

RELIABILITY ANALYSIS OF 33 kV NETWORK

3.1 Reliability status of 33kV network of C.E.B

According to CEB statistics of the year 2012 [1], there is a total length of 26,053 km of 33 kV overhead lines and 4,979,862 Nos of consumer accounts. The outage statistics of Western Province South - 1 (WPS - 1) shown in Table 3.1 indicates the breakdown status from 2010 to October 2013. It is difficult to obtain relevant data for the past 10 years as 33 kV breakdown data of CSC have not properly been maintained and the available data obtained from the Control Center of WPS - 1 which commenced in the year 2010. The data comprise only the reported breakdowns and actual figures are slightly higher than the reported figures.

Table 3.1 The statistics of 33kV distribution network in WPS - 1

Item	Unit	2010	2011	2012	Up to Oct 2013
Reported 33kV breakdowns	Nos	26,345	26,978	27,678	29,123
Reported outage time due to breakdowns	Hrs	54,352	56,789	58,743	59,765
Total 33 kV Line Length	kms	785	824	857	873
Total Consumers	Nos	223,200	230,717	240,341	247,530

However, internationally, there are some standard indices commonly used to analysis of power supply reliability are given below.

- SAIDI : System Average Interruption Duration Index
- SAIFI : System Average Interruption Frequency Index
- CAIDI ; Customer Average interruption Duration Index
- CAIFI : Customer Average interruption Frequency Index
- ASAI : Average service Availability Index, etc.

The SAIDI, SAIFI and CAIDI are the most widely used indices, because they focus on the system and the customer, as the affected parties, and then focus on the main aspects of reliability, the duration and frequency of outage.

- $$SAIDI = \frac{\sum_{vi} \text{Annual outage duration for customer, } i}{\text{Total no of customers}} \quad [2.1]$$

- $$SAIFI = \frac{\sum_{vi} \text{Annual interruptions count for customer, } i}{\text{Total no of customers}} \quad [2.2]$$

- $$CAIDI = \frac{\sum \text{Customer interruptions duration}}{\text{Total no of customer interruptions}} \quad [2.3]$$

Table 3.2 shows the reliability indices and other data of 33kV network of North Western Province (NWP) from 2003 to 2012 obtained from the Distribution Planning Branch of NWP. The indices have been calculated without incorporating planned interruptions, the breakdowns which were not reported and source side outages. This will give idea of reliability indices of other provinces of CEB. The total consumer accounts of NWP reported in 2012 was 672,150.

**Table 3.2 The statistics of 33kV network in NWP**

Item	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
No of Breakdowns	3,200	2,653	2,534	2,863	2,136	2,723	3,612	2,756	2,356	2,390
Outage Time(min)	1,863	1,876	1,719	1,830	1,569	1,725	1,890	1,732	1,652	1,690
Average SAIDI(min/yr)	863	756	721	796	556	786	896	787	653	690
SAIFI (int/yr)	7.52	6.53	5.41	5.66	4.27	8.45	5.36	5.66	4.33	3.25
Total 33kV Line Length (km)	2,653	2,732	2,890	3,086	3,290	3,432	3,590	3,700	3,860	3,962

The comparison of reliability indices of some countries, some CEB regions [2] and LECO areas [3] are shown in Table 3.3

**Table 3.3 Comparison of statistics on reliability indices of CEB/LECO regions and other countries**

Country/Utility	SAIDI Minute per year	SAIFI Event per year
CEB Region 1 (R 1) - NWP , MV only (2012)	690.0	3.25
CEB Region 4 (R 4), MV & LV (Hambantota District) , 2010	1,832.0	2.99
CEB Region 2 (R 2)	2,520.0	n.a
LECO, 2012	5,588.4	100.00
LECO (Moratuwa Branch), 2012	4,369.2	120.00
Singapore	3.0	0.02
Netherlands	2.0	0.23
France	62.0	1.00
Australia	72.0	0.90
UK	90.0	0.80
USA	95.9	1.18
Spain	104.0	2.20
Malaysia	150.0	0.12

When analyzing above data, it was found that reliability indices of some regions of the CEB are very far from the indices of other developed countries. The reliability indices of MV and LV networks of Hambantota district [2] are 1832.0 of SAIDI and 2.99 of SAIFI. This may not be the actual figures but would be higher as the information was collected for 60 days and does not cover the whole year. Anyhow this improvement may be due to the upgrading and development of MV and LV system under Lighting Sri Lanka Hambantota Project (LSHP).

The Colombo city area accounts for 14% of power consumption of the entire country and it is the highest revenue earning region in the CEB when compared to other provinces. The supply reliability of Colombo city area is maintained at a reasonably higher level which is represented by the SAIDI of 7 hours per consumer per annum [4].

In Western Province South-1, the SAIDI of Dehiwala area due to distribution system failures alone was estimated about 36 hours per consumer per annum [4] and need to be improved to a level below 15.

Hence, it is necessary to improve SAIDI and SAIFI of Ratmalana and Moratuwa areas because most of the commercial, Industrial and residential consumers pay for substantial amount of consumption at higher tariff rate. They are more concern about continuity of electricity supply.

### 3.2 Calculation of SAIFI / SAIDI in Ratmalana Feeder – 9

RF - 9 feeds power to Angulana PSS, Moratuwa PSS and Ratmalana economic center. The reliability indices for RF - 9 are computed with following assumptions.

- The planned interruptions are not considered as an outage.
- The 11 kV and LV outages of connected consumers are not included for computation.



- The customers connected to RF 9 are the customers who are connected to all 11 kV feeders in Angulana PSS, Moratuwa PSSs and consumers in four 33 kV distribution substations in Kademulla area.

- After clearing the fault in RF - 9, the supply system will be normalized immediately.

The outage data and the consumer statistics of the Ratmalana Feeder 9 are shown in Appendix - A.

According to the definition [2.2], [2.2] and [2.3] and assumptions stated above, the reliability indices of RF - 9 are calculated as follows.

$$\begin{aligned} \text{SAIDI} &= 1,152,506 / 24642 \\ &= 46.77 \text{ hrs / connected consumer} \end{aligned}$$

$$\begin{aligned} \text{SAIFI} &= 1,453,878 / 24642 \\ &= 59.0 \text{ interruption / connected consumer} \end{aligned}$$

$$\begin{aligned} \text{CAIDI} &= 1,152,506 / 1,453,878 \\ &= 0.7927 \end{aligned}$$

Therefore calculated reliability indices of the RF - 9 are,

$$\text{SAIDI} = 46.77 \text{ hrs / connected consumer}$$

$$\text{SAIFI} = 59.0 \text{ interruption / connected consumer}$$

$$\text{CAIDI} = 0.7927 \text{ hrs / interruption}$$

The calculated SAIDI and SAIFI values with the assumptions (Consider 33 kV outages only) cannot be compared with other countries. The actual value of Sri Lanka will be higher than the other developed countries as shown in Table 3.1.

Therefore, it is an essential requirement to improve reliability of RF - 9 at least to the level of Colombo city metropolitan area. The SAIDI of Colombo city metropolitan area is maintained at 7 hours per consumer per annum [4].

Hence it is important to find appropriate solutions to improve the reliability in RF - 9, in order to reduce the SAIFI and SAIDI.