RELIABILITY OF POWER SUPPLY

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INTRODUCTION

The distribution reforms have been identified as the key area for putting the power sector on the right track. The strategies identified are aimed at improving financial viability, reduction of T&D losses, improving customer satisfaction, increasing reliability and quality of power supply and adopting systems approach with MIS. Customer satisfaction is being given greater importance under Accelerated Power Development & Reform Programme, a Government of India assistance cum loan intervention aiming at improvement of sub-transmission and distribution system in the country. A large amount of investment to the tune of Rs. 40,000 crores is proposed to be made by the Government of India. Out of this Rs. 20,000 crores is earmarked for up gradation and modernization of distribution system and another Rs. 20,000 crores is provided to incentivise the States to reduce the cash loss of the SEBs/Utilities.

Indirectly or directly customer satisfaction is concerned with improving and modernization of the ST&D network. Customer satisfaction can be improved through providing better quality power in terms of voltage and frequency fluctuations and reliability by reducing outages. These necessarily call for technical intervention in , firstly, ensuring that the assets already created are maintained in proper working condition and secondly through augmenting the system. Further customer complaint redressal mechanism are to be made more responsive and proactive through building transparent and reliable system with the help of computerization. The system should be capable enough to meet the growing demand of information conscious customers.

When the expectation of the customer is more than the fulfillment there is resentment and the customer is reluctant to pay. On the other hand when his expectations are met the customer is satisfied and he may be less reluctant to share marginal increase in the tariff.

Reliability of Power Supply and Consumer Satisfaction

Reliability of Service needs to be always given primary importance by electric utility system. Consumer is least interested about the availability of power sources, grid conditions but he must be ensured a power supply, which is most reliable and qualitative. Reliability to a consumer means that power made available to him is fault free and the outage or interruptions are tolerable and do not disturb his normal life.

Reliability and quality of supply were rarely an issue till recent past and little or no attention was paid to the reliability and quality of power supply. But a change in attitude has been observed in the supplier as well as takers of energy and a customer friendly definition of reliability and benchmarking of performance has been laid down.

A reporting system for the reliability analysis to log type of consumer's interruption duration, number of consumer affected and reason for interruption with an aim to improve the reliability through adequate measures has become essential. Reliability analysis requires large amount of data regarding consumer interruption such as number of consumer affected, duration of interruption and the type of power cut viz. scheduled or unscheduled. The analysis can be made through a computer based software tool by measuring past performance, comparing with that of envisaged new system and predicting future performances. Creation of comprehensive up to date consumer index and system data basis on computerized environment are essential for efficient commercial and technical operation and management of any distribution system.

The APDRP programme has focused on this basic need and creation of such data base which is a prerequisite to reliability monitoring so as to identify the trouble some consumer and system element. Time is not far when customer will be given incentive for poor performance of the utility and utility will be awarded for their better performance through performance based tariff. Thus utility has to be more vigilant to improve their performance. The objective of reliability monitoring is manifold and is as follows:

i) Furnish management with performance data regarding the quality of customer service on the electrical system as a whole and for each voltage level and operating area.

ii) Provide data for an engineering comparison of electrical system performance among consenting companies.

iii) Provide a basis for individual companies to establish service continuity criteria. Such criteria could then be used to monitor system performance and to evaluate general policies, practices, standards and design.

iv) Provide data for analysis to determine reliability of service in a given area (geographical, political, operating, etc) to determine how factors such as design differences, environment or maintenance methods, and operating practices affect performance.

v) Provide reliability history of individual circuits for discussion with customers or prospective customers

vi) To identify substations and circuits with substandard performance and to ascertain the causes.

vii) Obtain the optimum improvement in reliability per rupee spent for design, maintenance and operating programs.

viii) Provide performance data necessary for a probabilistic approach to reliability studies. This can be done by comparing and consistently evaluating the effects on a system's performance of varying the configuration, protective methods, equipment, structural design and/or operating and maintenance practices. The purpose is to determine the design, operating and maintenance practices that prove optimum reliability per rupee spent and, in addition, to use this information to predict the performance of future transmission and distribution system arrangements.

RELIABILITY EVALUATION CRITERIA

Every customer is connected to a feeder. A feeder is the connection from a sub-station through wires, transformers etc. to a customer. It is fairly common practice in the electric utility industry to use the standard IEEE reliability indices like CAIDI, SAIFI, SAIDI to track and benchmark reliability performance.

SAIDI (System Average Interruption Duration Index)

SAIDI is more commonly known as "average customer minutes off supply" and is generally reported over a one-year period. It is the total of interruption duration in minutes per year per customer experienced by customers for both planned and unplanned interruptions.

A SAIDI of 200 minutes means that customers connected to the feeder or supply area being measured experience in average 200 minutes off supply in 12 months.

SAIFI (System Average Interruption Frequency Index)

SAIFI is a measure of how often an average customer loses supply during one year. A SAIFI of 3 means that the average customers connected to the feeder or supply area being measured on average lost supply thrice during the past 12 months.

For example Tasmanian Electricity Code is using SAIDI and SAIFI and have set average and lower bound requirement of reliability for these indices. Their endeavor is to ensure that total duration of planned and unplanned interruption to supply of electricity to a customer does not exceed on average the average reliability value set and that no more than 5% of all feeders in a supply area category exceed the lower bound of reliability. Their average reliability (SAIDI) for different category of feeders vary from 30 minutes to 480 minutes and lower bound of reliability is set to 60 minutes to 720 minutes. Their average reliability(SAIFI) for different category of feeders vary from 1 to 6 and lower bound of reliability is set to 2 to 9. There is no internationally accepted figure for this indices and utility have to set their own targets in consultation with regulators depending upon the past performance and allowed violations. In most of the developed countries, the average SAIFI ranges from 0.5 to 5.0 interruption per year. The average SAIFI in USA is 1.3. The data of various countries is indicated in Table 4.

Further in order to demonstrate the improvement in reliability of supply with the implementation of project, following other reliability indices are available for assessing performance.

Index Name	Formula
CAIFI	$\frac{\text{Total No of Customer Interruptions}}{\text{Total No of Customers affected}}$
CAIDI	$\frac{\text{Total No of Customer Interruption Durations}}{\text{Total No of Customers interruptions}}$
ASAI	$\frac{\text{Customers hours of available service}}{\text{Customers hours demanded}}$
ALII	$\frac{\text{Total load interruptions}}{\text{Total connected load}}$
ASCI	$\frac{\text{Total load Curtailment}}{\text{Total No of Customers}}$
ACCI	$\frac{\text{Total load Curtailment}}{\text{Total No of Customers affected}}$
MAIFI	$\frac{\text{Total No of momentary interruptions}}{\text{Total No of Customers}}$

SARFI (x)	Total No of Voltage Sags(below x%) per year

PRESENT STATUS OF RELIABILTY MONITORING IN THE COUNTRY

In the absence of data base for consumers and systems and also computerization of logging complaints ,following information in respect of 11 kV feeders of towns having population of more than 8 lakhs is initially being collected by CEA and soon will be published. Table 1.1 to 1.3 gives the performance of some towns for the month of April 2004 to July 2004. It is seen that the performance is not steady and there is large variation in the data. In some cases it has deteriorated.

- Total No. of 11 kV Feeders
- Total Outage Duration (Hrs) both Tripping &Scheduled in the month
- No of Scheduled Outage in the Year
- No. of Trippings Per Feeder
- Reliability Index

Table 2 gives the data of reliability indices collected by CPRI in one study of Eluru Circle of Andhra Pradesh. It can be seen that there is marked improvement in various reliability parameters in year 2002-03 over 2001-02.Table 3 is the reliability figures collected from NDPL for their system and the figures for Baltimore(US). It is seen that efforts are required to be made to bring this to inter-national level though the reliability figures

LIMITATIONS IN ASSESMENT OF CONSUMER SUPPLY RELIABILITY

- No Consumer Indexing
- No Computerised Based Trouble Call Management System
- No Data Base Of Consumers and System
- Lack of Awareness Of Utility Staff

ROAD MAP FOR RELIABILITY EVALUATION

Sl No	Particulars	Commenced/to be commenced from
1.	R.I(11 kV feeders) for towns having population of more than 8 lakhs	Jan ,2004
2.	R.I (11 kV feeders) for State Capitals	April, 2004
3	R.I (11 kv feeders) for Distt HQ	April, 2004
4.	R.I for Consumers based on CAIDI,SAIDI etc	Jan, 2007

MEASURES TO IMPROVE RELIABILTY

- Adequate maintenance
- Adoption of preventive maintenance rather than break down maintenance
- Better control of system operation
- Avoid over loading of lines & transformers
- Employ better quality equipments
- Minimisation voltage transformations
- Ensure coordinated protection settings
- Use of HVDS
- Improve power quality
- Human Resource Development

MONITORING OF DISTRIBUTION TRANSFORMERS FALIURE

Nearly 20 Lakh distribution transformers are in place in the country and every year 10 % transformers are being added to the system. The failure rate in India is around 20 %. This is considered to be very high and the monitoring of transformers failure is also very essential to improve reliability of power supply to consumers. The transformer failure rate of the order of 6-8 % is generally acceptable.

FACTORES RECKONED FOR RELIABILITY ANALYSIS:

The reliability indices can be evaluated considering the following factors:

- 33 kV breakdowns
- 11 kV breakdowns
- Incoming supply failure at 132 kV substations.
- Daily rostering of 11 kV rural feeders.
- Failure of distribution transformers.

The following factors, which affect reliability indices, shall also be considered subject to availability of data

- Momentary interruptions on 33kV and 11kV feeders.
- Momentary incoming supply failures
- Pre-arranged shutdowns on lines and feeders
- Breakdown on LT feeders
- Blowing of transformer fuses both HV and LV individual fuse off calls

CONCLUSION

Distribution system Reliability Monitoring which was rarely an issue some time back is now generating waves in the minds of management of the distribution utilities. The consumer who was tolerant earlier ha become demanding. He is becoming conscious about the interruption free service. He has started realizing that he should get electricity for which he is a stakeholder in the entire game.

Reliable service is directly associated with the proper asset utilization, adequate and timely maintenance, power availability, redundancy in the system and fixing of performance targets for improvement in years to come.

In our country maintaining of power supply has gained momentum and some utilities have started monitoring through the above indices. In years to come a performance standard will be set by utility on their own depending upon the type of network, customer and load profile and the power requirement.

Maintenance is one aspect, which should not be ignored at all. Strategic maintenance planning taking a higher view of how maintenance dovetails with other activities and events that impact reliability will enable optimum utilization of the assets which will go a long way in providing reliable supply to consumers.

The reporting process of reliability indices must begin with monthly submission of these indices to CEA for publishing in the newspaper etc. These indices must be displayed in each work location. This process will reinforce the point that reliability issues at the work location do impact the overall utility programme and all efforts will be made to improve the same with a target bound programme.

Statistical approach to reliability monitoring will also assist the regulators to set more optimum performance standards. Reliability is a random process. These standards will be undoubtedly violated. It is to be seen how often these standards are violated and what corrective actions are taken to bring them within limits. Average values of reliability indices are not enough to predict rate of violation of standards and utility need to know the probability distribution adopting statistical methods.

TABLE 1.1 : AVERAGE OUTAGE DURATION PER FEEDER FOR TOWNS HAVING POPULATION MORE THAN 8 LAKHS

STATE	**TOWN**	**UTILITY**	**AVERAGE OUTAGE DURATION PER FEEDER (In Hrs.)**			
			April, 2004	May, 2004	June, 2004	July, 2004
ANDHRA PRADESH	HYDERABAD	APTRANSCO	4.72	7.97	5.00	3.38
	VISHAKHAPATNAM	APTRANSCO	1.70	1.77	3.40	3.26
	VIJAYAVADA	APTRANSCO	4.41	5.63	5.82	4.90
DELHI	DELHI	NDPL	-	4.52	4.23	3.44
		BSES (RAJDHANI)	10.95	10.65	9.38	10.69
		BSES (YAMUNA)	12.84	11.08	11.43	4.22
GUJRAT	SURAT	SEC	1.09	1.09	0.38	5.58
	VADODRA	GEB	-	-	-	-
KARNATAKA	BANGALORE	BESCOM	-	-	-	-
KERALA	KOCHI	KSEB	16.50	27.67	13.80	7.04
	TIRUVANTHAPURAM	KSEB	14.15	14.68	5.87	0.78
MADHYA PRADESH	JABALPUR	MPEB	0.49	-	0.87	1.27
MAHARASHTRA	GR. MUMBAI	BEST	0.02	0.03	0.04	0.05
	MUMBAI (SUBURBS)	REL. ENERGY	0.07	0.08	0.09	0.11
	NAGPUR	MSEB	2.27	3.27	3.91	2.27
	NASIK	MSEB	19.81	-	-	-
PUNJAB	AMRITSAR	PSEB	5.89	7.65	8.38	2.57
	LUDHIANA	PSEB	3.09	7.13	8.47	4.21
TAMILNADU	CHENNAI	TNEB	1.29	2.19	1.51	1.61
	COIMBATORE	TNEB	8.42	7.89	9.90	9.24
	MADURAI	TNEB	1.21	0.92	1.44	0.47
	TRIUCHANAPALLI	TNEB	1.62	2.33	2.28	4.12
WEST BENGAL	KOLKATA	CESC	0.34	0.26	0.34	0.28

TABLE 1.2 :AVERAGE NUMBER OF TRIPPINGS OF TOWNS HAVING POPULATION MORE THEN 8 LAKHS

STATE	**TOWN**	**UTILITY**	**AVERAGE NO. OF TRIPPINGS PER FEEDER**			
			APRIL, 2004	May, 2004	June, 2004	July, 2004
ANDHRA PRADESH	HYDERABAD	APTRANSCO	14.63	11.54	14.08	11.99
	VISHAKHAPATNAM	APTRANSCO	1.44	1.26	2.59	2.49
	VIJAYAVADA	APTRANSCO	10.31	10.78	13.67	14.04
DELHI	DELHI	NDPL	-	3.30	3.66	2.26
		BSES(RAJDHANI)	8.22	8.28	7.98	3.10
		BSES (YAMUNA)	10.54	7.83	8.09	2.20
GUJARAT	SURAT	SEC	0.92	0.92	0.38	1.45
	VADODRA	GEB	-	-	7.37	-
KARNATAKA	BANGALORE	BESCOM	-	-	-	-
KERALA	KOCHI	KSEB	37.31	45.76	30.00	14.34
	TIRUVANTHAPURAM	KSEB	27.00	27.70	13.78	1.48
MADHYA PRADESH	JABALPUR	MPEB	5.86	-	6.06	5.86
MAHARASHTRA	GREATER MUMBAI	BEST	0.05	0.06	0.11	0.11
	MUMBAI(SUBURBS)	REL. ENERGY	0.27	0.33	0.30	0.34
	NAGPUR	MSEB	2.48	3.14	4.55	2.02
	NASIK	MSEB	10.47	-	-	-
PUNJAB	AMRITSAR	PSEB	8.46	11.79	10.83	10.96
	LUDHIANA	PSEB	-	-	-	-
TAMILNADU	CHENNAI	TNEB	6.84	10.09	9.13	9.59
	COIMBATORE	TNEB	10.98	4.94	7.61	9.55
	MADURAI	TNEB	2.63	1.71	2.33	3.71
	TRIUCHANAPALLI	TNEB	3.48	5.03	3.66	4.07
WEST BENGAL	KOLKATA	WBSEB	0.12	0.11	0.13	0.11

TABLE 1.3 : RELIABILITY INDEX OF TOWNS HAVING POPULATION MORE THEN 8 LAKHS

STATE	TOWN	UTILITY	RELIABILITY INDEX			
			April, 2004	May, 2004	June, 2004	July, 2004
ANDHRA	HYDERABAD	APTRANSCO	99.34	98.93	99.31	99.55
	VISHAKHAPATNAM	APTRANSCO	99.76	99.76	99.53	99.56
	VIJAYAVADA	APTRANSCO	99.39	99.24	99.19	99.34
DELHI	DELHI	NDPL	-	99.39	99.41	99.68
		BSES (RAJDHANI)	98.48	98.57	98.70	98.64
		BSES (YAMUNA)	98.22	98.51	98.41	98.46
GUJARAT	SURAT	SEC	99.85	99.85	99.95	99.25
	VADODRA	GEB	-	-	99.45	-
KERALA	KOCHI	KSEB	97.71	96.28	98.08	99.05
	TIRUVANTHAPURAM	KSEB	98.03	98.03	99.19	99.90
MADHYA PRADESH	JABALPUR	MPEB	99.93	-	99.88	99.83
MAHARASHTRA	GREATER MUMBAI	BEST	99.99	99.99	99.87	99.99
	MUMBAI (SUBURBS)	REL. ENERGY	99.99	99.99	99.99	99.99
	NAGPUR	MSEB	99.69	99.56	99.46	99.69
	NASIK	MSEB	97.25	-	-	-
PUNJAB	AMRITSAR	PSEB	99.18	98.97	98.84	99.65
	LUDHIANA	PSEB	99.57	99.04	98.82	99.43
TAMILNADU	CHENNAI	TNEB	99.82	99.71	99.79	99.78
	COIMBATORE	TNEB	98.82	98.94	98.63	98.76
	MADURAI	TNEB	99.83	99.88	99.80	99.94
	TIRUCHANAPALLI	TNEB	99.77	99.69	99.68	99.45
WEST BENGAL	KOLKATA	CESC	99.95	99.96	99.95	99.96

TABLE 2: PERFORMANCE OF ELURU CIRCLE OF ANDHRA PRADESH

Index	2001-02	2002-03	2003-04
SAIFI(per 1000 customers)	2.54	1.43	-
SAIDI(Minutes per 1000 customers)	578	181	-
ASAI	0.87	0.77	-
Feeder Outage(No)	1767	1045	995(Up to Aug 2003)
Feeder Outage Duration (Hrs/year)	66.93	2208	15.46(Up to Aug 2003)

TABLE 3 : NDPL PERFORMANCE AT A GLANCE

Index	Unit	US(Baltimore)	NDPL(2003-04)	NDPL(Apr-Sept2004)
SAIFI	Numbers	1.26	19.19	17.5
CAIDI	Hours	1.5	2	2
SAIDI	Hours	2	38.39	35
RI	%	99.3	99.57	99.60

Table 4 :WORLD PERORMANCE AT A GLANCE

	USA	DEVEOPED COUNTRIES	NETHE-RLAND	FRANCE	ITALY	NEWZE-LAND	NIAGARA	BALTI-MORE (USA)	INDIA
SAIDI (Min/Hr)	-	-	20	57	191	120	-	2	1.2-1680
SAIFI (No)	1.3	0.5-5.0	.23	-	-	1-6	-	1.26	0.05-40
CAIDI (Hr)	-	-	-	-	-	66-2000	>2 Hr	1.5	-
SARFI(70)-No	18	-	-	-	-	-	-	-	-