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METROPOLITAN AREA DISTRIBUTION FEEDER NETWORK ANALYSIS FOR RELIABILITY INDICE'S

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ABSTRACT

The parameters of reliability of power distribution are the major goal lines to define the health status of any utility and its customer satisfaction. The reliability parameters of power distribution engineering are SAIDI, SAIFI, CAIDI and CAIFI, which are the primary contributors, which access the Utility-Customer dynamics in terms of credibility, accountability and satisfaction. In this paper, the reliability parameters for local Metropolitan Area Electricity Supply Company has been analyzed for the year 2014 starting from 1st January 2014 to 31st December 2014. These reliability parameters would be beneficial for the Utility to make major overhauling decision or adaptation of any latest technologies to enable a good customer relation as well as utility status. This parameter can also become the path way for implementing technology at the substation level, feeder level or at the customer end or in other words adoption of distribution system automation at the fundamental levels, basically in the form of substation automation, feeder automation and customer automation. This research activity demonstrates need for greater fault management system for improvement of distribution network reliability as well as customer satisfaction by the utility.

KEYWORDS: Bangalore Electricity Supply Company [BESCOM]

INTRODUCTION

Reliabiity Studies are the benchmark to decide the status of utility in terms of their operational capabilities taking customer satisfaction as their primary motive. Bangalore Electricity Supply Company is the major revenue generating Escom's in the state of Karnataka after it as been carved out from the Karnataka Electricity Board [KEB] as per the restructuring of the Power Companies in the State. BESCOM has jurisdiction of 8 districts in South Karnataka coming under 3 Climatic Zones of the State covering 41,092 sq kms with estimated population of 2.07 crores in this region. BESCOM has total circuit area of 2,44,490 route kilometers, in which 84,579 route kilometers of HT lines and 1,60,311 route kilometers of LT lines operated with 2,03,803 Distribution Transformers with 419 sub stations stretched across the network area [1].

Reliability is termed as the ability of a system to operate continuously without any fault or disturbance for an extended period. Any utility to have good reliability indices it needs to have very robust technology such as fault detection, isolation and restoration mechanism along with the feeder reconfiguration topology embedded in it. Reliability parameters for distribution network are CAIDI, SAIDI, CAIFI, SAIFI, ASAI and MAIDI, which are basic parameters in deciding reliability of the utility. To have great reliability indices, the utility need to adopt with great technology emphasizing on automation in its distribution network for fault management and feeder reconfiguration. Feeder reconfiguration involves management of power flow from the under loaded feeder to the over loaded feeder by altering the sequences of tie switches, section switches and reclosers. Reliability indices are the major goal lines of any utility to get maximum benefits in terms of economics as well as customers satisfaction. [2]

Distribution system is a primary role of distributing power to the customer and revenue generation for the utility. Modernization or Adoptation of new technology in the distribution sector will be the tool to improve all the parameters of reliability, which is termed as Distribution System Automation which will helps to improve reliability and performance that meets economic and technical aspects. The Distribution Automation involving feeder automation system has substation-centered automation combined with various protective and measuring devices in a single control panel, which would be instrumental in protective gear mechanism. This automation platform involves highly capable architecture performing many operations such as SCADA RTU, communication, port switch, protocol converter, sequence of events recorder, and substation HMI. This platform engages utility to have more reliable, thrusted power distribution supply to the consumers with far more benefits in terms of economic as well as technical capabilities [3]

In the distribution system network it consists of two over current relays and a earth fault relay which are connected between two phases and earth fault between a phase and earth lines. These relays consist of instantaneous and inverse-time overcurrent elements. Feeder faults are backed up with the low voltage side relay connected to the transformer, which houses inverse time overcurrent elements. All the utilities normally uses automatic recloser for feeder fault, where as the transformer low voltage side breakers lacks automatic reclsoing for the feeder faults, but both the feeder relays and transformers relays are having instantaneous overcurrent relays which acts on fault. The transformers relays acts faster than the feeder relay for the feeder faults, even though it lacks automatic reclosers, these fast response is due to the measurement of currents, which are similar for both the feeder as well as transformers relay, but this transformer reclosers acts faster due to the distance and fast response. Even though transformer relays acts faster to the faulted feeder fault, but it also causes major disadvantage of removing healthy part of the feeder from the service causing interruption to the consumers at the healthy part of the feeder. [4]

Distribution System Automation depends on how the system makes decisions during the contingency or normal routine power flow. The decision-making at the local level always saves time and increase response speed. Under the automation of distribution network, the equipments normally doesn’t sends the larger amount of the power flow data to the control room or neither to the central system, and hence it saves time and increases response time. During the automated operation, these systems sends operational data to the control station rather requesting for action from the control time, thus it is only information is transmitted to the control after the operation is carried out. In the distribution system automation protocol there will many technologies embedded to carry out many operations of power system. The operations such as load management, Energy Management, Fault Detection Isolation and Restoration system and power flow studies will be carried out by different technologies and perform operations individual depending upon the utility needs. [5]

In the distribution automation, the basic and important fundamental automated area is feeder automation. In the feeder automation, the basic concept is to have automated fault detection, isolation and restoration mechanism along with the network restructuring capabilities. Feeder Automation involves realization of the feeder line for substation, feeder and master station line capable of restructuring topology for feeder reconfiguration and also detection of the feeder fault, isolating the feeder from fault and simultaneous restoration for temporal fault. In the network, mainly it consists of large number of switches, isolator's and instrumentation equipments, here the feeder automation involves designing of various other network restructuring mechanism for controlling fault and power flow for balancing load during overloading or under loading conditions for smooth operation of power system. This feeder automation helps to reduce economic losses as well as reliability improvement for both customer as well as utility. In the area of network reorganizing or restructuring, feeder automation is instrumental for safer, flexible, profitable operation for distribution systems utility. [6][7]

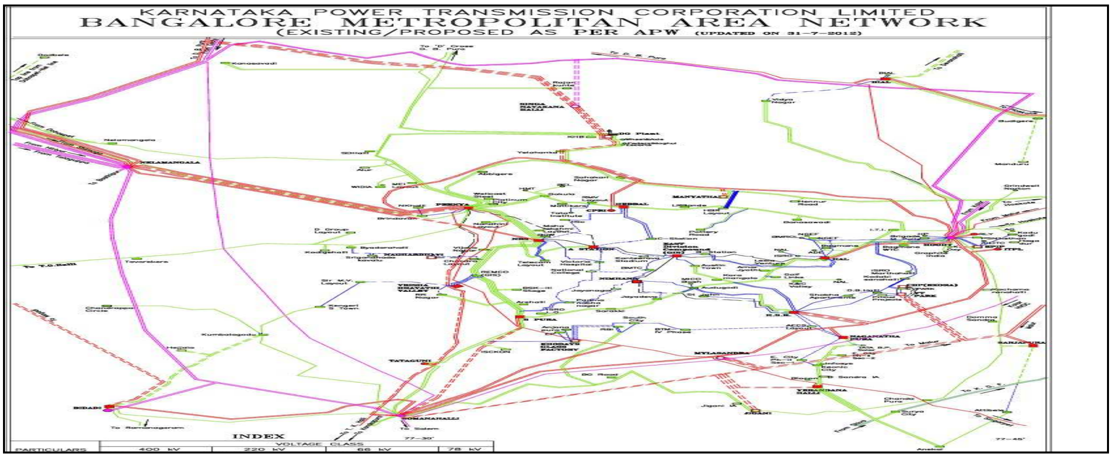

Figure 1: BESCOM Metropolitan Distribution Area Map

Utility Parameters for Reliability Studies

Utility that is distributing power in the Bangalore Metropolitan Network Area is BESCOM, which is the subsidiary of KPTCL. Figure 1 illustrates the BESCOM Metropolitan Distribution Network Area Map, which is the main source of revenue for entire state in terms of taxation, employment generation and revenue generation for Power Companies in the state. Under these circumstances, the Utility is facing severe power outages in its metropolitan network area due to the interruption in power supply to its consumers without any prior notification, which is surely as brought down the reliability of utility in terms of consumer satisfaction as well as utility parameters. Due to the massive unscheduled power outages due to the faults has caused huge losses to the industries, state revenue and to the Utility, this in turn as reduced employment generation capability of the state.

Table 1: Feeders Interruptions at Substation

Feeder No	No of Interruptions	Duration [Hr: Min: Sec]
Bank - 1	**3**	**0:58:00**
F-1	10	17:53:00
F-26	1	0:48:00
F-27	19	4:45:00
F-28	74	24:27:00
F-31	75	15:30:00
F-32	57	7:27:00
Bank - 2	**8**	**1:26:00**
F - 3	59	12:13:00
F - 6	38	7:49:00
F - 7	25	10:58:00
F - 17	52	7:49:00
F - 18	73	50:49:00

F - 19	38	4:49:00
Bank - 3	**8**	**1:42:00**
F - 8	67	18:25:00
F - 9	45	8:29:00
F - 11	127	14:46:00
F - 12	26	8:32:00
F - 13	21	3:02:00
Bank - 4	**4**	**1:35:00**
F - 2	35	9:32:00
F - 5	63	10:54:00
F - 14	31	8:14:00
F - 15	20	18:46:00
F - 16	163	23:44:00
F - 21	5	1:55:00
F - 22	4	2:20:00
F - 34 New ESI	9	3:21:00
Bank - 5	**10**	**4:41:00**
F4	47	6:26:00
F10	61	8:27:00
F20 - Old ESI	21	2:44:00
F23	51	7:31:00
F24	28	52:10:42
F-25	62	9:20:00
F29	55	12:33:00
F30	62	0:00:00
F33	14	3:38:00
Total	**1571**	**410:28:42**

Table 2: Feeders Interruptions at Substation Including L/C

Feeder No	No of Interruptions	Duration [Hr: Min: Sec]
Bank - 1	**3**	**0:58:00**
F-1	18	162:58:00
F-26	1	0:48:00
F-27	20	4:45:00
F-28	90	211:59:00
F-31	92	234:44:00
F-32	81	384:15:00
Bank - 2	**8**	**1:26:00**
F - 3	63	12:22:00
F - 6	40	13:54:00
F - 7	26	12:33:00
F - 17	57	11:07:00
F - 18	82	113:13:00
F - 19	39	5:15:00
Bank - 3	**10**	**6:40:00**
F - 8	70	44:30:00
F - 9	48	22:29:00
F - 11	130	17:19:00
F - 12	28	8:57:00
F - 13	25	56:26:00
Bank - 4	**4**	**1:35:00**
F - 2	36	9:57:00
F - 5	63	10:54:00
F - 14	44	44:45:00
F - 15	20	18:46:00

F - 16	178	23:44:00
F - 21	6	2:40:00
F - 22	7	23:33:00
F - 34 New ESI	9	3:21:00
Bank - 5	**10**	**4:41:00**
F4	47	6:26:00
F10	62	8:27:00
F20 - Old ESI	22	10:59:00
F23	55	10:13:00
F24	28	52:10:42
F-25	64	27:57:00
F29	58	36:53:00
F30	66	0:00:00
F33	17	4:43:00
Total	**1727**	**1757:06:42**

Distribution Feeder Interruptions occurs due to the Over Current Fault [OCR], Earth Fault [EFR], Line Clearance [L/C] and High Voltage Terminal Fault [H/T] during their routine operations. To minimize impacts of faults, every distribution sub stations houses three relays in control panel for each feeder namely Over Current Relays, which are two in numbers, and a Earth Fault Relay connected across the three phases and neutral, in the sequences such as OCR-OCR-EFR.

Table 1 shown above is Feeder Interruptions at the substation within the Bangalore Metropolitan Network Area which has 5 Banks of rating 66/11KV comprising of 34 feeders of rating 11KV studied for a period of one year starting from 01/01/2015 to 31/12/2015 for Distribution faults, namely Over current fault, Earth Fault, both Over current and Earth fault, and High Voltage Terminal Fault. During a year, this Substation feeder has interrupted 1571 times, causing unscheduled interruption to 1,37,431 customer for a period of 410 hours 28 minutes and 42 seconds without considering Interruption due to Bank Failures.

Table 2 shown above are Feeder Interruptions for the feeder at the same substation for the period of one year starting from 01/01/2015 to 31/12/2015 for Distribution faults, namely Over current fault, Earth Fault, both Over current and Earth fault, Line Clearance [L/C] and High Voltage Terminal Fault. During this period, this Substation feeder has interrupted 1727 times causing unscheduled interruption to 1,37,431 customer for a period of 1757 hours 06 minutes and 42 seconds, where Line Clearance is obtained for Operation and Maintenance from the service provider or maintenance workers of feeder during this period. This table is summation of Table 1 number of interruption added with the line clearance of same feeders.

Table 3: Feeders and Customer Details for NRS S/S

Feeder No	No of Customers	Feeder No	No of Customers
Bank	**Bank**	**Bank**	**Bank**
F-1	950	F-2	2627
F-26	100	F-5	2654
F-27	2013	F-14	3378
F-28	72	F-15	3027
F-31	4475	F-16	10665
F-32	2256	F-21	100
BANK	BANK	F-22	1
F-3	5300	F-34	42
F-6	2980	BANK	BANK
F-7	5610	F-4	11104
F-17	7476	F-10	11008

F-18	8088	F-20	2344
F-19	6958	F-23	3884
BANK	BANK	F-24	1463
F-8	5097	F-25	4534
F-9	729	F-29	4968
F-11	7813	F-30	9252
F-12	4474	F-30	1
F-13	1988	------	--------
Total Number of Customers			**1,37,431**

Utility in the metropolitan network area has 419 substation amounting for 2.07 crore population who are directly or indirectly effected due to the interruption during peak or off peak hour due to technical snag or unscheduled line clearance effecting reliable power supply to the customers. In the Table 3 above demonstrates feeder and customer details for NRS sub station which amounts for 34 feeders having 1,37,431 customers spread across the sub station network. In this research, reliability indices are analyzed for this feeders and are co-related to 2000 feeders of utility and for which indice's are calculated and tabulated below in the tables.

Table 4: Feeder Faults and Interruption Parameters

Type of Fault	No of Interruptions	Duration of Interruption [Minutes]
L/C	157	80,799
OCR	291	3,896
EFR	704	5,757
OCR/EFR	473	13,897
H/T	204	2,134
Total Fault excluding L/C	1571	24,628
Total Fault Including L/C	1727	1,05,427

In Bescom distribution network refering to 34 feeders of NRS feeder, their faults are distinguised has line clearanace [L/C], Over Current Relay Fault [OCR], Earth Fault [EFR], both OCR and EFR, and High Voltage Terminal Fault [H/T]. In the Table 4 above all the faults are tabulated for the one year starting from 1st January 2014 to 31st December 2014 with number of interruptions and duration of interruption in minutes.

Table 5: Reliability Indices

No of Customers	1,37,431	1,37,431
No of Interruption	1571	1727
Duration	24,628	1,05,427
SAIDI	0.18	0.77
SAIFI	0.01	0.01
CAIDI	15.68	61.05
CAIFI	0.01	0.01
ASAI	95.22%	69.12%

For total number of interruptions and total interrupted duration for 34 feeders of BESCOM's NRS Sub station tabulated above and reliability indices as being calculated for the year 2014. These are co-related to entire metropolitan area bescom feeders, which is 2000 in number, are tabulated in the Table 5 above under the title "Reliability Indices", which includes Average Service Availibility Indice's [ASAI] for the customers available during the year, for both conditions namely line clearance and without line clearance. Line clearance is forced interruption to the customer during normal hours.

Reliability Improvement for Distribution Network

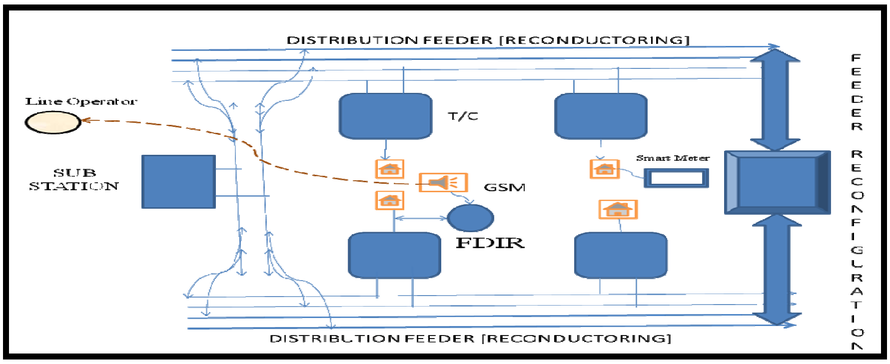

Figure 2: Distribution Automation System

The Figure 2 demonstrates Distribution Automation System, which involves Distribution Feeder Reconductoring, Feeder Reconfiguration, Fault Detection, Isolation and Restoration [FDIR] and Smart meter, these componentes constitutes Utility Automation, Inter Mediate Automation and Customer End Automation. Distribution Network Automation is a mechanism to improve reliability indice's of the distribution network.

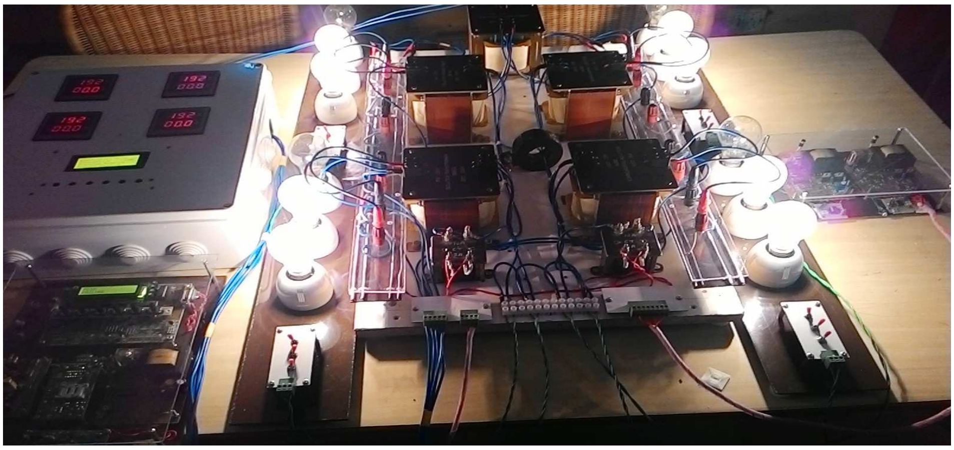

Figure 3: Distribution Automation System Prototype Module

Figure 3 above is of the prototype module of Distribution Automation System, which demonstrates Feeder Reconfiguration, Feeder Reconductoring, FDIR and Smart Meter. Figure 4 below demonstrates flow chart for element redundancy method of operation for Fault detection, Isolation and Restoration [FDIR] in the inter mediate level automation between the utility and customer, working primarily to detect fault which might be permanent or temperal in nature, which is helpful in detection of fault location as soon as fault is sensed by the relays and circuit breaker is activated to isolate the unhealthy section of feeder from healthy section using Global Service for Mobile Communication protocol as the medium to communication between operator and system for fault management and power restoring mechanism.

Feeder [F-11] which is supplying power to 7813 customer, had 127 interruption in a year for the network in traditional operation mode. Under the automated condition, assuming that the feeder F-11 are sectionised into 10 sections under the fault management mechanism condition adopting element redundancy method for feeder operation with FDIR at the sections patrolling for any interruptions would be instrumental in improvement of reliability parameters for the entire feeder, which would benefit entire utility as well as customers. This modus operandi shall be adapted to all the 34 feeders for the NRS sub station for improvement of power management by the substation for customer satisfaction and improved power management during contingency. The improved reliability parameters are tabulated in the Table 6 below.

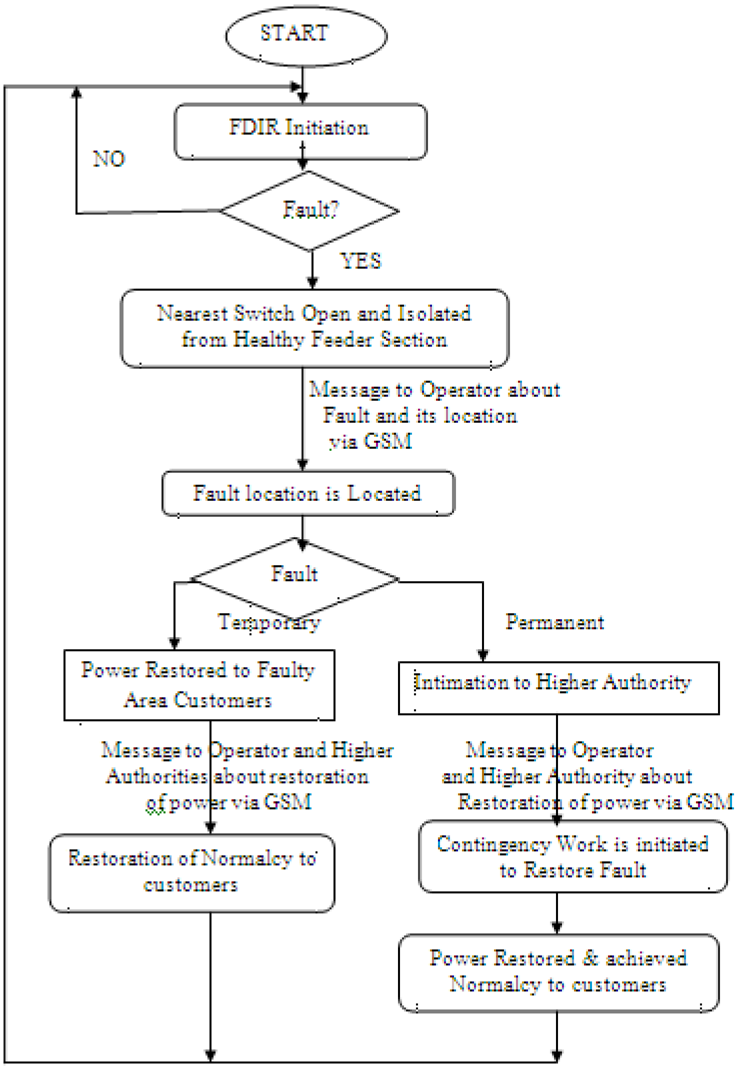

Figure 4: Flow Chart for Reliability Improvement Using FDIR

Table 6: Improved Reliability Indice's

No of Customers	**7813**	***Interruption Duration Per Section**	**86**
No of Interruptions	127	*SAIDI	0.11
*No of Sections	10	*SAIFI	0.01
*No of Customers per Section	780	*CAIDI	0.67
Total Interrupted Duration	866	*CAIFI	0.01
*No of Interruption per Section	13	*ASAI	99.98%

CONCLUSIONS

The primitive distribution network for any metropolitan area for power supply was under severe stress due to the very low reliability indices as well as poor customer satisfaction. This was due to lack of adoption of technology by utility for power management as well as fault management. After the implementation of technology at the suitable levels in feeder in the form of distribution automation system, as fault management system in the form FDIR system for early fault management which in turn improves reliability of the distribution network. In this research, reliability improvement objective has been achieved by demonstrating prototype of distribution system automation for feeders by adopting element redundancy method of reliability improvement by sectioning each feeder. This sectioning of distribution feeder along with implementation of the fault management system as improved reliability parameters of distribution network as well as customer satisfaction for metropolitan network area.

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