Establishment of Baseline Data in Power Distribution of Electric Utilities in Karnataka under R - APDRP

Chandhra Sekhar P*, Jairam C P*, Raghunatha T*, Sudhir Kumar R*,
Devendra Rao K*, Viji Bharathi* and Kiran V Madhugiri*

This paper presents the field experience of authors during the establishment of baseline data for designated project areas under R-APDRP Programme. This paper also brought out sample baseline parameters estimation. It also emphasizes problems in the field during collecting data and attempt to overcome the problems. The paper also emphasizes findings on ESCOM by focusing project area and Aggregate Technical and Commercial loss (AT&C).

Keywords: *Distribution reforms, AT&C losses, Baseline data, Energy meter, Deemed collection, Billing cycle.*

1.0 INTRODUCTION

To improve the distribution sector, Ministry of Power (MoP), Government of India (GoI), had undertaken the Accelerated Power Development Reforms Programme (APDRP) from the year 2001 to 2002 for restoring the economic viability of the Distribution Sector. Under this programme, funds were allocated to the State Electricity Boards/Utilities/DISCOMS to adopt the path of distribution reforms. There are 574 projects under APDRP Programme and the AT&C loss brought down to 20 % in 215 towns [1]. CPRI had been appointed as Advisor cum Consultant for APDRP programme in Karnataka, Andhra Pradesh and Kerala states, India.

But, the programme had not shown desired results because of delays in transfer of fund by the states, delay in finalizing IT road map for the utility, failure in implementation of Information Technology which is the building block for metering, billing, energy audit, etc. Therefore, the Govt. of India, Ministry of Power, has initiated Restructured Power Development Reforms Programme (R-APDRP) in the year 2008 for further improvement of distribution sector.

Govt. of India launched restructured APDRP (R-APDRP) in July 2008 as a central sector scheme for XI Plan, where Part-A of the scheme being dedicated to establishment of IT-enabled system for achieving reliable and verifiable baseline data system in all towns with population greater than 30,000 as per 2001 census. Installation of SCADA/DMS for towns with population greater than 4 lakhs and annual input energy greater than 350 MU is also envisaged under Part-A. Part-B deals with regular ST&D system strengthening and upgradation projects [2]. The focus of Part-B shall be loss reduction on sustainable basis. 100 % loan is provided under R-APDRP for Part-A projects and shall be converted to grant on completion of the same. 25 % loan is provided under Part-B projects and up to 50 % of scheme cost is convertible to grant depending on the extent of maintaining AT&C loss level at 15 % level for 5 years. Achieving AT&C loss level of 15 % shall

*Distribution Systems Division, Central Power Research Institute, P.B.No.8066, Sadhashivanagar, Bangalore - 560 080, India. E-mail: pcs@cpri.in

reduce loan conversion to grant accordingly for that financial year. Up to 10 % of scheme cost for Part-B can be converted to grant in each financial year.

On 11 May 2010, Ministry of Power has appointed CPRI as Third Party Independent Evaluation Agency-Energy Accounting (TPIEA-EA) for R-APDRP programme to establish and verify baseline data for all 100 project areas (Towns) in all five Electricity Supply Companies (ESCOMS) of Karnataka. CPRI is collecting data, verifying, analyzing and establishing baseline data for the past 1 year in all 100 Project areas. CPRI will be there in the field for the duration of approximately another 5 years to collect data in prescribed formats, analyze, establish, verify, update and submit the period reports to Ministry of Power, Govt. of India.

This paper presents the prerequisites for the establishment of baseline data, methodology adopted for estimation of baseline parameters, practical problems during field work, data sensitivity and recommendations to overcome the issues are presented in detail.

2.0   FUNDING MECHANISM

2.1   Allotment of Funding

The amount allotted for the various activities by the government is as follows:

(a)   ₹ 50,000 Crore for Part-A and Part-B of the projects.
      ₹ 10,000 Crore for Part-A activities, mainly focuses on IT applications.
      ₹ 40,000 Crore for Part-B activities, mainly focuses on system strengthening and upgradation of the distribution network.

(b)   ₹ 1,177 Crore for enabling activities to be implemented by Ministry of Power (Part-C). Part-C is for capacity building exercise for utilities.

2.2   Process of Funding

The process of funding to utilities for R-APDRP project is as follows:

(a)   Govt. of India will provide 100 % loan for Part-A of the R-APDRP schemes, which shall include projects for establishing baseline data and IT applications for energy accounting/ auditing and IT based consumer services, etc.

(b)   Govt. of India will provide up to 25 % (90 % for special category States) loan for Part-B of the R-APDRP schemes, which shall include regular distribution strengthening projects.

(c)   The entire loan from GoI will be routed through PFC/REC (FIs) for the respective schemes funded by them.

2.3   Conversion of Govt. of India Loan to Grant

The loan granted by Government of India is converted to grant as follows:

(a)   The entire amount of GoI loan (100 %) for Part-A of the project shall be converted into grant after establishment of the required baseline data system within a stipulated time frame and duly verified by TPIEA.

(b)   Up to 50 % (90 % for special category states) of loan for Part-B projects shall be converted into grant in five equal tranches on achieving 15 % AT&C loss in the project area duly verified by TPIEA on a sustainable basis for a period of 5 years.

(c)   If the utility fails to achieve or sustain the 15 % AT&C loss target in a particular year, that year is tranche of conversion of loan to grant will be reduced in proportion to the shortfall in achieving 15 % AT&C loss target from the starting AT&C loss figure.

3.0   PREREQUIREMENTS IN THE UTILITY

The utilities have to meet the following criteria for establishing baseline data like AT&C loss of the project area:

(a)   **Ring fencing:** The utilities shall ensure that project area is electrically ring fenced. This defines the scope of the project area and helps in proper placement of import and

export meters in the project area. The utilities are required to provide the nodal map of the project area with a clear indication of substations feeding energy to the project area, feeders supplying energy to the project area and border meters location for feeder supplying energy within as well as outside the project area.

(b) **Metering of input/import and export points:** It is essential that utilities install meters and maintain proper records of readings at all input and exit points of the project area. The difference of these reading gives us the net input energy to the project area. It is preferable that meters with capability of being read remotely be installed, as the same is the requirement of Part-A of the project.

(c) **Segregation of rural load:** The utilities are required to separate the rural (agricultural) load by installing a separate HT feeder.

(d) **Billing and revenue collection system:** The utilities are required to provide number of installations, sanctioned load, consumption, demand and collection for each feeder with separation of various tariffs in that feeder. This is available in the Demand Collection Billing (DCB) statements in the revenue section of the utility. It is important to separate the load outside the project area from within the project area.

4.0   ROLE OF CENTRAL POWER RESEARCH INSTITUTE (CPRI)

Central Power Research Institute (CPRI) has been appointed as Third Party Independent Evaluation Agency – Energy Accounting (TPIEA-EA) for verification of baseline data. The role of CPRI is as follows:

(a) **Establishment of baseline AT&C loss:** Verifying baseline AT&C losses for each of the project area according to the methodology provided by the nodal agency. The CPRI needs to verify the computation of losses as provided in the baseline methodology.

(b) **Establishment of annual AT&C Loss:** Verification of annual AT&C losses for each of the project area has to be done according to the methodology provided by nodal agency. The TPIEA needs to verify the computation of losses as provided in the baseline methodology.

(c) **Quarterly reporting progress:** Report on AT&C losses for each of the project areas shall be furnished to the nodal agency. The data from this reporting shall be utilized for annual loss reporting exercise.

5.0   METHODOLOGY

The baseline AT&C loss is estimated based on the R-APDRP guidelines [8]. CPRI officials verified substation log books, calibration certificates of feeder and border meters, Demand Collection and Billing (DCB) statement and random consumer bills in the project area. The baseline data has been established for three billing cycles. The following procedure was adopted to verify the data:

(a) **Computation of input energy:** Here the input energy is arrived at by subtracting the export energy from input/import energy meter.

(b) **Computation of sales:** The billing for metered consumers can be done through energy recorded by meters and the applicable tariff. In case of unmetered consumers, billing is generally done according to the norms defined by Karnataka State Regulatory Commission (KERC).

(c) **Billing efficiency:** Billing efficiency is an indicator of proportion of energy that has been supplied to an area which has been billed (includes both metered and unmetered sales) to consumers. It is calculated as billed energy divided by input energy [3].

$$\text{Billing Efficiency} = \frac{\text{Billed Energy}}{\text{Input Energy}} \times 100$$

(d) **Computation of collection efficiency:** All the consumers are billed on the basis of energy consumed by them which is obtained from meter reading and assessment of unmetered

connection. The bill amount is computed on the basis of tariff fixed by regulatory commission for applicable customer category. It is calculated as amount collected excluding arrears divided by amount billed.

$$\text{Collection Efficiency} = \frac{\text{Revenue Collected}}{\text{Amount Billed}} \times 100$$

(e) **Method of removing arrears:** When the collection exceeds the demand due to various reasons, the collection efficiency is restricted to 100 % based on PFC guidelines.

(f) **Revenue collection:** The deemed collection like agriculture has been removed from the total collection for the establishment of baseline data according to the R-APDRP guidelines.

(g) **Computation of AT&C losses:** Aggregate Technical and Commercial (AT&C) losses, which include theft, nonbilling, incorrect billing, inefficiency in collection and transmission and distribution losses [5], are is calculated as shown below:

AT&C Losses = {1 – (Billing Efficiency × Collection Efficiency)} × 100

6.0 PRACTICAL PROBLEMS IN THE FIELD

The CPRI team carried out extensive field work in 100 Project Areas in the ESCOMs of Karnataka. The major practical problems [4] for collecting data in the field are listed below.

(a) **PT failure:** The Potential Transformers of Banks got failed in the substations; subsequently, the PTs are replaced with new ones after a span of time and hence the energy is calculated in a thumbrule manner.

(b) **Tapping at LT side:** The billing efficiency is not in constant range for the billing period, which shows that there is a tapping at the LT side. The collection efficiency is also not in

the same range because of poor collection for street light and water sources.

(c) **Combination of rural and urban feeder:** owing to shortage of circuit breaker, urban and rural feeder is connected together. Hence, energy feeding to the project area and rural area has to be assessed. In this case, the billing cycle has to be changed.

(d) **Difference in timing of billing and recording of input energy:** The consumer billing is being done in general from 1st of every month to 25th of month. Whereas, input energy of the feeder is taken at the end of the month. Due to this, there is a large variation in the percentage AT&C loss calculations. However, this data will be streamlined in the longer duration like annual basis.

(e) **Assessment of energy:** It has been found that energy has been assessed due to various reasons like meter failure, meter bypass, etc. The billing cycle has been changed to avoid the months where assessment has been done.

(f) **Data compilation:** Compilation of data has been a challenge in large project area, as the number of feeder and number of divisions will be more. Moreover, spot bill is not practiced for tariffs like temporary connections, street light, water works, industrial, etc. Ledgers are maintained for these tariffs and chances of errors are high while transferring data from ledgers to computer.

(g) **Monitoring of border meters:** It is important that utilities maintain the border meters and the cubicles in which meters are installed. In some project area, no proper record of reading has been maintained.

(h) **Back feeding/cross feeding:** It is observed in some of the project areas, that the billed energy of feeder is more than input energy due to cross feeding.

(i) **DCB statement:** The software existing in the ESCOMs generates demand, collection and billing statement only for subdivision level, feeder level, whereas the generation of DCB statement for project area is not available.

(j) **Accuracy of meters:** Abnormalities were observed in the accuracy of meters at Bank, feeder level and consumer level. The balance between bank meter and feeder meter is more than 3 %.

(k) **IP sets consumption:** This is observed in general metered consumers, where IP sets are of more than 10 H.P, unmetered consumers, where IP sets are of less than 10 H.P. The IP sets without meter energy are assessed according to the KERC guidelines. The billing for IP sets is done monthly in some of project areas and bimonthly in some project areas. The revenue collection adjustments (deemed collection) against IP sets are removed for the establishment of AT&C loss.

(l) **Bifurification:** It is observed that bifurification of feeders, changes the name of feeders, and introduces New Border Meters in the Project Areas. It will have lot of impact on compiling data.

(m) **Calibration:** The calibration of Bank/Feeder and high-end consumer meters is not updated periodically.

The field verification of feeder meter and border meter in the project area by CPRI officials is shown in Figures 1 and 2.

7.0   CPRI FINDINGS

CPRI carried out extensive field visits in all project areas of Karnataka. CPRI officials visited and verified the data at substations and subdivision offices of various ESCOMS in Karnataka. The data was analyzed and ESCOM - wise findings are as follows:

ESCOM 1: There are 11 towns which have been verified in this ESCOM. Here, the AT&C loss varies from 10.88 % to 31.92 %. In this utility, 43.77 MU has been unaccounted as the losses in the project area from March 2010 to May 2010. The units lost could have been used to supply more than 95,000 houses for one month. The total revenue lost accounts to ₹ 17.73 crores considering average cost of supply as ₹ 4.05/kWh [9]. The Average rate of Realization (ARR) on input energy for the 11 towns under R-APDRP [6] project area was found to be approximately ₹ 4.15/kWh. In this ESCOM, the deemed collection had been done during the time period under consideration. It was observed that the conventional meters were replaced with static meters. The billing efficiency [7] varies from 83.46 % to 94.47 %. It was also observed that the collection efficiency ranges from 81.55 % to 98.22 % in the project areas.

FIG. 1   VERIFICATION OF FEEDER METER

FIG. 2   VERIFICATION OF EXPORT METER

ESCOM 2: There are 10 towns which have been verified in this ESCOM. Here, the AT&C loss varies from 22.24 % to 44.33 %. In this utility, 49.49 MU has gone unaccounted in the project area, considered over three billing cycles, generally from March 2010 to May 2010. The units lost could have been used to supply more than one lakh houses for one month. The total revenue lost accounts to ₹ 20.69 crores considering average cost of supply as ₹ 4.18/kWh [9]. The Average rate of Realization (ARR) on input energy for the 10 towns under R-APDRP project area was found to be approximately ₹ 3.17/kWh. Here, the deemed collection was removed as, it was not obtained from the IP sets and the other establishments.

It was observed that even today, some of the project areas have three-fourths of load in the feeder which is agriculture load. Hence, AT&C loss is high in that particular project area.

ESCOM 3: There are 21 towns which have been verified in this ESCOM. Here, the AT&C loss varies from 15.68 % to 35.30 %. In this utility, 28.08 MUs has been unaccounted as the losses in the project area from April 2010 to June 2010. The units lost could have been used to supply more than 62,000 consumers for one month. The total revenue lost accounts to ₹ 12.02 crores considering average cost of supply as ₹ 4.28/kWh [9]. The Average rate of Realization (ARR) on input energy for the 21 towns under R-APDRP project area was found to be approximately ₹ 3.67/kWh. Here, the deemed collection was removed as it was not obtained from the IP sets and the other establishments. It was observed that the billing efficiency ranges from 75.05 % to 93.15 %. It was also observed that the collection efficiency ranges from 77.75 % to 97.59 % in the project areas.

ESCOM 4: There are 24 towns which have been verified in this ESCOM. Here, the AT&C loss varies from 17.86 % to 38.82 %. In this utility, 73.04 MUs has been unaccounted as the losses in the project area from April 2010 to June 2010. The units lost could have been used to supply more than 150,000 consumers for one month. The total revenue lost accounts to ₹ 30.75 crores

considering average cost of supply as ₹ 4.21/kWh [9]. The Average rate of Realization (ARR) on input energy for the 24 towns under R-APDRP project area was found to be approximately ₹ 3.08/kWh. Here, the deemed collection was removed, as it was not obtained from the IP sets and the other establishments. It was observed that the billing efficiency ranges from 64.75 % to 88.83 %. It was also observed that the collection efficiency ranges from 78.80 % to 99.42 % in the project areas.

ESCOM 5: There are 21 project areas in ESCOM 5. Owing to delay in ring fencing, installation of border meters and three billing cycle data, the CPRI officials are just stated collecting data and verification is in process.

The Aggregate Technical and Commercial loss for individual project area for ESCOM 1 are shown in Graph 1.

The typical baseline parameters are calculated for ESCOM 1 as shown in Table 1. The similar baseline parameters are calculated for other ESCOM project areas.

The energy gone unaccounted is calculated as follows:

Energy Unaccounted(MU) = Input Energy(MU) – Energy Realized(MU)

Energy Realised(MU) = Collection Efficiency × Energy Billed

ARR on Input Energy (₹/kWh) = Revenue Collected (Crores) × 10/Input Energy(MU)
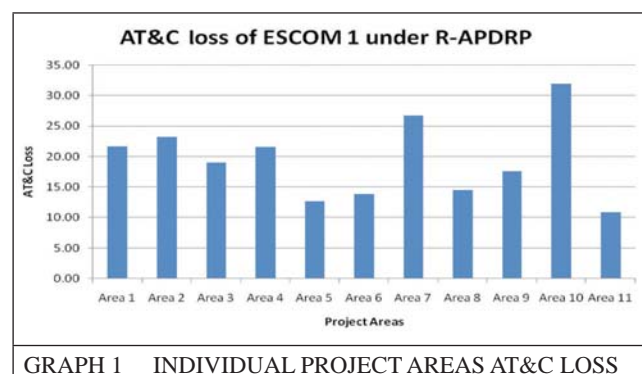
GRAPH 1   INDIVIDUAL PROJECT AREAS AT&C LOSS

SL. No.	Project Area	No. of Metered Consumers	Input Energy (MU)	Total Billed Energy (MU)	Amt Billed (₹.Cr)	Amt Collected w/o arrears (₹.Cr)	Energy Realized (MU)	i/p Energy - Energy realized (MU)	ARR i/p energy (₹/kWh)	Billing Efficiency (%)	Collection Efficiency (%)	AT&C Loss (%)
1	Area 1	10566	5.49	5.07	2.09	1.78	4.30	1.19	3.24	92.23	84.86	21.74
2	Area 2	43935	13.20	11.23	4.84	4.36	10.13	3.07	3.30	85.11	90.18	23.25
3	Area 3	38283	11.54	9.92	4.73	4.46	9.36	2.18	3.87	85.98	94.37	18.86
4	Area 4	11037	3.80	3.45	1.68	1.45	2.98	0.82	3.82	90.68	86.52	21.54
5	Area 5	15490	141.87	131.43	64.86	61.09	123.79	18.08	4.31	92.64	94.19	12.74
6	Area 6	18120	10.30	9.73	3.27	2.98	8.87	1.43	2.89	94.47	91.15	13.88
7	Area 7	18330	5.64	4.83	2.07	1.77	4.13	1.51	3.13	85.73	85.48	26.72
8	Area 8	8525	3.02	2.62	1.19	1.17	2.58	0.44	3.88	86.94	98.16	14.66
9	Area 9	95438	46.03	41.17	19.28	17.76	37.92	8.11	3.86	89.44	92.12	17.61
10	Area 10	10319	3.15	2.63	1.18	0.96	2.14	1.00	3.06	83.48	81.56	31.92
11	Area 11	51018	54.65	50.27	26.95	26.11	48.70	5.95	4.78	91.99	96.88	10.88
Total		**321061**	**298.68**	**272.35**	**132.13**	**123.89**	**254.90**	**43.77**	**4.15**	**91.18**	**93.76**	**14.50**

TABLE 1 — BASE LINE PARAMETERS FOR ESCOM1

The range of AT&C loss and no. of project areas in the range are shown in Graph 2.

GRAPH 2   RANGE OF AT&C LOSS IN PROJECT AREAS
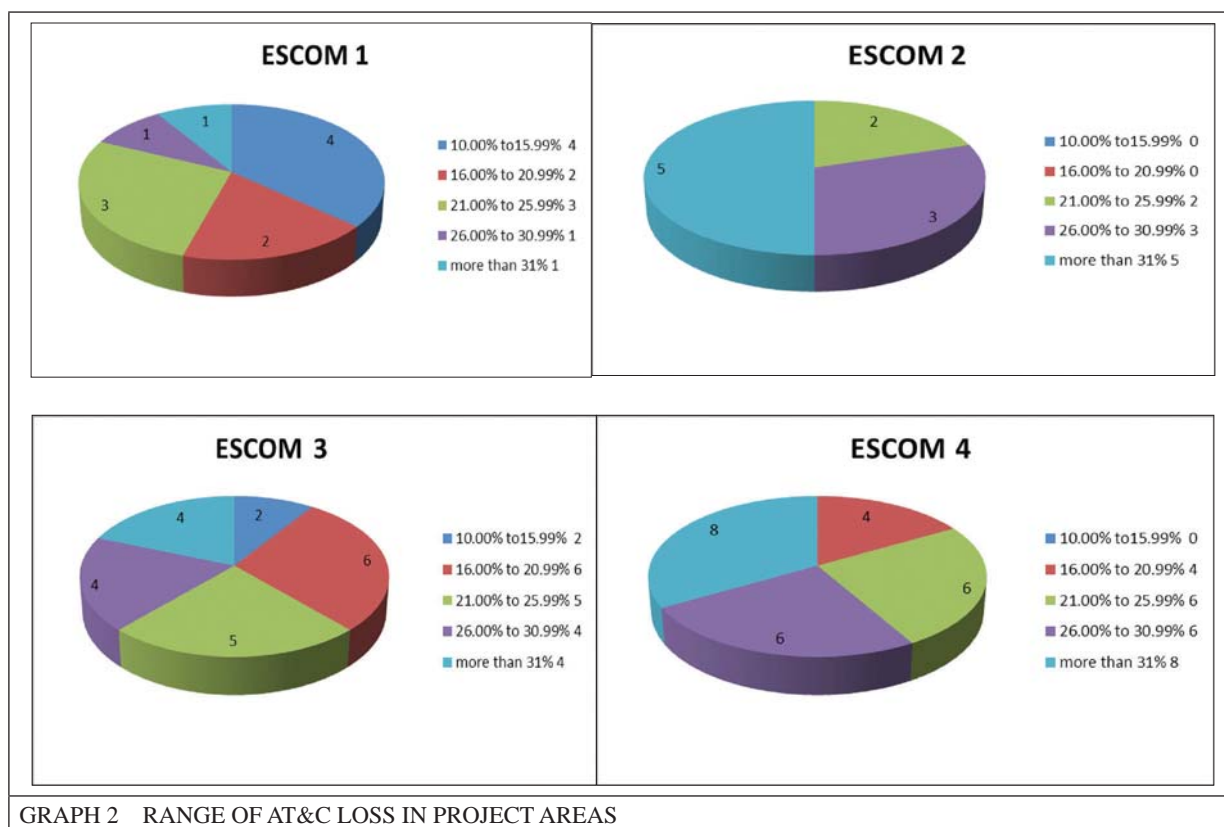
8.0 ATTEMPT TO OVERCOME PROBLEMS

From experience of CPRI by visiting 100 project areas, the following suggestions can be implemented in the ESCOMs

(a) **Static Metering:** The losses would come down if all consumers could me metered with static meters and preferably provide a mean of remote communication facility. This would improve the billing efficiency of the system.

(b) **Billing period:** It would be better if metering and billing could be done within the first week of every month. This would give a more realistic picture of AT&C loss of the project area.

(c) **Meter accuracy:** The difference in meter accuracy at Bank/feeder level and consumer level leads to slightly higher AT&C losses. The utilities should follow the CEA metering regulations issued as on 17th March 2006 [10].

(d) **Separation of loads:** The large number of agriculture load still exists in some of the project areas. It needs to be separated from project areas to improve AT&C loss.

(e) **Meters:** It is observed that Electronic Tri vector Meters are fixed at feeder level, some of the Distribution Transformers and Border (Import/Export locations). It is proposed under R-APDRP to fix meters according to IEC 62056 compliant with remote communication facility. With this facility, the energy audit and accounting will be carried out by collecting data at data center.

9.0 CONCLUSIONS

The established and verified data under R-APDRP programme will be useful to fix the target for ESCOMs for the reduction of AT&C loss. The subsequent loss reduction below 15 % will benefit the ESCOMs to convert loan into grant.

Under R-APDRP programme, Billing Efficiency can be improved with Distribution augmentation, System strengthening and IT applications, where as Collection Efficiency will remain same or less impact even after R-APDRP implementation. This is due to elimination of deemed collection/subsidy by government and methodology adopted for the establishment of baseline data.

This R-APDRP programme will be useful for healthy Project Areas (less AT&C=20–35 %) compared with bankrupt Project Areas (high AT&C loss=35–65 %). The healthy project areas can convert loan into grant easily, whereas in bankrupt project areas, the conversion of loan into grant will be difficult/impossible.

The awareness/training must be provided amongst the ESCOM field officials regarding the ongoing schemes: RAPDRP-TPIEA-EA, IT-related, Data Collection and its related formats, etc.

ACKNOWLEDGMENT

REFERENCES

[1] www.powermin.nic.in.

[2] Nagendra Rao P S and Ravishankar Deekshit. "Energy loss estimation in distribution feeders", *IEEE, Transactions on Power Delivery*, Vol. 21, No. 3, July 2006.

[3] Babu Narayanan M M, Bala Subramanian P V, Sri Devi, Prabhakar C. "Estimation of technical losses in transmission and sub transmission network of Andhra Pradesh, National Power System Conference (NPSC) at IIT, Chennai, December 27–30, pp. 946, 2004.

[4] Aradhya R S S, Sujatha Subhash, Shyam Sundar and Sri Devi. "Energy metering for distribution loss estimation–problems and solution, paper accepted for 14th National Power System Conference (NPSC) is being hosted by the IIT, rourkee, during December 27–29, 2006.

[5] Chandra Sekhar P. "Evaluation of 11kV and LT losses in SPDCL using a novel Method", A dissertation submitted in partial fulfillment of the requirements for the award of PG at MDI, Gurgaon.

[6] Chandhra Sekhar P, Raghunatha, Rajesh Kumar O, Babu Narayanan M M. "Power distribution sector reforms in India beyond 2007: Focus on APDRP", National Conference on Distribution Automation at CPRI, Bangalore during 29–31 October 2007.

[7] Chandhra Sekhar P, Aradhya R S S, and Babu Narayanan. "A novel method for estimation of HT and LT feeder losses in distribution system", *Fifteenth National Power Systems Conference (NPSC), IIT*, Bombay, December 2008.

[8] Chandhra Sekhar P, Jairm C P and Raghunatha T. "Energy audit: Present and future in Indian Power Distribution System", *IEEE*, Bangalore Section, 20th Symposium, 4 and 5 November 2011.

[9] R-APDRP Guidelines. "Methodology for Establishing Baseline AT&C losses", 4 September 2009.

[10] Revision of Retail Supply Tariff of ESCOMs for FY 2010.

[11] CEA Guidelines: Metering Regulations, 17 March 2006.