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Effect of a Single Fault Passage Indicator Placement on Radial Distribution System Reliability under Two Weather Conditions

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Abstract*: The components in the overhead electrical network are continuously exposed to the physical environment of varying weather conditions. If the weather around an electrical network is normal and consistent throughout a certain period of time, then the weather can be modelled as normal or single weather (SW). However, in practice, the overhead electrical network is always subjected to varying weather conditions such as normal weather and adverse weather then the weather is modelled as two weather (TW) model. Adverse weather (AW) can cause significant physical damage to the components, resulting in higher average failure rates and longer durations for power restoration. Without considering the weather conditions, the reliability assessment of the overhead electric power distribution system can be over-optimistic, and influence the planning and design decisions. The investigation of system reliability under two weather conditions provides the effect of percentage failures that occurs in severe weather conditions on average interruption duration per customer per year and the amount of energy not supplied per customer per year. This paper evaluates the reliability of a radial distribution system (RDS) considering single weather and two weather conditions. Further, the effect of the fault passage indicator placement on RDS under SW and TW is also evaluated. A fault passage indicator (FPI) is a device that indicates and communicates the fault's location to the operator hence reducing the fault identification time and improving the system reliability by reducing the outage duration time.

***Keywords*: Reliability, Radial Distribution System, FPI, and Two Weather.**

I. INTRODUCTION

According to customer failure statistics, radial feeder topology and high failure rates in line sections are responsible for more than 80% of customer service interruptions [12]. Weather is a critical factor that significantly impacts an electric utility's operational capability and reliability in overhead distribution networks.

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The weather environment was categorized into three types by IEEE Standard 346 and designated as NW, AW, and major adverse weather [1][2]. Adverse weather is caused by high winds, heavy precipitation, wide temperature fluctuations, and so on. It generates a high component failure rate that rises significantly, resulting in longer power supply restoration times [11]. In the case of high winds, research indicates that power distribution system failure rates increase significantly when wind speeds exceed eight meters per second (about 18 mph) [6, 8, 9, 13]. High precipitation occurs when rainfall exceeds two inches in 24 hours (or snowfall exceeds six inches per day). Extreme hot or cold temperatures can permanently harm (or hasten the depreciation of) distribution system equipment, resulting in power outages, as described in [13], [14]. Major adverse weather results in significant mechanical damage, more customers being out of service than expected, and a longer than expected time for service restoration. [5]

Power supply restoration depends on fault identification, repair or replacement of faulty components, and switching time. FPI provides a solution for quick fault detection time for fault events, which improves system reliability by reducing outage length. [3]

This paper describes briefly the effect of FPI location on RDS reliability in terms of system performance indices in SW and TW.

The following sections describe in detail the evaluation of power restoration time using FPI modelling and the approaches used to assess the reliability of the radial distribution system in SW and TW conditions.

II. EVALUATION OF POWER RESTORATION TIME WITH FPI MODELLING IN RDS

FPI is a device used to locate short-circuit and earth faults by sensing the magnetic field produced by the fault current flowing through a conductor. The location of the fault is indicated by an activated light on-site or by immediately delivering the message to the utility personnel via its communication interface. These capabilities enable the utility to promptly locate the fault, resulting in a shorter overall power restoration time. [7].

After a sustained fault occurs, the power restoration may be due to the repair/replacement of components or switching of appropriate disconnectors. Then the average restoration time is determined as:

- If the fault clearance is associated with repair action, then the average restoration time is determined as the sum of the average repair time and fault identification time.
- If the fault clearance is associated with switching action, then the average restoration time is determined as the sum of switching time and fault identification time.

The effect of FPI on identifying the fault location is as follows: let the total length of the radial feeder is L km, the distance between the substation and FPI is X km and is said to be part 1, the distance between FPI and downstream of feeder is Y km and is said to be part 2 as shown in figure 1.

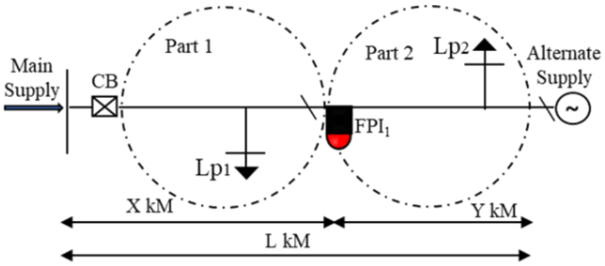

Fig. 1.Radial Feeder with FPI Placement

If the fault occurred in part 1, then the corresponding fault identification time (T_1) is given by equation 1, in case the fault occurred in part 2, the fault identification time (T_2) is given by equation 2.[10]

$$T_1=T_o\times(X/L) \quad \text{hr} \quad (1)$$

$$T_2=T_o\times(Y/L) \quad \text{hr} \quad (2)$$

Where T_o is the average time for identification of fault location when there is no FPI and is taken as 0.75 hr in both normal and adverse weather.

When a sustained fault in part 1, the i^{th} component in the faulty section with a repair time is r_i hrs and switching time is s_i hrs then the resultant restoration time of the component with the presence of FPI for the fault clearance is given by

$$r_i^{FPI}=r_i+T_1 \quad hr \quad (3)$$

$$s_i^{FPI}=s_i+T_1 \quad hr \quad (4)$$

Where r_i^{FPI} and S_i^{FPI} are the restoration times of repair and switching action respectively. Similarly, the restoration times are computed for the components of a faulty section in part 2.

III. RELIABILITY MODELING

The following section describes the component failure rate modeling and reliability indices in weather conditions

A. Component Failure Rate in Weather Conditions

The component failure rates of a radial distribution system in normal weather (λ^{NW}) and adverse weather (λ^{AW}) are calculated from the component average failure rate of utility data and weather duration probabilities [4].

The component failure rates in NW and AW are calculated using equations 5 and 6 respectively.

$$\lambda^{NW}=\lambda_{avg}(1-F_a)/P_{NW} \quad \text{f/yr} \quad (5)$$

$$\lambda^{AW}=\lambda_{avg}F_a/P_{AW} \quad \text{f/yr} \quad (6)$$

Where λavg = component average failure rate expressed in failures per year, P_{NW} = N/(N+A) is the steady-state probability of NW, P_{AW} = A/(N+A) is the steady-state probability of AW, N is the average duration of normal weather, A is the average duration of adverse weather. F_a is a fraction of the total number of failures that can be attributed to adverse weather.

B. Reliability Indices in Weather Conditions

The k^{th} load point indices such as average failure rate and unavailability in NW are calculated using equations 7 and 8 respectively.

$$\lambda_k^{NW}=\lambda_{Tfk}+\sum\lambda_{Si}^{NW} \quad \text{f/yr} \quad (7)$$

$$U_k^{NW}=\lambda_{Tfk}r_{Tfk}^{NW}+\sum\lambda_{Si}^{NW}r_{Si}^{NW} \quad \text{hrs/yr} \quad (8)$$

Similarly, the indices in AW are calculated using equations 9 and 10 respectively.

$$\lambda_k^{AW}=\lambda_{Tfk}+\sum\lambda_{Si}^{AW} \quad \text{f/yr} \quad (9)$$

$$U_k^{AW}=\lambda_{Tfk}r_{Tfk}^{AW}+\sum\lambda_{Si}^{AW}r_{Si}^{AW} \quad \text{hrs/yr} \quad (10)$$

Where Tf and Si indicate the distribution transformer and the feeder section respectively.

The above load point indices are used to determine the system performance indices such as System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and Energy Not Supplied (ENS). The feeder and system reliability indices are calculated using equations 11 to 13 in NW and equations 14 to 16 in AW [5].

$$SAIFI^{NW}=P_{NW}\sum_{k=1}^{m}\lambda_k^{NW}N_k/N \quad \text{Int./cust.-yr} \quad (11)$$

$$SAIDI^{NW}=P_{NW}\sum_{k=1}^{m}U_k^{NW}N_k/N \quad \text{hrs/cust.-yr} \quad (12)$$

$$ENS^{NW}=P_{NW}\sum_{k=1}^{m}U_k^{NW}L_{avgk} \quad \text{MWh/yr} \quad (13)$$

$$SAIFI^{AW}=P_{AW}\sum_{k=1}^{m}\lambda_k^{AW}N_k/N \quad \text{Int./cust.-yr} \quad (14)$$

$$SAIDI^{AW}=P_{AW}\sum_{k=1}^{m}U_k^{AW}N_k/N \quad \text{hrs/cust.-yr} \quad (15)$$

$$ENS^{AW}=P_{AW}\sum_{k=1}^{m}U_k^{AW}L_{avgk} \quad \text{MWh/yr} \quad (16)$$

Where m is the total number of load points, L_{avg} is the average load, N is the total number of customers (cust.) and Int. indicates interruptions.

The feeder and system performance indices in TW are calculated by using equations 17 to 19.

$$SAIFI^{TW}=SAIFI^{NW}+SAIFI^{AW} \quad \text{Int./cust.-yr} \quad (17)$$

$$SAIDI^{TW}=SAIDI^{NW}+SAIDI^{AW} \quad \text{hrs /cust.-yr} \quad (18)$$

$$ENS^{TW}=ENS^{NW}+ENS^{AW} \quad \text{MWh/yr} \quad (19)$$

The following section describes the radial distribution system data and assumptions considered for reliability evaluation with the placement of a single FPI on the feeder at different locations.

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IV. SYSTEM DATA AND ASSUMPTIONS

In this study, to evaluate the reliability the standard reliability test system Roy Billiton Test System 2 (RBTS2) and corresponding data are considered [1, 5]. The RBTS2 with the placement of a single FPI on the feeder at different locations is considered as one FPI at a time and is shown in Figure 2. The feeder section length data is shown in Table- I.

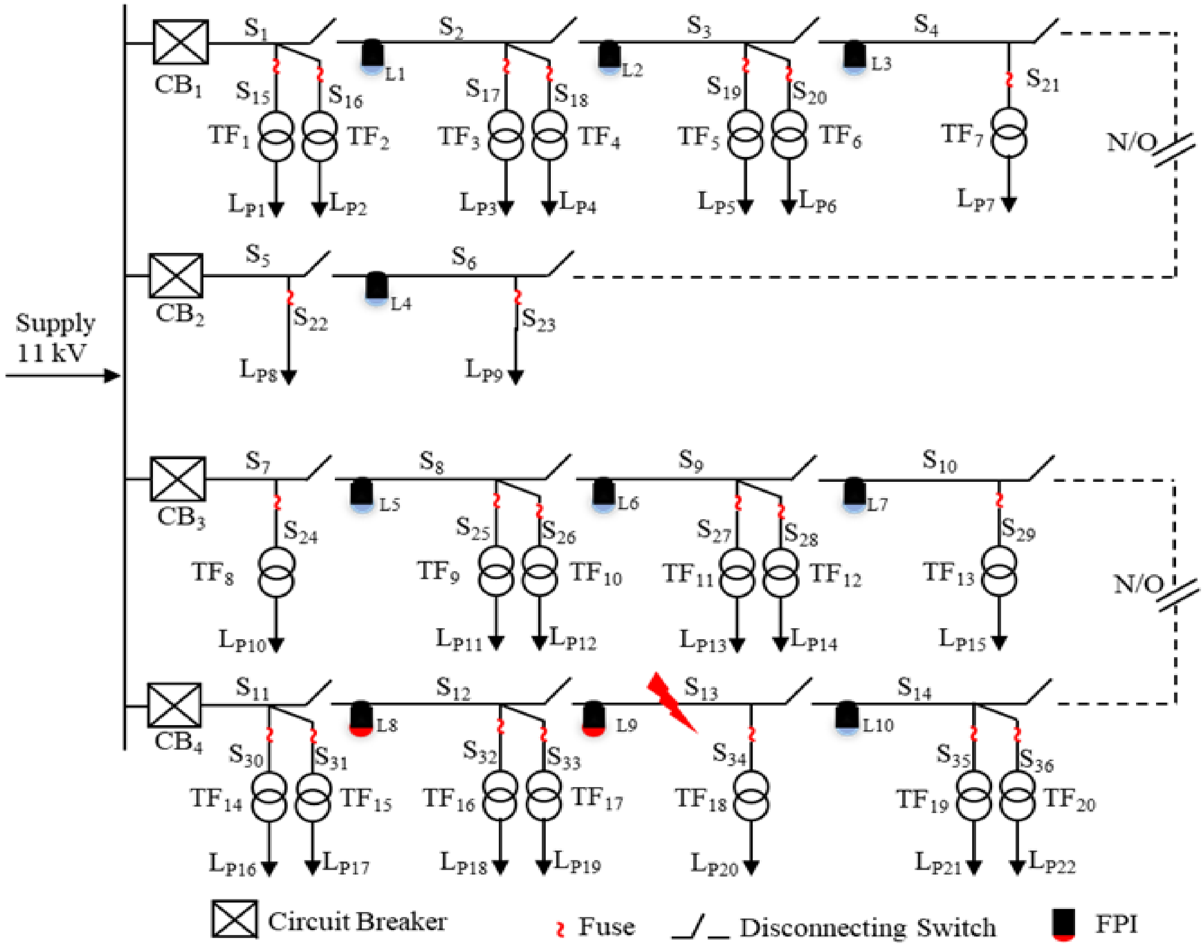

Fig. 2.RBTS 2 with the placement of a single FPI

In above figure 3, S indicates feeder sections, TF indicates distribution transformer and LP indicates load point.

Table- I: Feeder Sections Length Data

Length (km)	Feeder Sections
0.60	S4, S6, S9, S14, S16, S17, S22, S27, S30, S33
0.75	S1, S2, S3, S5, S7, S10, S12, S13, S15, S20 S23S25, S35
0.80	S8, S11, S18, S19, S21, S24, S26, S28, S29, S31, S32, S34, S36

In this work, the average failure rate of the feeder section is taken as 0.065 failure per km-year and for the distribution transformer, it is taken as 0.015 failure per year. The average load, type, and number of customers connected to each load point are shown in Table- II.

Table- II: Load Data

Load Point	Lavg (MW)	No. of Cust.	Type of Cust.
1,2,3,10,11	0.535	210	residential
12,17,18,19	0.450	200	residential
8	1.0	1	Small user
9	1.150	1	Small user
4,5,13,14,20,21	0.566	1	institutional
6,7,15,16,22	0.454	10	commercial

A. Assumptions

The assumptions considered for reliability evaluation are (a). Fuses are 100% reliable and can successfully isolate load point failures from sections so there is no effect of one load point failure on others. (b). FPI operation is 100% reliable and placed next to the disconnecting switch on the feeder. (c). FPI works on both line voltage and battery. It communicates to the control center through wireless communication. (d). The alternative supply connected through the normally open points is assumed to be 100 % reliable. (e). Regardless of the weather conditions supply from mains is assumed to be 100% reliable. The reliability evaluation of RBTS2 is evaluated for four different case studies and is shown in Table- III.

Table- III: Case Studies

Case Study	Weather Conditions	FPI	No. of FPIs on Feeder (F)			
			F1	F2	F3	F4
Case A	NW	NO	-	-	-	-
Case B	NW	YES	3	1	3	3
Case C	TW	NO	-	-	-	-
Case D	TW	YES	3	1	3	3

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In all the above cases the restoration of the distribution transformer is considered by its replacement if the fault occurred on the distribution transformer. The following section discusses the numerical results of four case studies.

V. RESULTS AND DISCUSSIONS

In all-case studies the average repair time for feeder sections in normal and adverse weather are considered 5 hr and 10 hr respectively, the average replacement time for distribution transformer in normal and adverse weather is considered 10 hr and 20 hr respectively, and the average switching time in both normal and adverse weather is considered as 1hr [4].

A. Case A

In this case, the weather is considered as NW hence the fraction of the total number of failures that can be attributed to adverse weather (Fa) is equal to zero. Load point indices are calculated using equations 7 and 8. Reliability indices of feeders and the whole system are calculated using equations 11 to 13. The results of case A are shown in Table- IV.

Table- IV: Reliability Indices of Case A

Feeder	$SAIFI^{NW}$ (int./cust.-yr)	$SAIDI^{NW}$ (hrs/cust.-yr)	ENS^{NW} (MWh/yr)
F1	0.248	0.770	2.790
F2	0.140	0.523	1.122
F3	0.250	0.775	2.356
F4	0.247	0.757	2.593
System	0.248	0.767	8.861

B. Case B

The weather is considered normal weather and the effect of the placement of a single FPI on RBTS2 feeder locations is considered and the results are shown in Table-V.

Table- V: Reliability Indices of case B

Feeder	Loc. of FPI	$SAIFI^{NW}$ (int./cust-yr)	$SAIDI^{NW}$ (hrs/cust-yr)	ENS^{NW} (MWh/yr)
F1	L1	0.248	0.674	2.458
	L2	0.248	0.693	2.493
	L3	0.248	0.751	2.704
F2	L4	0.140	0.486	1.040
F3	L5	0.250	0.684	2.079
	L6	0.250	0.693	2.085
	L7	0.250	0.760	2.293
F4	L8	0.247	0.665	2.280
	L9	0.247	0.681	2.310
	L10	0.247	0.720	2.439

From the above Tables IV and V, it is concluded that the placement of a single FPI on the RBTS2 feeder locations significantly affects the reduction of SAIDI and ENS. The percentage reduction of SAIDI and ENS for an overall system with the placement of a single FPI on RBTS2 feeder locations in normal weather is shown in Figures 3 and 4.

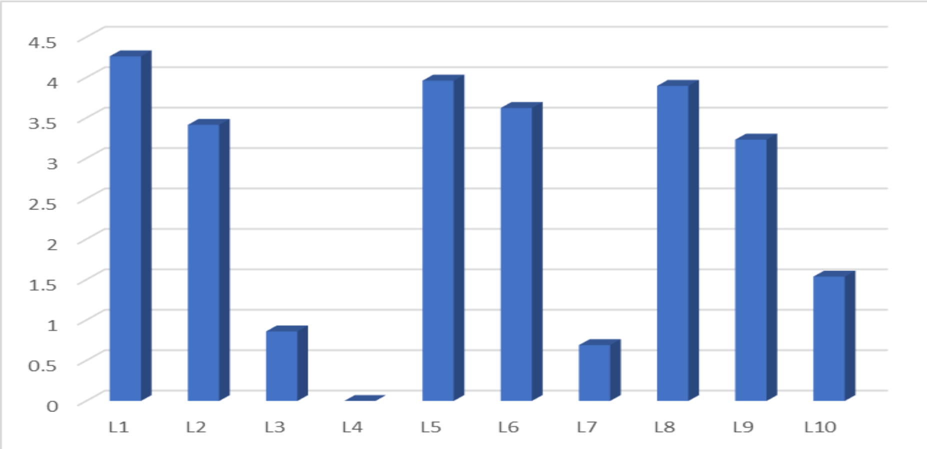

Fig. 3.Percentage reduction in system ENS

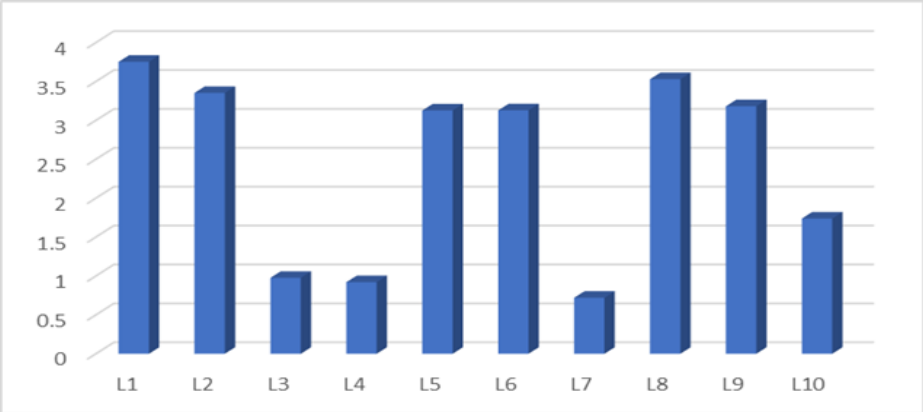

Fig. 4. Percentage reduction in system ENS

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C. Case C

The weather is modeled as two weather. The feeder section failure rates in normal and adverse weather are calculated using equations 4 and 5 respectively. Load point indices are calculated using equations 6 to 9. Feeder and system indices are calculated using equations 10 to 15. Reliability indices in two weather are calculated using equations 16 to 18. The reliability indices of four feeders and whole REBTS2 in normal, adverse, and two weather are shown for Fa=10% and 50% in Tables VI and VII.

Table- VI: SAIFI of four feeders and the whole REBTS2 at Fa=10% and Fa=50% for case C

	Fa=10%			Fa=50%		
	$SAIFI^{NW}$	$SAIFI^{AW}$	$SAIFI^{TW}$	$SAIFI^{NW}$	$SAIFI^{AW}$	$SAIFI^{TW}$
F1	0.225	0.023	0.248	0.131	0.117	0.248
F2	0.126	0.014	0.140	0.070	0.070	0.140
F3	0.226	0.024	0.250	0.132	0.118	0.250
F4	0.224	0.023	0.247	0.131	0.116	0.247
System	0.225	0.023	0.248	0.131	0.117	0.248

Table- VII: SAIDI of four feeders and the whole REBTS2 at Fa=10% and Fa=50% for case C

	Fa=10%			Fa=50%		
	$SAIDI^{NW}$	$SAIDI^{AW}$	$SAIDI^{TW}$	$SAIDI^{NW}$	$SAIDI^{AW}$	$SAIDI^{TW}$
F1	0.705	0.113	0.818	0.458	0.553	1.011
F2	0.471	0.100	0.571	0.262	0.501	0.763
F3	0.710	0.114	0.824	0.460	0.558	1.018
F4	0.693	0.110	0.803	0.451	0.539	0.990
System	0.703	0.112	0.815	0.456	0.550	1.006

Similarly, the impact of two weather with a different fraction of the total number of failures that can be attributed to adverse weather (Fa) from 0% to 100% in a step of 10% increment on RBTS2 is evaluated and corresponding results are shown in Figures 5 and 6.

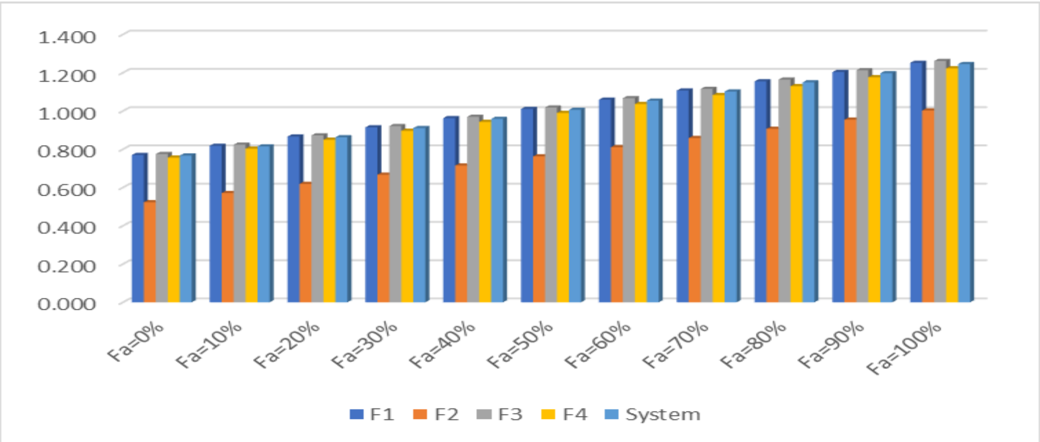

Fig. 5.SAIDI in case C

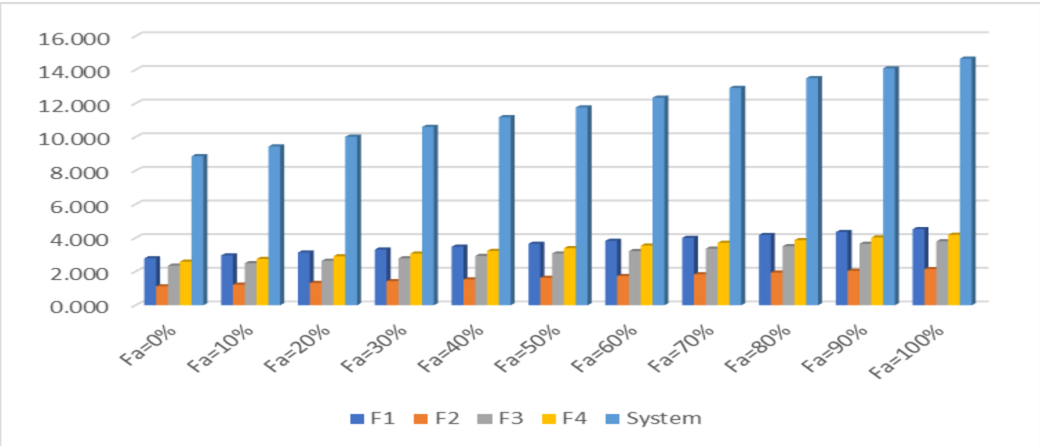

Fig. 6. ENS in case C

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D. Case D

In this case, the effect of weather and the placement of a single FPI on RBTS2 feeder locations are considered. Load point indices are calculated using equations 6 to 9. The feeders and system indices are calculated using equations 10 to 15. Indices in two weather are obtained by using equations 16 to 18. The results are shown in Tables VIII and IX.

Table- VIII: Feeder Indices of Case D

Feeder	Loc of FPI	Indices	Fa =10%	Fa =20%	Fa =30%	Fa =40%	Fa =50%	Fa =60%	Fa =70%	Fa =80%	Fa =90%	Fa =100%
F1	L1	$SAIDI^{TW}$	0.723	0.771	0.819	0.867	0.915	0.964	1.012	1.060	1.108	1.156
		ENS^{TW}	2.631	2.805	2.978	3.152	3.325	3.499	3.672	3.846	4.019	4.193
	L2	$SAIDI^{TW}$	0.742	0.790	0.838	0.886	0.934	0.982	1.031	1.079	1.127	1.175
		ENS^{TW}	2.666	2.840	3.013	3.187	3.360	3.534	3.707	3.881	4.054	4.228
	L3	$SAIDI^{TW}$	0.799	0.847	0.895	0.944	0.992	1.040	1.088	1.136	1.184	1.233
		ENS^{TW}	2.877	3.051	3.224	3.398	3.571	3.745	3.918	4.092	4.265	4.439
F2	L4	$SAIDI^{TW}$	0.534	0.582	0.630	0.678	0.726	0.774	0.822	0.869	0.917	0.965
		ENS^{TW}	1.143	1.246	1.349	1.451	1.554	1.657	1.759	1.862	1.965	2.067
F3	L5	$SAIDI^{TW}$	0.732	0.781	0.830	0.878	0.927	0.975	1.024	1.073	1.121	1.170
		ENS^{TW}	2.223	2.368	2.512	2.656	2.801	2.945	3.089	3.234	3.378	3.522
	L6	$SAIDI^{TW}$	0.740	0.789	0.837	0.886	0.935	0.983	1.032	1.080	1.129	1.178
		ENS^{TW}	2.223	2.368	2.512	2.656	2.801	2.945	3.089	3.234	3.378	3.522
	L7	$SAIDI^{TW}$	0.808	0.857	0.905	0.954	1.002	1.051	1.100	1.148	1.197	1.245
		ENS^{TW}	2.437	2.581	2.725	2.870	3.014	3.158	3.303	3.447	3.591	3.736
F4	L8	$SAIDI^{TW}$	0.712	0.758	0.805	0.852	0.898	0.945	0.991	1.038	1.085	1.131
		ENS^{TW}	2.439	2.599	2.759	2.919	3.079	3.238	3.398	3.558	3.718	3.877
	L9	$SAIDI^{TW}$	0.727	0.774	0.820	0.867	0.914	0.960	1.007	1.054	1.100	1.147
		ENS^{TW}	2.470	2.630	2.790	2.950	3.109	3.269	3.429	3.589	3.748	3.908
	L10	$SAIDI^{TW}$	0.767	0.814	0.860	0.907	0.954	1.000	1.047	1.093	1.140	1.187
		ENS^{TW}	2.598	2.758	2.918	3.078	3.237	3.397	3.557	3.717	3.876	4.036

Table- IX: System Indices of Case D

Loc of FPI	Indices	Fa =10%	Fa =20%	Fa =30%	Fa =40%	Fa =50%	Fa =60%	Fa =70%	Fa =80%	Fa =90%	Fa =100%
L1	$SAIDI^{TW}$	0.782	0.830	0.878	0.926	0.974	1.021	1.069	1.117	1.165	1.213
	ENS^{TW}	9.109	9.689	10.269	10.849	11.430	12.010	12.590	13.171	13.751	14.331
L2	$SAIDI^{TW}$	0.789	0.837	0.885	0.932	0.980	1.028	1.076	1.124	1.171	1.219
	ENS^{TW}	9.144	9.724	10.304	10.885	11.465	12.045	12.626	13.206	13.786	14.367
L3	$SAIDI^{TW}$	0.809	0.856	0.904	0.952	1.000	1.048	1.095	1.143	1.191	1.239
	ENS^{TW}	9.355	9.935	10.516	11.096	11.676	12.256	12.837	13.417	13.997	14.578
L4	$SAIDI^{TW}$	0.815	0.863	0.911	0.958	1.006	1.054	1.102	1.150	1.198	1.245
	ENS^{TW}	9.359	9.940	10.520	11.100	11.681	12.261	12.841	13.421	14.002	14.582
L5	$SAIDI^{TW}$	0.785	0.832	0.880	0.928	0.976	1.024	1.072	1.119	1.167	1.215
	ENS^{TW}	9.164	9.744	10.324	10.905	11.485	12.065	12.645	13.226	13.806	14.386
L6	$SAIDI^{TW}$	0.788	0.836	0.883	0.931	0.979	1.027	1.075	1.122	1.170	1.218
	ENS^{TW}	9.170	9.750	10.330	10.911	11.491	12.071	12.652	13.232	13.812	14.393
L7	$SAIDI^{TW}$	0.810	0.858	0.905	0.953	1.001	1.049	1.097	1.144	1.192	1.240
	ENS^{TW}	9.378	9.958	10.538	11.119	11.699	12.279	12.859	13.440	14.020	14.600
L8	$SAIDI^{TW}$	0.785	0.833	0.881	0.929	0.976	1.024	1.072	1.120	1.168	1.216
	ENS^{TW}	9.128	9.708	10.289	10.869	11.449	12.030	12.610	13.190	13.771	14.351
L9	$SAIDI^{TW}$	0.790	0.838	0.886	0.934	0.981	1.029	1.077	1.125	1.173	1.221
	ENS^{TW}	9.159	9.739	10.320	10.900	11.480	12.060	12.641	13.221	13.801	14.382
L10	$SAIDI^{TW}$	0.803	0.851	0.899	0.947	0.994	1.042	1.090	1.138	1.186	1.234
	ENS^{TW}	9.287	9.867	10.448	11.028	11.608	12.188	12.769	13.349	13.929	14.510

VI. CONCLUSIONS

The above results reveal that the placement of a single FPI on a radial distribution feeder improves the system's reliability in both single and two weather conditions. When the whole system is considered, L1 is the best location to place FPI in weather conditions. With FPI placement at Fa=100%, the percentage reduction of system SAIDI for the best three locations of L1, L5, and L8 are 2.60, 2.44, and 2.36 respectively. Similarly, the percentage increase of ENS is 2.27, 1.89, and 2.13 respectively.

DECLARATION

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REFERENCES

1. R. Billinton et al., 'A Reliability Test System for Educational Purposes - Basic Distribution System Data and Results', IEEE Transactions on Power Systems, Vo1.6, No. 2, May 1991, DOI: 10.1109/59.76730 [CrossRef]
2. R. Billinton and C. Wu, "Predictive Reliability Assessment of Distribution System Including Extreme Adverse Weather," CCECE, May 2001, Vol.02, pp.719-724. 10.1109/CCECE.2001.
3. H. Falaghi, M.R. Haghifam, M. R. Osouli Tabrizi, "Fault Indicators Effects on Distribution Reliability Indices", International Conference on Electricity Distribution, CIRED, June 6-9, 2005, pp. 1-4. DOI: 10.1049/cp:20050894. [CrossRef]
4. R. Billinton and G. Singh, "Application of adverse and extreme adverse weather: Modelling in transmission and distribution system reliability evaluation" , IET Proceedings - Generation Transmission and Distribution 153(1):115 – 120, February 2006, DOI:10.1049/ip-gtd:20045058 [CrossRef]
5. R. Billinton, J.R. Acharya, "weather-based distribution system reliability evaluation", IEE Proceedings - Generation, Transmission and Distribution, Volume 153, Issue 5, September 2006, pp. 499 – 506. [CrossRef]
6. Lallemand C. Methodology for a risk-based asset management. Royal Swedish Institute of Technology; 2008 [March].
7. Fault Indicators for the Safe, Reliable, and Economical Operation of Modern Power Systems, © 2010 Schweitzer Engineering Laboratories, Inc. https://selinc.com/api/ download/7394/
8. Caswell H, Forte V, Fraser J, Pahwa A, Short T, Thatcher M, Werner V. Weather normalizaton of reliability indices. IEEE Trans Power Deliv 2011;26(2): 1273e9. [CrossRef]
9. Alvehag K, Soder L. A reliability model for distribution systems incorporating seasonal variations in severe weather. IEEE Trans Power Deliv 2011;26(2): 910e9. [CrossRef]
10. E.Vidya Sagar, P.V.N. Prasad & Ather Fatima "Reliability Improvement of Radial Feeder using Multiple Fault Passage Indicators", International Journal of Energy Procedia, Elsevier March 2012, pp. 223-228. ISBN 1876-6102. [CrossRef]
11. E. Vidya Sagar, and P.V.N. Prasad, "Optimum location of FPI on radial feeder based on reliability and cost indices", 17th National Power System Conference at IIT (BHU), Varanasi, 12th -14th December, 2012
12. Jen-Hao Teng et al., "Automatic and fast faulted line-section location method for distribution systems based on FI", IEEE Transactions on Power Systems, Vol.29, No.4, June 2014. [CrossRef]
13. Charles Fant, Brent Boehlert, Kenneth Strzepek, Peter Larsen, Alisa W hite, Sahil Gulati, Yue Li and Jeremy Martinich, "Climate change impacts and costs to U.S. electricity transmission and distribution infrastructure", Energy, Volume 195, 15 March 2020. https://doi.org/10.1016/j.energy.2020.116899. [CrossRef]
14. Peter H.Larsen et al. Severe weather, utility spending, and the long-term reliability, of the U.S. power system, Energy Elsevier Ltd, Volume 198, 1 May 2020, 117387. DOI: 10.1016/j.energy.2020.117387 0360-5442. [CrossRef]

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