots\ldots\ldots R_{ir}^n]_{1xn}^T$ that calculates the output to input ratio.

Where k is defined in such a way that k = 1, when i = 1 and r = 1, k = 2 when i = 1 and r = 2 and so on upto $k = m_{xs}$ when $i = m$ and $r = s$.

Matrix 'D' is defined as follows:

$$D=[V^{(1)}, V^{(2)}, \ldots\ldots. V^{(m\ xs)}]_{\ nx(mxs)} \qquad (1)$$

PCA is performed on the correlation matrix of D to obtain combinations of variables represented by vectors $V^{(1)}, V^{(2)}, \ldots\ldots, V^{(mxs)}$ which produce the principal components PC_1 , PC_2,……,$PC_{p..}$

Let $\lambda_1, \lambda_2, \ldots\ldots, \lambda_p$ be the ordered Eigen values of the correlation matrix and $[l_1^{(i)}, l_2^{(i),} \ldots\ldots l_{mxs}^{(i)}]$ be the Eigen vectors corresponding to the i^{th} Eigen value λ_i so that the principal components for the j^{th} DMU can be defined as follows

$$PC_i^{(j)} = \sum_{k=1}^{mxs} l_k^{(i)} d_{jk} \text{ where j=1,…,n,i=1,….p} \qquad (2)$$

For ranking purposes of the DMUs the following index is used for each DMU j

$$Z_j = \sum_{k=1}^{M} w_k PC_k^{(j)} \text{ where j=1,…, n} \qquad (3)$$

where the value M is decided in such a way that cumulative proportion of variances for the first M principal components is greater than or equal to a selected threshold.

The PCA ranking procedure adopted by Joe Zhu does not take into account the following:

- The overall performance of a DMU with respect to all variables R_{ir}^{j} and,
- How well a particular DMU performs with respect to one variable R_{ir}^{j} when compared to other DMUs in the sample.

Thus, I.M. Premachandra included the following steps:

- Matrix D is modified D' by adding another variable (m_{xs}+1th variable) whose elements(d'_{ij}) for each DMU is equivalent to the sum of the elements in the first m_{xs} columns of the matrix D

$$d'_{i,(mxs+1)} = \sum_{j=1}^{mxs} d_{ij} \quad i=1 \ldots.n \qquad (4)$$

The new variable added d'_{ij} is supposed to take into account the overall performance of each DMU with respect to all the variables R_{ij}^{r} .

- In order to evaluate the performance of each DMU relative to other DMUs in the sample, the new matrix $D'' = [\, d_{ij}'' \,]$ is be obtained by dividing all elements in each column of the D' Matrix by its column minimum.

Afterwards, PCA is the performed on the matrix D'' in the usual manner**.**

4. Framework for the Study

Objective

The objectives of the study are to Benchmark PVVNL with other Discoms and identify the current positioning of PVVNL among its peers. The benchmarking should be done covering all aspects of a Discom like Operational, Financial and Cost performance.

Selection of Discoms

Based on the data availability and quality, though the algebraic parameter-wise ranking was done for 33 Discoms and 38 parameters, Benchmarking with PCA-DEA technique is done for PVVNL among 33 Discoms with 15 assumed to less dependent input and 2 output parameters.

The following Discoms (DMUs) selected for Benchmarking are:

1. APEPDCL
2. APSPDCL
3. NBPDCL
4. SBPDCL
5. CSPDCL
6. DGVCL
7. MGVCL
8. PGVCL
9. UGVCL
10. DHVBN
11. UHVBN
12. JBVNL
13. BESCOM
14. GESCOM
15. HESCOM
16. MESCOM
17. CHESCOM
18. MP-Central
19. MP-East
20. MP-West
21. MSEDCL
22. PSPCL
23. AVVNL
24. JVVNL
25. JdVVNL
26. TSSPDCL
27. TSNPDCL
28. WBSEDCL
29. DVVNL
30. MVVNL
31. PVVNL
32. PuVVNL
33. KESCO

Selection and Rating of variables

Data of 20 parameters pertaining to 33 Discoms was available for Benchmarking. However, only 17 parameters were selected for PCA-DEA based benchmarking.

The following variables were taken as the inputs for benchmarking:

1. R&M Expenses as % Gross Fixed Assets
2. O&M expense per unit of Energy Sales
3. Average Power Purchase Cost
4. Average Cost of Supply – Aggregate Revenue Realized Gap
5. Age of Debtors (Days)
6. Age of Creditors (Days)
7. Collection Efficiency
8. Aggregate Technical & Commercial Losses
9. E-Payment
10. Feeders with high SAIDI
11. Feeders with high SAIFI
12. Feeder Monitoring
13. HT to LT Ratio
14. Lead time for New Connections
15. Lead time for Complaint Redressal
16. Profit after Tax as % of Expenditure as output variable
17. Distribution Losses as output variable

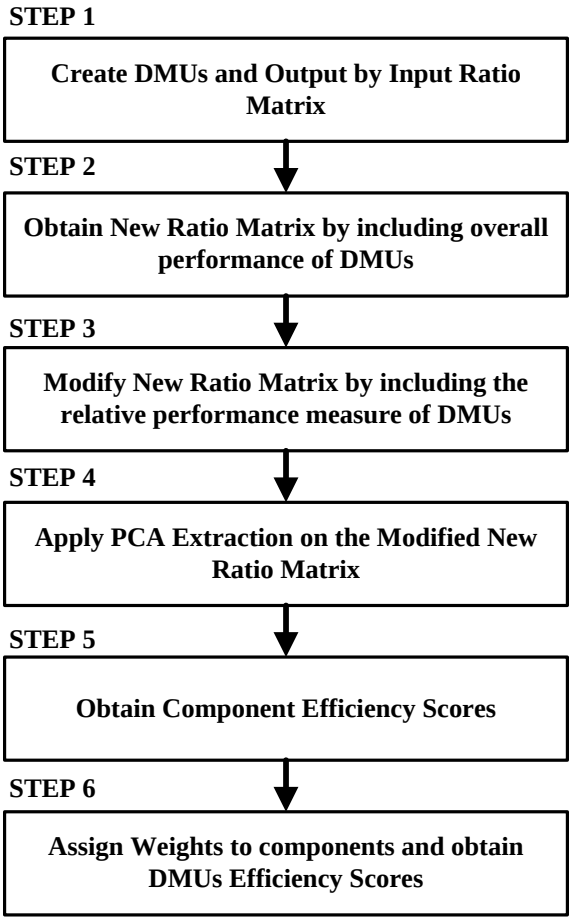
Ranks of each variable are used as input data for PCA-DEA as below:

5. PCA-DEA Methodology

Present study uses PCA and DEA combined method developed by Joe Zhu (1998) and the modification suggested by Premachandra (2001) on Zhu's method to measure the efficiency of the DMUs due to discriminatory power of the method to rank the units. A seven step procedure based on the Zhu's method and Premachandra (2001) modification was followed to obtain the efficiency score of the DMUs. Based on the efficiency scores the DMUs were ranked. The six step method is given below:

- Step 1: Create Ratio Matrix (Output by Input Matrix).
- Step 2: Modify Ratio Matrix to take account of overall performance of each DMU w.r.t each input variable.
- Step 3: Modify Matrix obtained in Step 2 to account for the performance relative to other DMUs.
- Step 4: Perform PCA extraction on the Matrix obtained in Step 3, obtain Variance Explained by components, Eigen-values and Eigen-vectors.
- Step 5: Normalize the matrix obtained from Step 3 and multiply it with Eigen-vector matrix obtained from Step 4.
- Step 6: Assign weight to DMU individual component efficiency score to obtain a single efficiency score.

Figure 3: Flow chart of DEA-PCA application based Benchmarking



Step 1: Create DMUs and Ratio Matrix

A 33X30 matrix was created (annexure) to accommodate all 33 DMUs. The 15 inputs and 2 outputs were used to calculate the ratios of individual inputs and outputs defined as:

R_{ir}^{j} = ratio of the '*i*th' input and '*r*th' output of DMU '*j*' = $\frac{y_{rj}}{x_{ij}}$

Where '*i*' = 1,2,3,……. ; '*r*'= 1; and '*j*' = 1,2,3,.....

The resultant Ratio Matrix (*D*) is a 33X31 Matrix.

Step 2: Modify Ratio Matrix to include overall performance of DMUs

A new column (31th column) is added to the 'Ratio Matrix' obtained in step 1. Matrix D is modified by adding another variable (30+1th variable) whose elements for each DMU is equivalent to the sum of the elements in the first 11 columns of the matrix D.

The new variable added is supposed to take into account the overall performance of each DMU with respect to all the variables R_{ij}^{r}.

The new 'Ratio Matrix (*D'*), is a 33x31 Matrix.

Step 3: Modify Ratio Matrix to include the relative performance measure of DMUs

The next step is to introduce the relative performance measure of each DMU w.r.t. each input variable. This was done by dividing each row element in the New Ratio Matrix (*D'*) by their column minimum values.

To evaluate the performance of each DMU relative to other DMUs in the sample, the new matrix $D'' = [d_{ij}'']$ was obtained by dividing all elements in each column of the D' Matrix by its column minimum.

The new 'Modified Ratio Matrix (D'')' obtained is again a 33x31 matrix and accounts for performance of each DMU relative to other DMUs for a given input.

Step 4: Apply PCA Extraction

Afterwards, PCA was applied for extraction on the new 'Modified Ratio Matrix (D'')' obtained in step 3. The individual rows or the DMUs are taken as cases and the columns (D1 to D31) are taken as the variables in the PCA extraction.

Step 5: Obtain Component Efficiency Scores

In the next step, normalization (taking natural log) was done for the 'Modified Ratio Matrix (D'')' in step 4 and it was multiplied with PCA extracted Eigen vectors. The resultant matrix contains efficiency scores for PC1, PC2 …… PC15 components.

Step 6: Assign component weights and obtain DMU efficiency scores

The PC1, PC2, PC3, to PC15 efficiency scores are assigned weights as per the Variance Explained by the components and combined to get a single efficiency score. The weight assigned to PC1, PC2, PC3 till PC15 are 89.11%, 2.81%, 1.68%, 1.57%, 1.33%, 0.75%, 0.69%, 0.68%, 0.48%, 0.42%, 0.24%, 0.11%, 0.06%, 0.04% and 0.02% respectively.

The ranking of the DMUs is done as per the efficiency scores such that DMU with higher efficiency score is ranked better.

IX. FINAL EFFICIENCIES OF DISCOMS

Final efficiencies of Discoms obtained by Principal Component Analysis and Data Envelopment Method are as below:

Table 56: Final Efficiency based ranking of sample Discoms

Final Efficiency and Ranking of the Discoms				
S. No	**State**	**Discom**	**Efficiency**	**Rank**
1	Andhra Pradesh	APEPDCL	6.09	5
2		APSPDCL	4.84	12
3	Bihar	NBPDCL	2.94	30
4		SBPDCL	3.32	26
5	Chhattisgarh	CSPDCL	3.64	20
6	Gujarat	DGVCL	7.52	1
7		MGVCL	6.93	3
8		PGVCL	6.40	4
9		UGVCL	7.09	2
10	Haryana	DHVBN	3.64	19
11		UHVBN	3.54	21
12	Jharkhand	JBVNL	2.87	31
13	Karnataka	BESCOM	3.66	18
14		GESCOM	5.30	8
15		HESCOM	3.35	25
16		MESCOM	4.44	14
17		CHESCOM	3.38	24
18	Madhya Pradesh	Central	3.76	17
19		East	3.24	28
20		West	3.51	22
21	Maharashtra	MSEDCL	4.67	13
22	Punjab	PSPCL	4.91	11
23	Rajasthan	AVVNL	5.62	7
24		JVVNL	4.43	15
25		JdVVNL	5.05	9
26	Telangana	TSSPDCL	4.95	10
27		TSNPDCL	4.43	16
28	West Bengal	WBSEDCL	3.25	27

Final Efficiency and Ranking of the Discoms				
29	Uttar Pradesh	DVVNL	2.81	32
30		MVVNL	2.43	33
31		PVVNL	3.49	23
32		PuVVNL	3.10	29
33		KESCO	5.66	6

X. CONCLUSION - POSITIONING OF PVVNL

PVVNL ranks 23 in the league of 33 Discoms with efficiency score of 3.49. The list is topped by the Discoms of Gujarat and Andhra Pradesh with efficiency scores ranging between 7.52 and 6.09. PVVNL lagging in the parameters like Feeders with high SAIDI and SAIFI, HT to LT ratio and compliant redressal played a major role in the rank. PVVNL also need to focus on the Feeder Monitoring and thus reducing the feeder wise losses and interruptions, which will help in reducing inefficiency in power distribution to reduce the distribution losses and focus on cost management to improve the financial position of the Discom.

The lower Employee Cost (O&M costs) per unit of energy sales is contrasted by lower efficiency scores in respect of operational performance, commercial performance, financial performance and customer service. In view thereof, the lower Employee cost per unit of energy sales reflects under-staffing. This is further corroborated by the submissions of the PVVNL in the MYT Tariff Petition wherein it has furnished the details of the working strength of the employees versus the sanctioned strength of the employees. The submissions of PVVNL depict that the actual deployment of staff is hardly 59% against the sanctioned employee strength, there by depicting that it is acutely under-staffed. The shortage is even more pronounced in respect of technical staff as compared to non-technical staff, which is reflective of both lower Employee cost per unit of energy sales as well as lower efficiency scores.

The high age of creditors, another parameter which have high influence on one of the output variable, reflects strained financial condition of the UP Discoms, owing to high AT&C losses. The power producers provide a rebate of 2% on timely payment of energy bills, which the UP Discoms are not able to avail. Payable management also has an impact on optimizing the power procurement cost. The UP Discoms may not be in a position to improve the age of creditors unless it attains the overall efficiency on all key parameters such as T&D losses, collection efficiency etc. Lower creditor days improves the credit rating of Discoms which has an impact on the cost of lending as well as loading of lower risk premium by various generators when bidding in power procurement tenders in UP.

For improving another important parameters such as APPC, UP Discoms may implement an Energy/Load Management and Cost Optimization system and build a time block wise demand-supply model to strategize on the power procurement at competitive prices. UP Discoms should also develop standard operating procedures for load management, bidding for bilateral contracts and determination of quantum and rate of bid to be filed in the power exchanges. This measure will help the UP Discoms, in improving the APPC positioning.

XI. ANNEXURES

The working tables of DEA-PCA technique are as below:

Table 57: Ratio Matrix of DEA-PCA Technique

Ratio Matrix																														
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30
1.23	16.00	3.20	0.64	16.00	16.00	0.84	0.53	0.64	1.00	2.00	1.45	1.23	1.60	16.00	0.08	1.00	0.20	0.04	1.00	1.00	0.05	0.03	0.04	0.06	0.13	0.09	0.08	0.10	1.00
0.84	1.14	8.00	0.64	3.20	16.00	0.73	0.57	0.70	0.73	1.14	0.84	2.67	1.07	3.20	0.05	0.07	0.50	0.04	0.20	1.00	0.05	0.04	0.04	0.05	0.07	0.05	0.17	0.07	0.20
0.62	0.52	1.07	1.00	0.70	0.59	1.07	2.00	0.59	0.67	0.80	1.07	0.57	0.76	0.55	0.04	0.03	0.07	0.06	0.04	0.04	0.07	0.13	0.04	0.04	0.05	0.07	0.04	0.05	0.03
0.64	0.62	0.70	0.84	0.84	0.53	1.78	0.84	0.89	0.89	1.00	1.14	5.33	0.89	0.53	0.04	0.04	0.04	0.05	0.05	0.03	0.11	0.05	0.06	0.06	0.06	0.07	0.33	0.06	0.03
0.73	0.89	2.00	0.53	1.23	1.00	0.62	0.73	8.00	0.67	1.07	0.67	0.67	1.78	0.80	0.05	0.06	0.13	0.03	0.08	0.06	0.04	0.05	0.50	0.04	0.07	0.04	0.04	0.11	0.05
16.00	16.00	16.00	1.33	16.00	16.00	2.67	16.00	0.48	5.33	16.00	16.00	2.29	0.84	5.33	1.00	1.00	1.00	0.08	1.00	1.00	0.17	1.00	0.03	0.33	1.00	1.00	0.14	0.05	0.33
16.00	16.00	2.67	1.14	1.78	16.00	0.94	1.33	0.94	16.00	8.00	4.00	16.00	4.00	4.00	1.00	1.00	0.17	0.07	0.11	1.00	0.06	0.08	0.06	1.00	0.50	0.25	1.00	0.25	0.25
1.78	16.00	5.33	2.67	4.00	16.00	2.29	2.67	4.00	4.00	3.20	16.00	3.20	0.57	1.00	0.11	1.00	0.33	0.17	0.25	1.00	0.14	0.17	0.25	0.25	0.20	1.00	0.20	0.04	0.06
16.00	16.00	4.00	3.20	1.45	16.00	0.80	5.33	1.78	8.00	5.33	16.00	8.00	0.94	8.00	1.00	1.00	0.25	0.20	0.09	1.00	0.05	0.33	0.11	0.50	0.33	1.00	0.50	0.06	0.50
0.52	1.07	0.52	2.29	0.73	0.62	8.00	1.23	0.80	1.14	0.70	1.23	0.64	5.33	0.73	0.03	0.07	0.03	0.14	0.05	0.04	0.50	0.08	0.05	0.07	0.04	0.08	0.04	0.33	0.05
0.53	0.84	0.53	2.00	0.76	0.57	3.20	2.29	0.73	0.80	1.33	0.80	0.73	8.00	0.62	0.03	0.05	0.03	0.13	0.05	0.04	0.20	0.14	0.05	0.05	0.08	0.05	0.05	0.50	0.04
0.55	0.50	0.57	1.07	0.55	0.55	1.33	4.00	0.84	0.94	0.52	0.48	0.50	0.50	0.52	0.03	0.03	0.04	0.07	0.03	0.03	0.08	0.25	0.05	0.06	0.03	0.03	0.03	0.03	0.03
1.14	0.67	0.67	0.80	0.57	0.94	4.00	3.20	1.45	2.29	0.64	0.76	0.84	2.29	1.60	0.07	0.04	0.04	0.05	0.04	0.06	0.25	0.20	0.09	0.14	0.04	0.05	0.05	0.14	0.10
16.00	16.00	0.76	0.94	0.53	0.50	1.14	0.94	16.00	1.45	0.67	0.50	1.33	0.52	1.33	1.00	1.00	0.05	0.06	0.03	0.03	0.07	0.06	1.00	0.09	0.04	0.03	0.08	0.03	0.08
0.50	0.48	0.80	0.76	0.94	0.48	0.89	0.89	5.33	2.00	0.76	0.57	1.14	3.20	1.45	0.03	0.03	0.05	0.05	0.06	0.03	0.06	0.06	0.33	0.13	0.05	0.04	0.07	0.20	0.09
0.70	0.59	1.45	0.55	0.62	16.00	0.70	0.62	3.20	1.60	0.94	3.20	0.80	0.53	2.29	0.04	0.04	0.09	0.03	0.04	1.00	0.04	0.04	0.20	0.10	0.06	0.20	0.05	0.03	0.14
0.67	0.57	1.60	0.70	1.00	1.45	0.76	0.64	2.67	3.20	0.57	0.52	0.62	0.55	1.23	0.04	0.04	0.10	0.04	0.06	0.09	0.05	0.04	0.17	0.20	0.04	0.03	0.04	0.03	0.08
1.60	0.70	0.55	1.78	0.64	0.64	16.00	1.14	2.29	0.59	0.62	0.62	0.59	1.14	0.64	0.10	0.04	0.03	0.11	0.04	0.04	1.00	0.07	0.14	0.04	0.04	0.04	0.04	0.07	0.04
0.94	0.76	0.84	1.78	0.89	0.70	2.00	0.52	1.00	0.70	0.59	1.33	0.70	1.45	0.84	0.06	0.05	0.05	0.11	0.06	0.04	0.13	0.03	0.06	0.04	0.04	0.08	0.04	0.09	0.05
0.76	0.73	0.89	1.78	0.80	1.07	0.67	1.07	2.00	1.07	1.78	1.78	0.89	1.23	0.70	0.05	0.05	0.06	0.11	0.05	0.07	0.04	0.07	0.13	0.07	0.11	0.11	0.06	0.08	0.04
1.45	16.00	0.94	0.67	5.33	0.76	0.64	0.76	0.76	1.33	0.89	0.73	0.76	2.00	1.07	0.09	1.00	0.06	0.04	0.33	0.05	0.04	0.05	0.05	0.08	0.06	0.05	0.05	0.13	0.07
0.80	1.00	0.50	4.00	0.67	16.00	1.23	0.48	1.60	1.23	2.67	2.67	1.60	16.00	1.78	0.05	0.06	0.03	0.25	0.04	1.00	0.08	0.03	0.10	0.08	0.17	0.17	0.10	1.00	0.11
16.00	16.00	2.29	16.00	0.48	0.89	1.60	0.50	1.07	0.48	4.00	2.00	1.60	0.48	0.94	1.00	1.00	0.14	1.00	0.03	0.06	0.10	0.03	0.07	0.03	0.25	0.13	0.10	0.03	0.06
2.00	1.23	1.14	16.00	1.14	1.23	5.33	0.59	1.33	0.53	1.78	1.60	2.00	1.00	0.67	0.13	0.08	0.07	1.00	0.07	0.08	0.33	0.04	0.08	0.03	0.11	0.10	0.13	0.06	0.04
1.33	16.00	1.00	16.00	1.07	1.14	1.45	1.00	1.23	0.50	2.29	2.29	1.00	0.73	0.89	0.08	1.00	0.06	1.00	0.07	0.07	0.09	0.06	0.08	0.03	0.14	0.14	0.06	0.05	0.06
16.00	1.33	1.78	0.64	2.00	1.33	0.57	1.60	0.67	2.67	1.78	0.70	4.00	2.67	2.67	1.00	0.08	0.11	0.04	0.13	0.08	0.04	0.10	0.04	0.17	0.11	0.04	0.25	0.17	0.17
1.00	16.00	1.33	0.64	1.33	0.84	0.59	0.55	0.62	0.62	0.84	0.89	0.94	0.59	2.00	0.06	1.00	0.08	0.04	0.08	0.05	0.04	0.03	0.04	0.04	0.05	0.06	0.06	0.04	0.13
1.07	0.80	0.64	0.73	0.59	0.67	1.00	0.67	1.14	2.00	1.23	1.00	1.07	0.80	0.76	0.07	0.05	0.04	0.05	0.04	0.04	0.06	0.04	0.07	0.13	0.08	0.06	0.07	0.05	0.05
0.59	0.55	0.59	0.89	0.52	1.60	0.53	1.78	0.52	0.52	0.53	0.59	0.52	0.70	0.48	0.04	0.03	0.04	0.06	0.03	0.10	0.03	0.11	0.03	0.03	0.03	0.04	0.03	0.04	0.03
0.57	0.64	0.62	0.50	0.50	0.52	0.50	0.70	0.57	0.55	0.55	0.55	0.48	0.67	0.50	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.03
0.48	0.53	0.73	0.52	1.60	0.73	0.55	8.00	0.53	0.84	0.73	0.94	1.78	1.33	1.14	0.03	0.03	0.05	0.03	0.10	0.05	0.03	0.50	0.03	0.05	0.05	0.06	0.11	0.08	0.07
0.89	0.94	1.23	0.48	2.29	0.80	0.52	1.45	0.50	0.57	0.50	0.53	0.53	0.64	0.57	0.06	0.06	0.08	0.03	0.14	0.05	0.03	0.09	0.03	0.04	0.03	0.03	0.03	0.04	0.04
16.00	16.00	0.50	1.23	2.67	16.00	0.48	0.80	0.55	0.76	0.48	0.64	0.55	0.62	0.59	1.00	1.00	0.03	0.08	0.17	1.00	0.03	0.05	0.03	0.05	0.03	0.04	0.03	0.04	0.04

Table 58: Modification Matrix of DEA-PCA Technique

Modification Matrix 1																															
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30	D31
1.23	16.00	3.20	0.64	16.00	16.00	0.84	0.53	0.64	1.00	2.00	1.45	1.23	1.60	16.00	0.08	1.00	0.20	0.04	1.00	1.00	0.05	0.03	0.04	0.06	0.13	0.09	0.08	0.10	1.00	83.27
0.84	1.14	8.00	0.64	3.20	16.00	0.73	0.57	0.70	0.73	1.14	0.84	2.67	1.07	3.20	0.05	0.07	0.50	0.04	0.20	1.00	0.05	0.04	0.04	0.05	0.07	0.05	0.17	0.07	0.20	44.06
0.62	0.52	1.07	1.00	0.70	0.59	1.07	2.00	0.59	0.67	0.80	1.07	0.57	0.76	0.55	0.04	0.03	0.07	0.06	0.04	0.04	0.07	0.13	0.04	0.04	0.05	0.07	0.04	0.05	0.03	13.35
0.64	0.62	0.70	0.84	0.84	0.53	1.78	0.84	0.89	0.89	1.00	1.14	5.33	0.89	0.53	0.04	0.04	0.04	0.05	0.05	0.03	0.11	0.05	0.06	0.06	0.06	0.07	0.33	0.06	0.03	18.56
0.73	0.89	2.00	0.53	1.23	1.00	0.62	0.73	8.00	0.67	1.07	0.67	0.67	1.78	0.80	0.05	0.06	0.13	0.03	0.08	0.06	0.04	0.05	0.50	0.04	0.07	0.04	0.04	0.11	0.05	22.70
16.00	16.00	16.00	1.33	16.00	16.00	2.67	16.00	0.48	5.33	16.00	16.00	2.29	0.84	5.33	1.00	1.00	1.00	0.08	1.00	1.00	0.17	1.00	0.03	0.33	1.00	1.00	0.14	0.05	0.33	155.42
16.00	16.00	2.67	1.14	1.78	16.00	0.94	1.33	0.94	16.00	8.00	4.00	16.00	4.00	4.00	1.00	1.00	0.17	0.07	0.11	1.00	0.06	0.08	0.06	1.00	0.50	0.25	1.00	0.25	0.25	115.60
1.78	16.00	5.33	2.67	4.00	16.00	2.29	2.67	4.00	4.00	3.20	16.00	3.20	0.57	1.00	0.11	1.00	0.33	0.17	0.25	1.00	0.14	0.17	0.25	0.25	0.20	1.00	0.20	0.04	0.06	87.87
16.00	16.00	4.00	3.20	1.45	16.00	0.80	5.33	1.78	8.00	5.33	16.00	8.00	0.94	8.00	1.00	1.00	0.25	0.20	0.09	1.00	0.05	0.33	0.11	0.50	0.33	1.00	0.50	0.06	0.50	117.77
0.52	1.07	0.52	2.29	0.73	0.62	8.00	1.23	0.80	1.14	0.70	1.23	0.64	5.33	0.73	0.03	0.07	0.03	0.14	0.05	0.04	0.50	0.08	0.05	0.07	0.04	0.08	0.04	0.33	0.05	27.12
0.53	0.84	0.53	2.00	0.76	0.57	3.20	2.29	0.73	0.80	1.33	0.80	0.73	8.00	0.62	0.03	0.05	0.03	0.13	0.05	0.04	0.20	0.14	0.05	0.05	0.08	0.05	0.05	0.50	0.04	25.21
0.55	0.50	0.57	1.07	0.55	0.55	1.33	4.00	0.84	0.94	0.52	0.48	0.50	0.50	0.52	0.03	0.03	0.04	0.07	0.03	0.03	0.08	0.25	0.05	0.06	0.03	0.03	0.03	0.03	0.03	14.27
1.14	0.67	0.67	0.80	0.57	0.94	4.00	3.20	1.45	2.29	0.64	0.76	0.84	2.29	1.60	0.07	0.04	0.04	0.05	0.04	0.06	0.25	0.20	0.09	0.14	0.04	0.05	0.05	0.14	0.10	23.22
16.00	16.00	0.76	0.94	0.53	0.50	1.14	0.94	16.00	1.45	0.67	0.50	1.33	0.52	1.33	1.00	1.00	0.05	0.06	0.03	0.03	0.07	0.06	1.00	0.09	0.04	0.03	0.08	0.03	0.08	62.29
0.50	0.48	0.80	0.76	0.94	0.48	0.89	0.89	5.33	2.00	0.76	0.57	1.14	3.20	1.45	0.03	0.03	0.05	0.05	0.06	0.03	0.06	0.06	0.33	0.13	0.05	0.04	0.07	0.20	0.09	21.48
0.70	0.59	1.45	0.55	0.62	16.00	0.70	0.62	3.20	1.60	0.94	3.20	0.80	0.53	2.29	0.04	0.04	0.09	0.03	0.04	1.00	0.04	0.04	0.20	0.10	0.06	0.20	0.05	0.03	0.14	35.89
0.67	0.57	1.60	0.70	1.00	1.45	0.76	0.64	2.67	3.20	0.57	0.52	0.62	0.55	1.23	0.04	0.04	0.10	0.04	0.06	0.09	0.05	0.04	0.17	0.20	0.04	0.03	0.04	0.03	0.08	17.79
1.60	0.70	0.55	1.78	0.64	0.64	16.00	1.14	2.29	0.59	0.62	0.62	0.59	1.14	0.64	0.10	0.04	0.03	0.11	0.04	0.04	1.00	0.07	0.14	0.04	0.04	0.04	0.04	0.07	0.04	31.38
0.94	0.76	0.84	1.78	0.89	0.70	2.00	0.52	1.00	0.70	0.59	1.33	0.70	1.45	0.84	0.06	0.05	0.05	0.11	0.06	0.04	0.13	0.03	0.06	0.04	0.04	0.08	0.04	0.09	0.05	15.98
0.76	0.73	0.89	1.78	0.80	1.07	0.67	1.07	2.00	1.07	1.78	1.78	0.89	1.23	0.70	0.05	0.05	0.06	0.11	0.05	0.07	0.04	0.07	0.13	0.07	0.11	0.11	0.06	0.08	0.04	18.27
1.45	16.00	0.94	0.67	5.33	0.76	0.64	0.76	0.76	1.33	0.89	0.73	0.76	2.00	1.07	0.09	1.00	0.06	0.04	0.33	0.05	0.04	0.05	0.05	0.08	0.06	0.05	0.05	0.13	0.07	36.23
0.80	1.00	0.50	4.00	0.67	16.00	1.23	0.48	1.60	1.23	2.67	2.67	1.60	16.00	1.78	0.05	0.06	0.03	0.25	0.04	1.00	0.08	0.03	0.10	0.08	0.17	0.17	0.10	1.00	0.11	55.49
16.00	16.00	2.29	16.00	0.48	0.89	1.60	0.50	1.07	0.48	4.00	2.00	1.60	0.48	0.94	1.00	1.00	0.14	1.00	0.03	0.06	0.10	0.03	0.07	0.03	0.25	0.13	0.10	0.03	0.06	68.36
2.00	1.23	1.14	16.00	1.14	1.23	5.33	0.59	1.33	0.53	1.78	1.60	2.00	1.00	0.67	0.13	0.08	0.07	1.00	0.07	0.08	0.33	0.04	0.08	0.03	0.11	0.10	0.13	0.06	0.04	39.93
1.33	16.00	1.00	16.00	1.07	1.14	1.45	1.00	1.23	0.50	2.29	2.29	1.00	0.73	0.89	0.08	1.00	0.06	1.00	0.07	0.07	0.09	0.06	0.08	0.03	0.14	0.14	0.06	0.05	0.06	50.91
16.00	1.33	1.78	0.64	2.00	1.33	0.57	1.60	0.67	2.67	1.78	0.70	4.00	2.67	2.67	1.00	0.08	0.11	0.04	0.13	0.08	0.04	0.10	0.04	0.17	0.11	0.04	0.25	0.17	0.17	42.92
1.00	16.00	1.33	0.64	1.33	0.84	0.59	0.55	0.62	0.62	0.84	0.89	0.94	0.59	2.00	0.06	1.00	0.08	0.04	0.08	0.05	0.04	0.03	0.04	0.04	0.05	0.06	0.06	0.04	0.13	30.59
1.07	0.80	0.64	0.73	0.59	0.67	1.00	0.67	1.14	2.00	1.23	1.00	1.07	0.80	0.76	0.07	0.05	0.04	0.05	0.04	0.04	0.06	0.04	0.07	0.13	0.08	0.06	0.07	0.05	0.05	15.05
0.59	0.55	0.59	0.89	0.52	1.60	0.53	1.78	0.52	0.52	0.53	0.59	0.52	0.70	0.48	0.04	0.03	0.04	0.06	0.03	0.10	0.03	0.11	0.03	0.03	0.03	0.04	0.03	0.04	0.03	11.59
0.57	0.64	0.62	0.50	0.50	0.52	0.50	0.70	0.57	0.55	0.55	0.55	0.48	0.67	0.50	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.03	8.94
0.48	0.53	0.73	0.52	1.60	0.73	0.55	8.00	0.53	0.84	0.73	0.94	1.78	1.33	1.14	0.03	0.03	0.05	0.03	0.10	0.05	0.03	0.50	0.03	0.05	0.05	0.06	0.11	0.08	0.07	21.72
0.89	0.94	1.23	0.48	2.29	0.80	0.52	1.45	0.50	0.57	0.50	0.53	0.53	0.64	0.57	0.06	0.06	0.08	0.03	0.14	0.05	0.03	0.09	0.03	0.04	0.03	0.03	0.03	0.04	0.04	13.23
16.00	16.00	0.50	1.23	2.67	16.00	0.48	0.80	0.55	0.76	0.48	0.64	0.55	0.62	0.59	1.00	1.00	0.03	0.08	0.17	1.00	0.03	0.05	0.03	0.05	0.03	0.04	0.03	0.04	0.04	61.50

Table 59: Modification Matrix 2 of DEA-PCA Technique

Modification Matrix 2																														
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30	D31
2.54	33.00	6.40	1.32	33.00	33.00	1.74	1.10	1.32	2.00	4.13	3.00	2.54	3.30	33.00	0.16	2.00	0.41	0.08	2.06	2.06	0.11	0.07	0.08	0.13	0.26	0.19	0.16	0.21	2.06	166.54
1.74	2.36	16.00	1.32	6.60	33.00	1.50	1.18	1.43	1.45	2.36	1.74	5.50	2.20	6.60	0.11	0.14	1.03	0.08	0.41	2.06	0.09	0.07	0.09	0.09	0.15	0.11	0.34	0.14	0.41	88.11
1.27	1.06	2.13	2.06	1.43	1.22	2.20	4.13	1.22	1.33	1.65	2.20	1.18	1.57	1.14	0.08	0.06	0.14	0.13	0.09	0.08	0.14	0.26	0.07	0.09	0.10	0.14	0.07	0.10	0.07	26.70
1.32	1.27	1.39	1.74	1.74	1.10	3.67	1.74	1.83	1.78	2.06	2.36	11.00	1.83	1.10	0.08	0.08	0.09	0.11	0.11	0.07	0.23	0.11	0.11	0.11	0.13	0.15	0.69	0.11	0.07	37.11
1.50	1.83	4.00	1.10	2.54	2.06	1.27	1.50	16.50	1.33	2.20	1.38	1.38	3.67	1.65	0.09	0.11	0.26	0.07	0.16	0.13	0.08	0.09	1.00	0.09	0.14	0.09	0.09	0.23	0.10	45.41
33.00	33.00	32.00	2.75	33.00	33.00	5.50	33.00	1.00	10.67	33.00	33.00	4.71	1.74	11.00	2.06	2.00	2.06	0.17	2.06	2.06	0.34	2.06	0.06	0.69	2.06	2.06	0.29	0.11	0.69	310.84
33.00	33.00	5.33	2.36	3.67	33.00	1.94	2.75	1.94	32.00	16.50	8.25	33.00	8.25	8.25	2.06	2.00	0.34	0.15	0.23	2.06	0.12	0.17	0.12	2.06	1.03	0.52	2.06	0.52	0.52	231.21
3.67	33.00	10.67	5.50	8.25	33.00	4.71	5.50	8.25	8.00	6.60	33.00	6.60	1.18	2.06	0.23	2.00	0.69	0.34	0.52	2.06	0.29	0.34	0.50	0.52	0.41	2.06	0.41	0.07	0.13	175.74
33.00	33.00	8.00	6.60	3.00	33.00	1.65	11.00	3.67	16.00	11.00	33.00	16.50	1.94	16.50	2.06	2.00	0.52	0.41	0.19	2.06	0.10	0.69	0.22	1.03	0.69	2.06	1.03	0.12	1.03	235.54
1.06	2.20	1.03	4.71	1.50	1.27	16.50	2.54	1.65	2.29	1.43	2.54	1.32	11.00	1.50	0.07	0.13	0.07	0.29	0.09	0.08	1.03	0.16	0.10	0.15	0.09	0.16	0.08	0.69	0.09	54.25
1.10	1.74	1.07	4.13	1.57	1.18	6.60	4.71	1.50	1.60	2.75	1.65	1.50	16.50	1.27	0.07	0.11	0.07	0.26	0.10	0.07	0.41	0.29	0.09	0.10	0.17	0.10	0.09	1.03	0.08	50.43
1.14	1.03	1.14	2.20	1.14	1.14	2.75	8.25	1.74	1.88	1.06	1.00	1.03	1.03	1.06	0.07	0.06	0.07	0.14	0.07	0.07	0.17	0.52	0.11	0.12	0.07	0.06	0.06	0.06	0.07	28.53
2.36	1.38	1.33	1.65	1.18	1.94	8.25	6.60	3.00	4.57	1.32	1.57	1.74	4.71	3.30	0.15	0.08	0.09	0.10	0.07	0.12	0.52	0.41	0.18	0.29	0.08	0.10	0.11	0.29	0.21	46.45
33.00	33.00	1.52	1.94	1.10	1.03	2.36	1.94	33.00	2.91	1.38	1.03	2.75	1.06	2.75	2.06	2.00	0.10	0.12	0.07	0.06	0.15	0.12	2.00	0.19	0.09	0.06	0.17	0.07	0.17	124.58
1.03	1.00	1.60	1.57	1.94	1.00	1.83	1.83	11.00	4.00	1.57	1.18	2.36	6.60	3.00	0.06	0.06	0.10	0.10	0.12	0.06	0.11	0.11	0.67	0.26	0.10	0.07	0.15	0.41	0.19	42.96
1.43	1.22	2.91	1.14	1.27	33.00	1.43	1.27	6.60	3.20	1.94	6.60	1.65	1.10	4.71	0.09	0.07	0.19	0.07	0.08	2.06	0.09	0.08	0.40	0.21	0.12	0.41	0.10	0.07	0.29	71.78
1.38	1.18	3.20	1.43	2.06	3.00	1.57	1.32	5.50	6.40	1.18	1.06	1.27	1.14	2.54	0.09	0.07	0.21	0.09	0.13	0.19	0.10	0.08	0.33	0.41	0.07	0.07	0.08	0.07	0.16	35.58
3.30	1.43	1.10	3.67	1.32	1.32	33.00	2.36	4.71	1.19	1.27	1.27	1.22	2.36	1.32	0.21	0.09	0.07	0.23	0.08	0.08	2.06	0.15	0.29	0.08	0.08	0.08	0.08	0.15	0.08	62.76
1.94	1.57	1.68	3.67	1.83	1.43	4.13	1.06	2.06	1.39	1.22	2.75	1.43	3.00	1.74	0.12	0.10	0.11	0.23	0.11	0.09	0.26	0.07	0.13	0.09	0.08	0.17	0.09	0.19	0.11	31.95
1.57	1.50	1.78	3.67	1.65	2.20	1.38	2.20	4.13	2.13	3.67	3.67	1.83	2.54	1.43	0.10	0.09	0.11	0.23	0.10	0.14	0.09	0.14	0.25	0.14	0.23	0.23	0.11	0.16	0.09	36.54
3.00	33.00	1.88	1.38	11.00	1.57	1.32	1.57	1.57	2.67	1.83	1.50	1.57	4.13	2.20	0.19	2.00	0.12	0.09	0.69	0.10	0.08	0.10	0.10	0.17	0.11	0.09	0.10	0.26	0.14	72.46
1.65	2.06	1.00	8.25	1.38	33.00	2.54	1.00	3.30	2.46	5.50	5.50	3.30	33.00	3.67	0.10	0.13	0.06	0.52	0.09	2.06	0.16	0.06	0.20	0.16	0.34	0.34	0.21	2.06	0.23	110.98
33.00	33.00	4.57	33.00	1.00	1.83	3.30	1.03	2.20	0.97	8.25	4.13	3.30	1.00	1.94	2.06	2.00	0.29	2.06	0.06	0.11	0.21	0.06	0.13	0.06	0.52	0.26	0.21	0.06	0.12	136.72
4.13	2.54	2.29	33.00	2.36	2.54	11.00	1.22	2.75	1.07	3.67	3.30	4.13	2.06	1.38	0.26	0.15	0.15	2.06	0.15	0.16	0.69	0.08	0.17	0.07	0.23	0.21	0.26	0.13	0.09	79.87
2.75	33.00	2.00	33.00	2.20	2.36	3.00	2.06	2.54	1.00	4.71	4.71	2.06	1.50	1.83	0.17	2.00	0.13	2.06	0.14	0.15	0.19	0.13	0.15	0.06	0.29	0.29	0.13	0.09	0.11	101.82
33.00	2.75	3.56	1.32	4.13	2.75	1.18	3.30	1.38	5.33	3.67	1.43	8.25	5.50	5.50	2.06	0.17	0.23	0.08	0.26	0.17	0.07	0.21	0.08	0.34	0.23	0.09	0.52	0.34	0.34	85.84
2.06	33.00	2.67	1.32	2.75	1.74	1.22	1.14	1.27	1.23	1.74	1.83	1.94	1.22	4.13	0.13	2.00	0.17	0.08	0.17	0.11	0.08	0.07	0.08	0.08	0.11	0.11	0.12	0.08	0.26	61.18
2.20	1.65	1.28	1.50	1.22	1.38	2.06	1.38	2.36	4.00	2.54	2.06	2.20	1.65	1.57	0.14	0.10	0.08	0.09	0.08	0.09	0.13	0.09	0.14	0.26	0.16	0.13	0.14	0.10	0.10	30.09
1.22	1.14	1.19	1.83	1.06	3.30	1.10	3.67	1.06	1.03	1.10	1.22	1.06	1.43	1.00	0.08	0.07	0.08	0.11	0.07	0.21	0.07	0.23	0.06	0.07	0.07	0.08	0.07	0.09	0.06	23.18
1.18	1.32	1.23	1.03	1.03	1.06	1.03	1.43	1.18	1.10	1.14	1.14	1.00	1.38	1.03	0.07	0.08	0.08	0.06	0.06	0.07	0.06	0.09	0.07	0.07	0.07	0.07	0.06	0.09	0.06	17.89
1.00	1.10	1.45	1.06	3.30	1.50	1.14	16.50	1.10	1.68	1.50	1.94	3.67	2.75	2.36	0.06	0.07	0.09	0.07	0.21	0.09	0.07	1.03	0.07	0.11	0.09	0.12	0.23	0.17	0.15	43.43
1.83	1.94	2.46	1.00	4.71	1.65	1.06	3.00	1.03	1.14	1.03	1.10	1.10	1.32	1.18	0.11	0.12	0.16	0.06	0.29	0.10	0.07	0.19	0.06	0.07	0.06	0.07	0.07	0.08	0.07	26.46
33.00	33.00	1.00	2.54	5.50	33.00	1.00	1.65	1.14	1.52	1.00	1.32	1.14	1.27	1.22	2.06	2.00	0.06	0.16	0.34	2.06	0.06	0.10	0.07	0.10	0.06	0.08	0.07	0.08	0.08	123.00

Table 60: Normalization Matrix of DEA-PCA Technique

Normalization Matrix																														
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30	D31
0.93	3.50	1.86	0.28	3.50	3.50	0.55	0.10	0.28	0.69	1.42	1.10	0.93	1.19	3.50	(1.84)	0.69	(0.89)	(2.49)	0.72	0.72	(2.22)	(2.68)	(2.53)	(2.05)	(1.36)	(1.67)	(1.84)	(1.58)	0.72	5.12
0.55	0.86	2.77	0.28	1.89	3.50	0.41	0.16	0.36	0.37	0.86	0.55	1.70	0.79	1.89	(2.22)	(1.95)	0.03	(2.49)	(0.89)	0.72	(2.37)	(2.61)	(2.44)	(2.37)	(1.92)	(2.22)	(1.07)	(1.98)	(0.89)	4.48
0.24	0.06	0.76	0.72	0.36	0.20	0.79	1.42	0.20	0.29	0.50	0.79	0.16	0.45	0.13	(2.53)	(2.74)	(1.98)	(2.05)	(2.41)	(2.57)	(1.98)	(1.36)	(2.60)	(2.45)	(2.27)	(1.98)	(2.61)	(2.32)	(2.64)	3.28
0.28	0.24	0.33	0.55	0.55	0.10	1.30	0.55	0.61	0.58	0.72	0.86	2.40	0.61	0.10	(2.49)	(2.56)	(2.41)	(2.22)	(2.22)	(2.68)	(1.47)	(2.22)	(2.20)	(2.17)	(2.05)	(1.92)	(0.37)	(2.17)	(2.68)	3.61
0.41	0.61	1.39	0.10	0.93	0.72	0.24	0.41	2.80	0.29	0.79	0.32	0.32	1.30	0.50	(2.37)	(2.20)	(1.36)	(2.68)	(1.84)	(2.05)	(2.53)	(2.37)	-	(2.45)	(1.98)	(2.45)	(2.45)	(1.47)	(2.27)	3.82
3.50	3.50	3.47	1.01	3.50	3.50	1.70	3.50	-	2.37	3.50	3.50	1.55	0.55	2.40	0.72	0.69	0.72	(1.76)	0.72	0.72	(1.07)	0.72	(2.80)	(0.37)	0.72	0.72	(1.22)	(2.22)	(0.37)	5.74
3.50	3.50	1.67	0.86	1.30	3.50	0.66	1.01	0.66	3.47	2.80	2.11	3.50	2.11	2.11	0.72	0.69	(1.07)	(1.92)	(1.47)	0.72	(2.11)	(1.76)	(2.14)	0.72	0.03	(0.66)	0.72	(0.66)	(0.66)	5.44
1.30	3.50	2.37	1.70	2.11	3.50	1.55	1.70	2.11	2.08	1.89	3.50	1.89	0.16	0.72	(1.47)	0.69	(0.37)	(1.07)	(0.66)	0.72	(1.22)	(1.07)	(0.69)	(0.66)	(0.89)	0.72	(0.89)	(2.61)	(2.05)	5.17
3.50	3.50	2.08	1.89	1.10	3.50	0.50	2.40	1.30	2.77	2.40	3.50	2.80	0.66	2.80	0.72	0.69	(0.66)	(0.89)	(1.67)	0.72	(2.27)	(0.37)	(1.50)	0.03	(0.37)	0.72	0.03	(2.11)	0.03	5.46
0.06	0.79	0.03	1.55	0.41	0.24	2.80	0.93	0.50	0.83	0.36	0.93	0.28	2.40	0.41	(2.71)	(2.01)	(2.71)	(1.22)	(2.37)	(2.53)	0.03	(1.84)	(2.30)	(1.92)	(2.41)	(1.84)	(2.49)	(0.37)	(2.37)	3.99
0.10	0.55	0.06	1.42	0.45	0.16	1.89	1.55	0.41	0.47	1.01	0.50	0.41	2.80	0.24	(2.68)	(2.25)	(2.68)	(1.36)	(2.32)	(2.61)	(0.89)	(1.22)	(2.40)	(2.27)	(1.76)	(2.27)	(2.37)	0.03	(2.53)	3.92
0.13	0.03	0.13	0.79	0.13	0.13	1.01	2.11	0.55	0.63	0.06	-	0.03	0.03	0.06	(2.64)	(2.77)	(2.61)	(1.98)	(2.64)	(2.64)	(1.76)	(0.66)	(2.25)	(2.11)	(2.71)	(2.77)	(2.74)	(2.74)	(2.71)	3.35
0.86	0.32	0.29	0.50	0.16	0.66	2.11	1.89	1.10	1.52	0.28	0.45	0.55	1.55	1.19	(1.92)	(2.48)	(2.45)	(2.27)	(2.61)	(2.11)	(0.66)	(0.89)	(1.70)	(1.22)	(2.49)	(2.32)	(2.22)	(1.22)	(1.58)	3.84
3.50	3.50	0.42	0.66	0.10	0.03	0.86	0.66	3.50	1.07	0.32	0.03	1.01	0.06	1.01	0.72	0.69	(2.32)	(2.11)	(2.68)	(2.74)	(1.92)	(2.11)	0.69	(1.67)	(2.45)	(2.74)	(1.76)	(2.71)	(1.76)	4.82
0.03	-	0.47	0.45	0.66	-	0.61	0.61	2.40	1.39	0.45	0.16	0.86	1.89	1.10	(2.74)	(2.80)	(2.27)	(2.32)	(2.11)	(2.77)	(2.17)	(2.17)	(0.41)	(1.36)	(2.32)	(2.61)	(1.92)	(0.89)	(1.67)	3.76
0.36	0.20	1.07	0.13	0.24	3.50	0.36	0.24	1.89	1.16	0.66	1.89	0.50	0.10	1.55	(2.41)	(2.60)	(1.67)	(2.64)	(2.53)	0.72	(2.41)	(2.53)	(0.92)	(1.58)	(2.11)	(0.89)	(2.27)	(2.68)	(1.22)	4.27
0.32	0.16	1.16	0.36	0.72	1.10	0.45	0.28	1.70	1.86	0.16	0.06	0.24	0.13	0.93	(2.45)	(2.64)	(1.58)	(2.41)	(2.05)	(1.67)	(2.32)	(2.49)	(1.10)	(0.89)	(2.61)	(2.71)	(2.53)	(2.64)	(1.84)	3.57
1.19	0.36	0.10	1.30	0.28	0.28	3.50	0.86	1.55	0.17	0.24	0.24	0.20	0.86	0.28	(1.58)	(2.44)	(2.64)	(1.47)	(2.49)	(2.49)	0.72	(1.92)	(1.25)	(2.57)	(2.53)	(2.53)	(2.57)	(1.92)	(2.49)	4.14
0.66	0.45	0.52	1.30	0.61	0.36	1.42	0.06	0.72	0.33	0.20	1.01	0.36	1.10	0.55	(2.11)	(2.35)	(2.22)	(1.47)	(2.17)	(2.41)	(1.36)	(2.71)	(2.08)	(2.41)	(2.57)	(1.76)	(2.41)	(1.67)	(2.22)	3.46
0.45	0.41	0.58	1.30	0.50	0.79	0.32	0.79	1.42	0.76	1.30	1.30	0.61	0.93	0.36	(2.32)	(2.40)	(2.17)	(1.47)	(2.27)	(1.98)	(2.45)	(1.98)	(1.39)	(1.98)	(1.47)	(1.47)	(2.17)	(1.84)	(2.41)	3.60
1.10	3.50	0.63	0.32	2.40	0.45	0.28	0.45	0.45	0.98	0.61	0.41	0.45	1.42	0.79	(1.67)	0.69	(2.11)	(2.45)	(0.37)	(2.32)	(2.49)	(2.32)	(2.35)	(1.76)	(2.17)	(2.37)	(2.32)	(1.36)	(1.98)	4.28
0.50	0.72	-	2.11	0.32	3.50	0.93	-	1.19	0.90	1.70	1.70	1.19	3.50	1.30	(2.27)	(2.08)	(2.74)	(0.66)	(2.45)	0.72	(1.84)	(2.77)	(1.61)	(1.84)	(1.07)	(1.07)	(1.58)	0.72	(1.47)	4.71
3.50	3.50	1.52	3.50	-	0.61	1.19	0.03	0.79	(0.03)	2.11	1.42	1.19	-	0.66	0.72	0.69	(1.22)	0.72	(2.77)	(2.17)	(1.58)	(2.74)	(2.01)	(2.77)	(0.66)	(1.36)	(1.58)	(2.77)	(2.11)	4.92
1.42	0.93	0.83	3.50	0.86	0.93	2.40	0.20	1.01	0.06	1.30	1.19	1.42	0.72	0.32	(1.36)	(1.87)	(1.92)	0.72	(1.92)	(1.84)	(0.37)	(2.57)	(1.79)	(2.68)	(1.47)	(1.58)	(1.36)	(2.05)	(2.45)	4.38
1.01	3.50	0.69	3.50	0.79	0.86	1.10	0.72	0.93	-	1.55	1.55	0.72	0.41	0.61	(1.76)	0.69	(2.05)	0.72	(1.98)	(1.92)	(1.67)	(2.05)	(1.87)	(2.74)	(1.22)	(1.22)	(2.05)	(2.37)	(2.17)	4.62
3.50	1.01	1.27	0.28	1.42	1.01	0.16	1.19	0.32	1.67	1.30	0.36	2.11	1.70	1.70	0.72	(1.79)	(1.47)	(2.49)	(1.36)	(1.76)	(2.61)	(1.58)	(2.48)	(1.07)	(1.47)	(2.41)	(0.66)	(1.07)	(1.07)	4.45
0.72	3.50	0.98	0.28	1.01	0.55	0.20	0.13	0.24	0.21	0.55	0.61	0.66	0.20	1.42	(2.05)	0.69	(1.76)	(2.49)	(1.76)	(2.22)	(2.57)	(2.64)	(2.56)	(2.53)	(2.22)	(2.17)	(2.11)	(2.57)	(1.36)	4.11
0.79	0.50	0.25	0.41	0.20	0.32	0.72	0.32	0.86	1.39	0.93	0.72	0.79	0.50	0.45	(1.98)	(2.30)	(2.49)	(2.37)	(2.57)	(2.45)	(2.05)	(2.45)	(1.95)	(1.36)	(1.84)	(2.05)	(1.98)	(2.27)	(2.32)	3.40
0.20	0.13	0.17	0.61	0.06	1.19	0.10	1.30	0.06	0.03	0.10	0.20	0.06	0.36	-	(2.57)	(2.67)	(2.57)	(2.17)	(2.71)	(1.58)	(2.68)	(1.47)	(2.74)	(2.71)	(2.68)	(2.57)	(2.71)	(2.41)	(2.77)	3.14
0.16	0.28	0.21	0.03	0.03	0.06	0.03	0.36	0.16	0.10	0.13	0.13	-	0.32	0.03	(2.61)	(2.53)	(2.53)	(2.74)	(2.74)	(2.71)	(2.74)	(2.41)	(2.64)	(2.64)	(2.64)	(2.64)	(2.77)	(2.45)	(2.74)	2.88
-	0.10	0.37	0.06	1.19	0.41	0.13	2.80	0.10	0.52	0.41	0.66	1.30	1.01	0.86	(2.77)	(2.71)	(2.37)	(2.71)	(1.58)	(2.37)	(2.64)	0.03	(2.71)	(2.22)	(2.37)	(2.11)	(1.47)	(1.76)	(1.92)	3.77
0.61	0.66	0.90	-	1.55	0.50	0.06	1.10	0.03	0.13	0.03	0.10	0.10	0.28	0.16	(2.17)	(2.14)	(1.84)	(2.77)	(1.22)	(2.27)	(2.71)	(1.67)	(2.77)	(2.61)	(2.74)	(2.68)	(2.68)	(2.49)	(2.61)	3.28
3.50	3.50	-	0.93	1.70	3.50	-	0.50	0.13	0.42	-	0.28	0.13	0.24	0.20	0.72	0.69	(2.74)	(1.84)	(1.07)	0.72	(2.77)	(2.27)	(2.67)	(2.32)	(2.77)	(2.49)	(2.64)	(2.53)	(2.57)	4.81

Table 61: Variance obtained through Principal Component Analysis and Factor Analysis

Total Variance Explained			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5264.07	89.11	89.11
2	165.74	2.81	91.92
3	99.05	1.68	93.6
4	92.91	1.57	95.17
5	78.47	1.33	96.5
6	44.51	0.75	97.25
7	41.04	0.69	97.95
8	40.1	0.68	98.62
9	28.52	0.48	99.11
10	25.01	0.42	99.53
11	14.24	0.24	99.77
12	6.57	0.11	99.88
13	3.25	0.06	99.94
14	2.52	0.04	99.98
15	1.15	0.02	100
16	0	0	100
17	0	0	100
18	0	0	100
19	0	0	100
20	0	0	100
21	0	0	100
22	0	0	100
23	0	0	100
24	0	0	100
25	0	0	100
26	0	0	100
27	0	0	100
28	0	0	100
29	0	0	100
30	0	0	100
31	0	0	100

Table 62: Component Matrix in DEA-PCA Technique

Component Matrix															
Var	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VAR001	9.1	5.5	(3.8)	4.4	1.6	2.2	(2.3)	1.0	0.6	0.8	0.7	0.3	0.1	(0.0)	0.0
VAR002	11.2	6.5	6.6	0.7	1.0	(1.6)	0.6	(0.6)	(0.2)	1.6	(0.3)	(0.1)	(0.2)	0.1	(0.0)
VAR003	4.2	(1.8)	(0.5)	(1.9)	1.8	(0.0)	(1.3)	0.6	(0.0)	(0.3)	(1.5)	1.1	(1.0)	0.3	0.3
VAR004	1.4	4.7	(0.0)	(4.1)	(5.7)	0.6	(2.0)	0.2	(0.1)	(1.4)	(0.1)	(0.2)	0.1	(0.1)	0.1
VAR005	4.6	(2.2)	2.7	(2.4)	3.0	2.6	(0.1)	(0.8)	(0.1)	(0.5)	(0.2)	0.5	0.9	(0.7)	0.2
VAR006	10.3	(6.8)	3.1	3.9	(2.9)	(0.0)	(2.0)	1.7	1.1	0.5	(0.6)	(0.4)	0.1	-	(0.1)
VAR007	(0.3)	(0.0)	(1.8)	(2.3)	(1.2)	1.0	3.1	0.6	3.5	1.7	(0.2)	(0.0)	(0.0)	0.0	(0.0)
VAR008	3.2	(1.3)	(2.0)	(2.5)	2.8	(0.4)	(1.0)	0.1	(0.8)	1.0	(0.0)	(2.0)	(0.2)	(0.2)	0.1
VAR009	0.3	1.8	(0.2)	1.5	1.1	(0.5)	2.7	3.8	(0.9)	(2.5)	(0.6)	(0.3)	0.1	(0.1)	(0.1)
VAR010	3.8	(0.4)	(1.8)	2.1	(0.2)	(1.7)	0.9	(2.5)	0.1	(0.7)	(0.5)	(0.2)	0.7	0.7	0.5
VAR011	5.1	(0.6)	(1.7)	(1.5)	0.9	(0.1)	(0.6)	(0.8)	(0.9)	0.2	(1.0)	0.3	0.4	0.6	(0.8)
VAR012	6.9	(1.8)	(0.9)	(2.0)	0.6	(4.1)	(0.7)	1.2	0.2	0.4	2.1	0.8	0.2	(0.2)	-
VAR013	3.4	-	(1.8)	2.5	(1.1)	(1.4)	0.7	(3.0)	0.4	(1.1)	(0.4)	0.0	(0.5)	(0.9)	(0.2)
VAR014	0.2	(1.9)	(1.0)	0.7	(2.9)	1.6	2.1	0.1	(3.4)	2.0	0.6	0.3	(0.2)	(0.0)	0.1
VAR015	3.5	(1.7)	2.3	0.2	0.8	2.1	0.6	(1.4)	0.6	(1.9)	2.1	(0.3)	(0.5)	0.5	(0.1)
VAR016	0.6	0.3	(0.2)	0.3	0.1	0.1	(0.1)	0.1	0.0	0.1	0.0	0.0	0.0	-	-
VAR017	0.7	0.4	0.4	0.0	0.1	(0.1)	0.0	(0.0)	(0.0)	0.1	(0.0)	(0.0)	(0.0)	-	-
VAR018	0.3	(0.1)	(0.0)	(0.1)	0.1	-	(0.1)	0.0	-	(0.0)	(0.1)	0.1	(0.1)	0.0	0.0
VAR019	0.1	0.3	-	(0.3)	(0.4)	0.0	(0.1)	0.0	(0.0)	(0.1)	-	(0.0)	0.0	-	0.0
VAR020	0.3	(0.1)	0.2	(0.2)	0.2	0.2	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	0.0	0.1	(0.0)	0.0
VAR021	0.6	(0.4)	0.2	0.2	(0.2)	-	(0.1)	0.1	0.1	0.0	(0.0)	(0.0)	0.0	-	-
VAR022	(0.0)	-	(0.1)	(0.2)	(0.1)	0.1	0.2	0.0	0.2	0.1	(0.0)	-	-	-	-
VAR023	0.2	(0.1)	(0.1)	(0.2)	0.2	(0.0)	(0.1)	-	(0.1)	0.1	-	(0.1)	(0.0)	(0.0)	0.0
VAR024	0.0	0.1	(0.0)	0.1	0.1	(0.0)	0.2	0.2	(0.1)	(0.2)	(0.0)	(0.0)	0.0	(0.0)	-
VAR025	0.3	(0.0)	(0.1)	0.1	(0.0)	(0.1)	0.1	(0.2)	0.0	(0.0)	(0.0)	(0.0)	0.1	0.0	0.0
VAR026	0.3	(0.0)	(0.1)	(0.1)	0.1	(0.0)	(0.0)	(0.1)	(0.1)	0.0	(0.1)	0.0	0.0	0.0	(0.1)
VAR027	0.4	(0.1)	(0.1)	(0.1)	0.0	(0.3)	(0.0)	0.1	0.0	0.0	0.1	0.1	0.0	(0.0)	-
VAR028	0.2	-	(0.1)	0.2	(0.1)	(0.1)	0.0	(0.2)	0.0	(0.1)	(0.0)	-	(0.0)	(0.1)	(0.0)
VAR029	0.0	(0.1)	(0.1)	0.1	(0.2)	0.1	0.1	-	(0.2)	0.1	0.0	0.0	(0.0)	-	0.0
VAR030	0.2	(0.1)	0.1	0.0	0.1	0.1	0.0	(0.1)	0.0	(0.1)	0.1	(0.0)	(0.0)	0.0	(0.0)
VAR031	69.2	(0.2)	(0.8)	(0.8)	(0.4)	0.3	0.7	0.0	(0.1)	(0.3)	(0.0)	(0.1)	(0.0)	(0.0)	0.0

Table 63: Variance and PC Matrix of DEA-PCA Technique

Variance vs PC Matrix															
Variance	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15
VAR001	0.1	0.4	(0.4)	0.5	0.2	0.3	(0.4)	0.2	0.1	0.2	0.2	0.1	0.1	(0.0)	0.0
VAR002	0.2	0.5	0.7	0.1	0.1	(0.2)	0.1	(0.1)	(0.0)	0.3	(0.1)	(0.0)	(0.1)	0.1	(0.0)
VAR003	0.1	(0.1)	(0.0)	(0.2)	0.2	(0.0)	(0.2)	0.1	(0.0)	(0.1)	(0.4)	0.4	(0.6)	0.2	0.3
VAR004	0.0	0.4	(0.0)	(0.4)	(0.6)	0.1	(0.3)	0.0	(0.0)	(0.3)	(0.0)	(0.1)	0.1	(0.0)	0.1
VAR005	0.1	(0.2)	0.3	(0.2)	0.3	0.4	(0.0)	(0.1)	(0.0)	(0.1)	(0.1)	0.2	0.5	(0.4)	0.1
VAR006	0.1	(0.5)	0.3	0.4	(0.3)	(0.0)	(0.3)	0.3	0.2	0.1	(0.2)	(0.2)	0.1	-	(0.1)
VAR007	(0.0)	(0.0)	(0.2)	(0.2)	(0.1)	0.1	0.5	0.1	0.7	0.3	(0.1)	(0.0)	(0.0)	0.0	(0.0)
VAR008	0.0	(0.1)	(0.2)	(0.3)	0.3	(0.1)	(0.2)	0.0	(0.2)	0.2	(0.0)	(0.8)	(0.1)	(0.1)	0.1
VAR009	0.0	0.1	(0.0)	0.2	0.1	(0.1)	0.4	0.6	(0.2)	(0.5)	(0.2)	(0.1)	0.1	(0.1)	(0.0)
VAR010	0.1	(0.0)	(0.2)	0.2	(0.0)	(0.2)	0.1	(0.4)	0.0	(0.1)	(0.1)	(0.1)	0.4	0.4	0.5
VAR011	0.1	(0.0)	(0.2)	(0.2)	0.1	(0.0)	(0.1)	(0.1)	(0.2)	0.0	(0.3)	0.1	0.2	0.3	(0.7)
VAR012	0.1	(0.1)	(0.1)	(0.2)	0.1	(0.6)	(0.1)	0.2	0.0	0.1	0.6	0.3	0.1	(0.1)	-
VAR013	0.0	-	(0.2)	0.3	(0.1)	(0.2)	0.1	(0.5)	0.1	(0.2)	(0.1)	0.0	(0.3)	(0.6)	(0.2)
VAR014	0.0	(0.1)	(0.1)	0.1	(0.3)	0.2	0.3	0.0	(0.6)	0.4	0.2	0.1	(0.1)	(0.0)	0.1
VAR015	0.0	(0.1)	0.2	0.0	0.1	0.3	0.1	(0.2)	0.1	(0.4)	0.6	(0.1)	(0.3)	0.3	(0.1)
VAR016	0.0	0.0	(0.0)	0.0	0.0	0.0	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0	-	-
VAR017	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)	-	-
VAR018	0.0	(0.0)	(0.0)	(0.0)	0.0	-	(0.0)	0.0	-	(0.0)	(0.0)	0.0	(0.0)	0.0	0.0
VAR019	0.0	0.0	-	(0.0)	(0.0)	0.0	(0.0)	0.0	(0.0)	(0.0)	-	(0.0)	0.0	-	0.0
VAR020	0.0	(0.0)	0.0	(0.0)	0.0	0.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	0.0	0.0	(0.0)	0.0
VAR021	0.0	(0.0)	0.0	0.0	(0.0)	-	(0.0)	0.0	0.0	0.0	(0.0)	(0.0)	0.0	-	-
VAR022	(0.0)	-	(0.0)	(0.0)	(0.0)	0.0	0.0	0.0	0.0	0.0	(0.0)	-	-	-	-
VAR023	0.0	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	-	(0.0)	0.0	-	(0.0)	(0.0)	(0.0)	0.0
VAR024	0.0	0.0	(0.0)	0.0	0.0	(0.0)	0.0	0.0	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	-
VAR025	0.0	(0.0)	(0.0)	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0	(0.0)	(0.0)	(0.0)	0.0	0.0	0.0
VAR026	0.0	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)	0.0	0.0	0.0	(0.0)
VAR027	0.0	(0.0)	(0.0)	(0.0)	0.0	(0.0)	(0.0)	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	-
VAR028	0.0	-	(0.0)	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0	(0.0)	(0.0)	-	(0.0)	(0.0)	(0.0)
VAR029	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0	0.0	-	(0.0)	0.0	0.0	0.0	(0.0)	-	0.0
VAR030	0.0	(0.0)	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	(0.0)	0.0	(0.0)
VAR031	1.0	(0.0)	(0.1)	(0.1)	(0.0)	0.0	0.1	0.0	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	0.0

Table 64: Principal Component Matrix of DEA-PCA Technique

Principal Component Matix														
PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15
6.78	(1.46)	3.66	0.37	0.63	1.55	(0.11)	(0.81)	0.23	(0.12)	0.45	1.02	(0.20)	0.21	(0.42)
5.49	(2.47)	1.23	0.59	(0.26)	0.96	(0.64)	(0.17)	0.45	(0.75)	(0.89)	0.99	(1.35)	(0.39)	(0.02)
3.34	(0.29)	(0.90)	(1.28)	(0.02)	(0.05)	0.12	0.24	(0.10)	0.23	(0.06)	(0.55)	(0.26)	(0.05)	0.22
3.77	(0.06)	(1.25)	(0.39)	(0.51)	(0.49)	1.24	(0.83)	0.32	(0.34)	(0.31)	0.07	(0.30)	(1.35)	(0.52)
4.07	(0.29)	(0.10)	0.03	0.43	0.44	1.48	1.64	(1.25)	(1.10)	(0.86)	0.31	(0.34)	(0.05)	(0.00)
8.45	(0.95)	0.32	(0.75)	2.28	(0.20)	(2.21)	(0.77)	0.90	1.30	(0.03)	0.20	0.24	0.57	(0.28)
7.76	0.04	(0.04)	2.68	(0.39)	(0.71)	(0.45)	(1.92)	(0.31)	0.48	(0.11)	0.59	0.09	0.46	(0.59)
7.19	(0.36)	1.19	(0.39)	0.13	(2.22)	(0.38)	0.85	0.88	(0.18)	(0.84)	0.23	0.51	(0.44)	0.10
7.94	0.32	0.13	1.25	0.22	(1.56)	(1.65)	(0.62)	0.34	(0.48)	0.91	(0.43)	(0.38)	0.52	(0.40)
4.12	0.12	(0.84)	(1.62)	(1.80)	0.48	2.26	0.21	0.01	1.28	0.46	(0.43)	0.13	0.03	0.45
4.03	(0.09)	(1.10)	(1.59)	(1.48)	0.77	1.72	0.02	(1.13)	1.33	0.12	(0.80)	(0.01)	(0.09)	(0.10)
3.25	0.03	(1.00)	(1.15)	0.01	0.12	0.48	0.27	0.20	0.03	(0.35)	(1.87)	(0.03)	0.01	0.55
4.13	(0.34)	(1.35)	(0.27)	(0.39)	0.57	1.79	0.14	0.21	0.38	0.39	(1.46)	(0.22)	0.49	0.65
5.76	3.80	0.09	1.85	1.08	0.26	1.42	1.40	0.17	(0.84)	(0.24)	(0.69)	(0.37)	0.12	0.04
3.78	(0.31)	(0.89)	(0.06)	(0.32)	0.51	2.40	0.31	(1.35)	(1.36)	(0.11)	(0.34)	(0.02)	0.13	0.46
5.03	(2.25)	0.42	1.08	(0.57)	(0.88)	0.03	1.54	0.65	(1.40)	0.25	(0.05)	0.01	0.72	(0.10)
3.81	(0.61)	(0.19)	0.33	0.06	0.21	0.89	0.39	0.17	(1.52)	(0.77)	(0.15)	0.21	0.79	1.07
4.21	0.86	(1.42)	(1.09)	(1.01)	1.14	2.14	1.42	1.53	0.55	(0.10)	(0.71)	(0.00)	(0.22)	0.02
3.64	0.28	(0.49)	(0.86)	(1.01)	0.42	0.91	0.54	0.21	(0.01)	0.46	0.46	(0.02)	(0.20)	0.28
3.97	(0.11)	(0.69)	(0.67)	(0.62)	(0.44)	0.33	0.64	(0.81)	(0.68)	(0.10)	(0.08)	0.37	0.07	(0.36)
5.15	1.22	1.94	(0.06)	0.84	0.69	0.84	(0.77)	(0.97)	0.88	(0.17)	0.45	0.56	(0.33)	0.50
5.59	(1.61)	0.07	0.52	(3.49)	0.24	0.78	0.74	(1.35)	0.22	0.68	0.18	0.43	0.21	(0.98)
6.22	3.87	(0.04)	(0.58)	(1.19)	(0.01)	(1.41)	0.55	0.73	0.16	(0.18)	1.00	(0.71)	0.28	(1.28)
4.99	1.34	(0.90)	(1.69)	(2.34)	0.55	0.17	0.64	1.04	(0.36)	(0.31)	0.46	0.08	(0.83)	(0.65)
5.63	2.48	1.32	(1.85)	(1.52)	(0.51)	(0.39)	0.46	0.04	0.07	(0.12)	(0.11)	0.01	(0.17)	(0.84)
5.53	0.39	(1.42)	1.63	0.70	1.51	(0.40)	(1.32)	(0.70)	0.04	0.32	0.25	(0.37)	(0.19)	0.11
4.88	1.28	2.19	(0.04)	0.70	(0.08)	0.34	(0.63)	(0.01)	0.29	0.12	0.40	(0.79)	0.15	(0.26)
3.66	0.23	(0.90)	0.15	(0.19)	(0.33)	0.84	(0.24)	0.00	(0.37)	(0.09)	0.02	0.39	0.40	(0.09)
3.19	(0.59)	(0.21)	(0.32)	(0.52)	0.10	(0.42)	0.44	(0.23)	0.26	(0.17)	(1.14)	(0.16)	(0.17)	0.14
2.73	0.02	(0.24)	(0.23)	0.01	0.06	0.30	0.12	(0.35)	0.08	(0.07)	(0.17)	(0.18)	0.07	0.07
3.98	(1.19)	(0.78)	(0.94)	0.76	0.14	0.30	(0.89)	(0.98)	0.06	0.33	(1.72)	(0.41)	(0.99)	0.21
3.47	(0.32)	0.24	(0.53)	0.92	0.76	(0.24)	(0.02)	(0.28)	0.25	(0.38)	(0.21)	(0.01)	(0.58)	0.64
6.22	1.32	2.11	2.19	(0.22)	1.10	(1.88)	0.87	0.64	1.44	(0.13)	(0.43)	1.03	(0.63)	0.37

Table 65: Weights of each Principal Component

PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15
0.8911	0.0281	0.0168	0.0157	0.0133	0.0075	0.0069	0.0068	0.0048	0.0042	0.0024	0.0011	0.0006	0.0004	0.0002

Table 66: Final Efficiency Scores of Discoms using DEA-PCA Technique

S.No	State	Discom	Efficiency	Rank
1	Andhra Pradesh	APEPDCL	6.09	5
2		APSPDCL	4.84	12
3	Bihar	NBPDCL	2.94	30
4		SBPDCL	3.32	26
5	Chhattisgarh	CSPDCL	3.64	20
6	Gujarat	DGVCL	7.52	1
7		MGVCL	6.93	3
8		PGVCL	6.40	4
9		UGVCL	7.09	2
10	Haryana	DHVBN	3.64	19
11		UHVBN	3.54	21
12	Jharkhand	JBVNL	2.87	31
13	Karnataka	BESCOM	3.66	18
14		GESCOM	5.30	8
15		HESCOM	3.35	25
16		MESCOM	4.44	14
17		CHESCOM	3.38	24
18	Madhya Pradesh	Central	3.76	17
19		East	3.24	28
20		West	3.51	22
21	Maharashtra	MSEDCL	4.67	13
22	Punjab	PSPCL	4.91	11
23	Rajasthan	AVVNL	5.62	7
24		JVVNL	4.43	15
25		JdVVNL	5.05	9
26	Telangana	TSSPDCL	4.95	10
27		TSNPDCL	4.43	16
28	West Bengal	WBSEDCL	3.25	27

S.No	State	Discom	Efficiency	Rank
29	Uttar Pradesh	DVVNL	2.81	32
30		MVVNL	2.43	33
31		PVVNL	3.49	23
32		PuVVNL	3.10	29
33		KESCO	5.66	6

XII. APPENDIX: COMPARISON OF UP DISCOMS WITH DISTRIBUTION UTILITIES OF OTHER COUNTRIES

This instant additional chapter of the benchmarking study has been inserted on the specific request of the Hon'ble Commission and is intended to focus on the functional areas and parameters which can be quantified, as the Discoms are expected to work on these parameters in the near to mid-term future, in or beyond the control period. These metrics are developed and identified in-line with the main study, considering the availability of data and the exhaustiveness for conducting the Benchmarking study of the Discoms with respect to private Discoms.

However, retaining the spirit prescribed in the revised Tariff Policy 2016 and also to establish the 'desired position', UP Discoms are compared with the Discoms of Brazil, Bangladesh and Australia.

The Discoms considered for the study are as below:

1. AES Electropaulo:
    - Continent: South America;
    - Country-Brazil;
    - Metropolitan Region: Sao Paulo
2. Ergon Energy:
    - Continent: Australia;
    - Country-Australia;
    - State: Queensland
3. Dhaka Electric Supply Company Limited (DESCO):
    - Continent: Asia;
    - Country-Bangladesh;
    - Region: Dhaka

Basis for selection of the Discoms: In an attempt to understand the electricity distribution function of the other countries one Discom from Asia, One Discom from developed continents (Australia, Europe and North America) and one Discom from peer group (developing continent) i.e South America are considered for study.

Particulars of the study: Initially the Business Environment and Regulatory Environment of the Discoms are studied, compared with each other and relevance will be drawn based on the maturity of the market. Later the Financial and Technical condition of each Discom is studied and inference is drawn on the desired position.

1. AES Electropaulo (Brazil)

AES Electropaulo is the largest electricity distributor in Brazil and Latin America in terms of revenue from energy supply according to the Brazilian Association of Electric Power Distributors (ABRADEE). The Company supplies electricity to 6.9 million consumer units covering the metropolitan area of São Paulo, which is the largest metropolitan area of the most developed and industrialized state in Brazil. In comparison with concession areas of other distributors in Brazil, the Company's concession area has a high GDP / per capita ratio and a high population density, as well as one of the highest per capita electricity consumption indices within Brazil. AES Electropaulo follows accounting principle, by which financial year coincides with Gregorian calendar year and is computed from January 1st to December 31st of each year. Exchange rate considered for 1 Brazilian Real is 1R$= INR 20.98 as on 14th March, 2017 1535hours.

A. Regulatory Regime

The Brazilian power industry is regulated by the Regulatory Agency for Electric Energy ("ANEEL") and has its guidelines established by the Ministry of Mines and Energy ("MME") and with the participation of the following institutional agents: the National System Operator ("ONS"), which has the authority to coordinate and control the operation of the National Interconnected System ("SIN"); the Chamber of Electric Energy Commercialization ("CCEE"), which is responsible for the accounting and settlement of transactions in the spot market and under delegation by ANEEL, performs the electricity auctions; and the Energy Research Company ("EPE"), which conducts studies and research for the planning of the sector.

B. Tariff Mechanism

The electricity supply tariffs are adjusted annually from a parametric formula provided in the concession agreement. This formula considers the transfer of so-called costs "unmanageable" by ANEEL (Parcel A - sector charges, energy purchase costs for resale and transmission costs) and corrects the "controllable costs" of the concessionaire (Parcel B - Operating expenses, compensation of assets and depreciation) by the IGP-M of the 12 months prior to the base date of its adjustment, net of a gain in productivity index, called "X Factor."

Annual Tariff Adjustment: This mechanism is annual and defines the tariff for the next 12 months considering: (i) the non-manageable costs (Parcel A) by the concessionaire, such as sector charges, expenses with the purchase of energy and transmission costs; (ii) monetarily updates the manageable costs (Parcel B), which includes operation and maintenance of the distributors network, by the IGPM and the X Factor; and (iii) assigns to the tariff the regulatory assets and liabilities incurred during the last regulatory year.

Periodic Tariff Adjustment: Periodic Tariff Adjustment is defined by the National Electric Energy Agency (ANEEL) every four years, as defined in the concession contract. Unlike the annual tariff readjustment, in addition to the readjustment of Portion A to contemplate the non-manageable costs for the next 12 months, the periodic tariff review reviews, the entire methodology for calculating Portion B and its components. The objective is to preserve the economic-financial balance of concession and tariff realism. The last AES Electropaulo tariff review occurred in 2015.

Extraordinary Tariff Review: The Extraordinary Tariff revision may occur at any time, regardless of adjustments and revisions, in order to re-establish the economic-financial balance of the concession in case any extraordinary event comes to such equilibrium at risk. The extraordinary tariff review may be granted to an individual concessionaire, or if the imbalance is sectorial, to all concessionaires collectively. The last extraordinary tariff revision occurred in 2015.

C. Financial and Operational statistics

A total of 69 Lakhs (6.90 Million) households/commercial Establishments/ are catered by AES Electropaulo in the license area of 4526 sq.kms. AES Electropaulo is bigger than any of the UP Discoms in terms of number of connections within the license area. The average power purchase cost per unit of energy sales is 0.145 R$ (equivalent to Rs. 3.04/kWh). Employee cost is 0.017 R$ (equivalent to Rs. 0.36/kWh). AES Electropaulo earns a revenue of 0.538 R$/kWh (equivalent to Rs. 11.29/kWh) which is a combination of 0.354 R$/kWh (equivalent to Rs. 7.43/kWh) from Retail supply of electricity and 0.184R$/kWh (equivalent to Rs. 3.86/kWh). The system reliability of AES Electropaulo is decent and seems to provide world class services to its consumers. DEC (equivalent length of interruptions per consumer – SAIDI) is only 23.62 Hours in a year and FEC (equivalent frequency of interruptions per consumer – SAIFI) is only 6.48 times in a year. EBITDA of AES Electropaulo for the year 2015 is 101.1 Mn R$ (equivalent to Rs. 0.05/kWh of sale). The other details of AES Electropaulo are as below:

Table 67: AES Electropaulo at a Glance

S. No	Particulars	Units	Amount
1	Number of Connections	Mn	6.90
2	Power Purchase Cost	R $	6,411,630,000
2(a)	Average Power Purchase Cost	R $/kWh	0.14494
3	Employee Expenses	R $	763,612,000
3(a)	Employee Expense per unit sale	R $/kWh	0.01726
4	Revenue from Operations	R $	23,805,848,000
5	Retail	R $	15,661,364,000
6	Distribution	R $	8,144,484,000
7	ABR	R $/MWh	405

S. No	Particulars	Units	Amount
8	SAIDI (DEC)	Hrs	23.62
9	SAIFI (FEC)	Nos	6.48
10	Number of Connections	Nos	6,852,145
11	Energy Sales	GWh	44,237
12	Area	sq.km	4,526
13	Consumer Density	/sq.km	1,500
14	Net Income	Mn R$	101.1

2. Ergon Energy (Australia)

Ergon is both distributor and retailer of electricity in the area of Queensland. As a distributor Ergon transmits electricity along the 'poles and wires' across regional Queensland. The distribution network, which is part of the National Electricity Market (NEM), is regulated by the Australian Energy Regulator (AER). The regulator determines the revenue the company is allowed to collect from the customers for the use of the network. These charges are just one of the components making up the price of electricity. The company also operates under Queensland Government electricity industry laws and regulations.

The retailer arm (Ergon Energy Queensland Pty Ltd) buys electricity from the generators, through the market and in direct deals, and on-sells it to the customers. Company sells electricity at the Queensland Government's notified prices, which are set by the Queensland Competition Authority (QCA). This enables Queenslanders to access the same regulated electricity tariffs (with the support of the government's Community Service Obligation payment). Ergon Energy follows accounting principle, by which financial year starts fro, July 1st and closes on June 30th of each year. Exchange rate considered for 1 Australian Dollar is 1A$= INR 49.73 as on 14th March, 2017 1730hours.

A. Regulatory Regime

The main legislation governing Queensland's electricity industry is the Electricity Act 1994, and the Electricity Regulation 2006. The retail supply business and wheeling business in the area are separated and consumers have an option of choosing the retail suppliers of Electricity.

The Electricity Act and Regulation deal with (i) regulating the electricity industry and electricity use, including licensing of electricity industry participants and monitoring of license compliance; (ii)making and approving industry codes, such as the Electricity Industry Code, which deals with supply reliability, standard customer contracts of electricity distributors and retailers, and other customer service matters; (iii) approving electricity prices for existing customers; (iv) assisting in settling disputes between electricity entities and between electricity entities and public entities; (v) administrating electricity restrictions and electricity rationing procedures. In regional Queensland,

retail competition is not so strong, i.e. most customers are on a standard retail contract with Ergon Energy. The Queensland Competition Authority (QCA) reviews the regulated electricity tariffs each year and determines new prices based on a number of factors.

B. Tariff Mechanism

In regional Queensland, retail competition is not so strong, i.e. most customers are on a standard retail contract with Ergon Energy. The Queensland Competition Authority (QCA) reviews the regulated electricity tariffs each year and determines new prices based on a number of factors. These regulated tariffs or prices are sometimes referred to as 'notified prices'. The electricity tariff notified by the QCA is a combination of (i) generation costs: creating electricity at a power station; (ii) transmission costs: to build and maintain the state's network of high voltage power line infrastructure; (iii) distribution costs: to build and maintain the network of low-voltage poles and wires that deliver electricity to homes and businesses; (iv) retail costs: connecting customers, billing customers and managing their accounts; (v) green scheme costs: costs associated with the Commonwealth Government's Renewable Energy Target; (vi) metering costs: costs associated with your metering equipment, including maintenance and meter reading, and is determined once in a year.

C. Financial and Operational statistics

A total of 7.33 Lakhs (0.73 Million) households/commercial Establishments/ are catered by Ergon Energy in regional Queensland. The average power purchase cost per unit of energy sales is 0.104 A$ (equivalent to Rs. 5.155/kWh). Employee cost is 0.0145 A$ (equivalent to Rs. 0.72/kWh). Ergon Energy earns a revenue of 0.127 A$/kWh (equivalent to Rs. 6.34/kWh) from Retail supply of electricity. The system reliability of Ergon Energy is decent and seems to provide world class services to its consumers. SAIDI (equivalent length of interruptions per consumer) is only 22.0944 Minutes in a year for Urban Consumers, 56.1637 minutes for short rural and 115.6240 minutes for long rural consumers. SAIFI (equivalent frequency of interruptions per consumer) is only 0.2452 times in a year for urban consumers, 0.5227 times for short rural consumers and 0.8747 times for long rural consumers in a year. PAT of Ergon Energy's Retail arm for the year 2014-15 is 204 Mn A$ (equivalent to Rs. 0.67/kWh per unit of energy sold). Ergon Energy has creditor payables of 20 Mn A$ for the year FY 2014-15. The other details of Ergon Energy are as below:

Table 68: Ergon Energy at a Glance

S. No	Particulars	Units	Amount
1	Number of Connections	Nos	733,261
2	Energy Sales	GWh	15,140
3	DTs	Nos	110,000
4	HT Dist. Length	ckm	118,600
5	LT Dist. Length	ckm	225,000

S. No	Particulars	Units	Amount
6	Number of Employees	Nos	4,447
7	Revenue from Sale of Power	Mn A$	1,929
8	Employee Expenses	Mn A$	219
9	Power Purchase Cost	Mn A$	1,569
10	Creditor Amount	Mn A$	20
11	PAT	Mn A$	204

3. Dhaka Electric Supply Company (Bangladesh)

After the creation of an independent Bangladesh, in 1972, the first Government of Bangladesh, in an effort to speed up the investment in the sector issued an Ordinance creating the Bangladesh Power Development Board (BPDB) as the successor organization of the power side of EWAPDA. The Ordinance recognized the divergence of energy related issues in development. In 1990, another ordinance was issued, which was subsequently enacted as an Act transferring the 132 kV, 33 kV Transmission and distribution system in the Greater Dhaka Area including the Metropolitan City to a newly created Government agency called the Dhaka Electric supply Authority (DESA). This was done to lessen the administrative burden on BPDB's management by relieving it of the burden of managing about 50 percent of the energy distribution in the entire country. Vision of Dhaka Electric Supply Company (DESCO after corporatization of DESA) is, to be an enabler of economic development and social progress by providing safe, reliable and sustainable electricity.

DESCO is responsible for supplying electricity to all the consumers of Dhaka area and also to maintain the distribution network under its purview.

A. Regulatory Regime

The Bangladesh Energy Regulatory Commission (BERC) was established on March 13, 2003 through a legislative Act of the Government of Bangladesh. The Commission became effective on April 27, 2004 with the appointment of two, of the five member Commission including the Chairman. The 1st Chairman was appointed on June 4, 2005.

The Commission has the mandate to regulate electricity, gas and petroleum products for the whole of Bangladesh. The Regulator deals with (i) Issuance, cancellation, amendment and determination of conditions of licenses, exemption of licenses and determination of the conditions to be followed by exempted persons; (ii) Ensuring efficient usage, quality services, determining tariff and safety enhancement of electricity generation and transmission, marketing, supply, storage and distribution of energy; (iii) Approving schemes on the basis of overall program of the licensee and take decision taking into consideration the load forecast and financial status; (iv) Extend co-operation and advice to the Government, if necessary, regarding electricity generation, transmission, marketing, supply, distribution and storage of energy.

B. Tariff Mechanism

In Dhaka, retail competition has not evolved, i.e. all the customers are on a standard retail contract with DESCO. The BERC reviews the regulated electricity tariffs each year and determines new prices based on a number of factors. The electricity tariff notified by the BERC is a combination of (i) generation costs; (ii) transmission costs; (iii) distribution costs; (iv) metering costs and is determined once in a year.

C. Financial and Operational statistics

A total of 7.05 Lakhs households/commercial Establishments/ are catered by DESCO in capital region of Bangladesh. The average power purchase cost per unit of energy sales is 5.6341 Tk (equivalent to Rs. 4.6199/kWh). Employee cost is 0.3073 Tk (equivalent to Rs. 0.2520/kWh). DESCO earns a revenue of 6.909Tk/kWh (equivalent to Rs. 5.67/kWh) from sale of electricity. The system reliability of DESCO is decent and seems to provide world class services to its consumers. SAIDI (equivalent length of interruptions per consumer) is only 577.94 Minutes in a year. SAIFI (equivalent frequency of interruptions per consumer) is only 22.54 times in a year. PAT of DESCO for the year 2014-15 is 1634.87 Mn Tk (equivalent to Rs. 0.34/kWh per unit of energy sold). DESCO has receivables of 1.61 Month for the year FY 2014-15. Aggregate Technical & Commercial losses recorded for year ending June 30th 2015 is 7.01%, which is appreciable. Collection efficiency stands at 101.48 for the year FY 2014-15. HT to LT ratio observed in DESCO is 1.08. R&M expenses as % of GFA is considerable low at 1.25%. The other details of DESCO are as below:

Table 69: DESCO at a Glance

S. No	Particulars	Units	Amount
1	HT 33	ckm	416
2	HT 11	ckm	1,722
3	LT	ckm	1,978
4	DTs	Nos	5,932
5	Energy Sales	MUs	3,959
6	Distribution Losses	%	8.37
7	Collection Efficiency	%	101.48
8	Total Efficiency (1-AT&C)	%	92.99
9	Number of Consumers	Nos	705,234
10	Revenue from Sale of Energy	Mn Tk	27,358
11	Profit After Tax	Mn Tk	1,635
12	Expenditure	Mn Tk	26,982
13	Power Purchase Cost	Mn Tk	24,345
14	Employee Expenses	Mn Tk	1,217

S. No	Particulars	Units	Amount
15	A&G Expenses	Mn Tk	278
16	Power Purchase	MUs	4,321
17	R&M Expenses	Mn Tk	231
18	GFA	Mn Tk	18,514
19	Accounts Receivable	Months	1.61

Comparison between UP Discoms and the samples discoms in other countries considered for the study

The operational conditions of the Electricity Distribution Companies are very different from each other. Most of the differences attribute to the social factors, natural resources and climatic conditions of the country.

1. Fuel Source: Major fuel source for generating electricity plays a vital role in determining the cost of electricity in India, the major source of fuel for generation of electricity is coal. However, in the neighboring country Bangladesh, Natural Gas is the major source of electricity for generation of electricity; whereas in Brazil the largest contributor of electricity is Hydro Electric because of the presence of large rivers and suitable terrain; in Australia the condition is similar to that of India where the coal contributes most of electricity generated in the country.
2. Economic Status: Economic status plays a vital role in determining the market design and emerging utility market in which a Discom is operating. In developing countries, Electricity is more a social subject than a business aspect. The income levels of the consumers and consumption pattern is very important to understand how the retailers of electricity (Electricity Distribution companies) operate. Economic status of the consumers in Bangladesh is similar to that of India. However, Brazil and Australia have a different pattern of consumers because of the economic activity and the status of the population.

Electricity Distribution business in developed countries is carried out on pure commercial principles with adequate competition and provides option to consumers to switch between the service providers and paying for Value Added Services over and above the normal quality power supply. In India, aspects such as energy access, 24/7 electricity supply and reliability of power supply are the main considerations. Apart from the above, electricity in India is a social subject and historically attempts are made to provide adequate energy to improve the economic standard of the people treating electricity as a social subject with additional emphasis on providing minimum life-line energy to all the citizens. Some of the other important parameters which affect the functioning and market conditions of the Discoms are energy intensity, federal structure of Government, role of agriculture in economy and maturity of the industry.

S. No.	Country	Energy Intensity* (koe/$2005p (2015))	Responsibility of Distribution function in Federal Structure	Year when Reforms were initiated	Share of Agriculture (%) in GDP
1	India	0.131	State	2003	17.5
2	Brazil	0.119	National	1996	5
3	Australia	0.145	State	1990's	2.5
4	Bangladesh*	0.154	National	1996	15.5

The Discoms of India are relatively new (post reforms) and not so mature as compared to the utilities considered in the sample. The share of agriculture in economy also plays a vital role in determining the conditions in which the electricity distribution utilities are working. In countries like India and Bangladesh the share of agriculture in GDP is of the order of 17.5% and 15.5% which indicates the priority of the sector. Agriculture is generally subsidized owing to lower disposable income of farmers and due to lower farm income.

In view of the above, at this stage this Report has attempted to focus on benchmarking the operational, financial and other parameters of the electricity distribution utility performance only with other state owned Discoms of the country.

XIII. APPENDIX: DEVIATIONS & EXEMPTIONS

The Hon'ble UPERC has notified the Uttar Pradesh Electricity Regulatory Commission (Multi Year Distribution Tariff) Regulations, 2014 (UPERC MYDT Regulations, 2014) on 12.5.2014. It is for the first time, that the Hon'ble Commission has issued tariff regulations for Multi Year Tariff control period encompassing the financial years 2017-18 to 2019-20.

The Hon'ble Commission vide its regulation 4.2.1 of the UPERC MYDT Regulations, 2014 has directed the distribution licensees to undertake a study involving benchmarking of the performance of the Discoms with the other distribution licensees of the country, with the objective to establish the baseline norms and determine the desired performance standards for the distribution licensees of the State.

In continuation of the same, the Hon'ble Commission has directed all the state owned Discoms of Uttar Pradesh to conduct the Benchmarking studies on certain parameters through a letter vide UPERC/Secy/D(Tariff)/15-1219 dated 14th September, 2015. The list of performance parameters are divided into 4 categories namely:

1. Operational Performance Parameters
2. Operations & Maintenance Expenses
3. Capital Cost Benchmarking
4. Financial Parameters

In this regard, there are certain parameters which have not been considered for benchmarking because of limitations regarding un-availability of data and lack of authentic data sources in UP Discoms as well other Discoms in the country. Such parameters which have not been considered for Benchmarking are listed below:

1. Voltage wise AT&C Losses
2. Category wise AT&C Losses
3. Consumer Metering Status
4. Percentage of defective meters and replacement performance
5. Proportion of bills raised on actual meter reading basis and bills raised on assessment basis.
6. Capital cost benchmarking of 11kV Underground line in rs. Per Ckt. Km
7. Capital cost benchmarking of LT Underground Network
8. Capital cost benchmarking of metering equipment
9. Category wise cost of supply
10. Category wise receivables ageing

It is also submitted that in place of above parameters, the following aspects are considered so as to increase the scope and to compensate for the parameters which couldn't be considered for the study due to data insufficiency:

1. Feeder Monitoring
2. Feeders with high SAIFI
3. Feeders with high SAIDI
4. Peak Demand – Supply Scenario
5. Employee Cost per 1000 consumers
6. A&G expenses per Employee
7. A&G expenses per unit of energy sale
8. R&M Expenses per unit of Energy sale
9. Age of Creditors
10. Age of Debtors
11. Average Wheeling Cost
12. Profit After Tax as a % of Expenditure
13. ACS-ARR Gap

It is respectfully submitted that the above stated deviations may kindly be approved in the interest of the study.