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Reliability Comparison of Rural & Urban LVDS Networks with Corresponding HVDS Networks Including Substation Reliability

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Abstract: This paper primarily compares the reliability of an existing rural area and urban area LVDS (low-voltage distribution system) with their respective proposed HVDS (high-voltage distribution system) and includes their 33/11 kV Substation. Ring main substation and single bus bar substation configuration are considered for urban and rural distribution systems respectively. The reliability of a ring bus substation used in urban areas is higher than that of a single bus substation used in rural areas. The load point reliability indices are calculated considering both substation reliability indices and radial feeder indices. The substation failure rate is calculated using the overlapping outages approach, whereas the radial feeder indices are computed using the cut set approach. Furthermore, the LVDS Network is converted into the HVDS Network by replacing a high-voltage distribution transformer (DTR) that supplies a large number of customers with multiple small-rating distribution transformers near consumer terminals, each serving a smaller number of customers. This conversion results in a Minimum length of LT Lines in HVDS, leading to an improved voltage profile, reliability, and efficiency. In this paper, the disconnecting switches and alternative supply are also considered for both LVDS and HVDS Networks in the calculation of reliability to assess the radial distribution system (FMEA). Failure mode and effect analysis is used. This study utilises an LVDS and HVDS system, employing an alternative power source and disconnectors, to assess the reliability indices of the rural area network and urban area network distribution systems. In this paper, the critical distribution reliability indices to reduce system average interruption durations (SAIDI), Energy Not Supplied (ENS) and ASAI for LVDS and corresponding HVDS are calculated. The research idea is proposed on an Indian practical network.

Keywords: LVDS, HVDS, Reliability Evaluation, System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), Energy Not Supplied (ENS), Average Service Availability Index (ASAI).

I. INTRODUCTION

A power system is composed of numerous types of generating stations connected by a network of distribution grids, transmission lines, and feeders to supply various kinds of loads to multiple consumers.

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The distribution grid is the component of an ‘electrical power system’ that is in charge of distributing electricity to consumers. The distribution grid employs the secondary substation, main feeder, load transformer, and distribution feeder to distribute electricity to the loads. Since the distribution grid accounts for 90% of all load reliability issues, enhancing distribution reliability is crucial to improving overall load reliability. To develop effective modifications, a basic understanding of distribution grid parameters, submodules, topologies, and working principles is mandatory. The distribution grid is a component of an electrical power system responsible for distributing electricity to consumers. To supply electric power to consumers, the distribution system employs the distribution substation, primary feeder, distribution transformer (DTR), and distribution feeder. The secondary substation converts electrical power to lower voltage levels and usually enhances facilities for voltage regulation of the distribution voltage. It directly supplies power to large consumers and has working voltages of 220 kV, 132 kV, 66 kV, 33 kV, 22 kV, 11 kV, 6.6 kV, and 3.3 kV. 22 kV and 11 kV are the primary and secondary distribution voltages utilised in India. The higher voltage is used for larger rating loads [1-3].

The DTR is fed from the distribution substation to the primary feeder. DTR is typically integrated at the poles or near load sites, where it transforms high voltage levels to low voltage levels. Its working voltage ranges are 400/230 V and 440/240 V for 3-phase, 4-wire; 415/220 V single phase to neutral; and 440/260 V for high-tension (HT) service. The distribution feeder, which may be overhead or underground cable, supplies electric power to consumers for utilization at 400/230 V with a specified tolerance of ±6% [4].

Distribution exists between the secondary transmission and the consumer service point. It contains

1. Substations
2. Primary feeders
3. Distribution transformers
4. Secondary circuits
5. Service

Among these given modules, various types of substations, including ring and single-bus substation configurations, are utilised for both urban and rural distribution systems.

A. Low Voltage Distribution System (HVDS)

Currently, most Indian electrical distribution networks operate radially, featuring short feeders (11 kV), high-rated distributed transformers (11 kV/440 V), and long distribution lines (440 V).

This type of network is known as a Low-Voltage Distribution System (LVDS). The primary drawbacks of LVDS in agricultural feeders are: (i) The entire unit must be replaced or repaired if a three-phase, high-capacity distribution transformer fails, which affects more users. ii) DTR replacement and repair take additional time. iii) Due to overloading, frequent faults occur in lines and distribution transformers. iv) Improper 433 V line hookup, which affects the voltage profile of the lines and increases power losses. v) The low-voltage feeder monitoring is difficult [9].

Primarily in rural areas, three-phase HVDS is used to give power to users in agriculture [12]. With a voltage drop above 5%, the majority of low-voltage feeders are challenging to maintain in the field, resulting in higher current losses than allowed by loading restrictions. In rural locations, loads are dispersed widely, and low-tension 433-volt lines must travel great distances just to serve a modest load. Significant defects in the low-voltage distribution network cause frequent power outages.

Low-tension fault currents can cause distribution transformer failure. A minimum voltage of 370 V or less is recorded at the customer's meter, and there are 15,000 low tension faults every 100circuit km on lines that power agricultural pumps [1]. To confirm the technical and financial viability of the HVDS, it is crucial to assess reliability indices.

The LT network at 433 V is converted to 11 kV to address these drawbacks in the LT distribution system. The 11 kV power delivery to consumer premises is referred to as HVDS.

B. High Voltage Distribution System (HVDS)

The purpose of the HVDS project is to convert the current low-voltage (LT) network into a high-voltage distribution System. To provide a higher-quality power supply, the 11kV line is placed as close to the loads as possible, and the LT power supply is fed by supplying an appropriate-capacity transformer and a minimal length of LT line, thereby reducing losses and improving consumer service. The existing system provides a single point where large capacity transformers are available, and long LT lines are used to connect each load. This extended length of LT lines is causing a low voltage condition to the majority of the consumers and high technical losses [10,11]. Long LT mains are transformed into 11 kV mains as part of the HVDS project, building the proper capacity distribution transformer as close to the end as possible, and supplying the consumer at the correct voltage level. These lines can be converted to HVDS, which will dramatically minimise the technical losses in the LT line and allow the current flowing through the lines to be reduced by 28 times. This can be demonstrated by the fact that a 100 KVA load draws 5 amps at 11 kV, but 140 amps at the LT voltage of 415 volts [13,14].

C. Conversion of an Existing LVDS Network to a Corresponding HVDS Network

The LT network must be rebuilt with new 11 kV pin insulators and 11 kV crossarms to provide the necessary clearances between the phases of an existing network and the ground. The existing conductor and poles were left alone. However, if there is more sag, the conductor is straightened, and a few poles are inserted in the middle to provide sufficient space for the ground. The LT lines would carry 133 A of current for LVDS (using a Weasel or Rabbit conductor), and once the line was converted to HT, the current would be around 5% of the LVDS current that was flown in the original line. Therefore, a conductor change is not required. A plinth or double pole (DP) construction is not required because the poles are used for low-capacity three-phase transformers. To connect 2 to 5 customers, service wires are run from the secondary distribution box. An aerial bunched cable (ABC) rather than a bare conductor is used as the LT conductor where necessary [5,7].

II. RELIABILITY EVALUATION FOR THE COMBINATION OF SUBSTATION & FEEDER

For distribution systems, there are two sets of index types: the fundamental load point indices and the system performance indices. The load point indices are mainly used as substation reliability indices. The performance indices are used for the feeder system [15].

These load point indices are calculated using the parallel system approach, i.e., by employing the overlapping forced outage method. In rural locations, the loads are widely dispersed, and low-tension 433-volt lines must travel great distances to serve a modest load. Significant defects in the low-voltage distribution network cause frequent supply interruptions [17-18]. Low-tension fault currents can cause distribution transformer failure. A minimum voltage of 370 V or less is recorded at the customer's metre, and there are 15,000 low tension faults every 100circuit km on lines that power agricultural pumps [6]. To confirm the technical and financial viability of the HVDS, it is crucial to assess reliability indices.

The primary drawbacks of LVDS in agricultural feeders are: (i) The entire unit must be replaced or repaired if a three-phase, high-capacity distribution transformer fails, which affects more users. ii) DTR replacement and repair take additional time. iii) Due to overloading, frequent faults occur in lines and distribution transformers. iv) Improper 433 V line hookup, which affects the voltage profile of the lines and increases power losses. v) The low-voltage feeder monitoring is difficult [19].

The LT network at 433 V is converted to 11 kV to address these drawbacks in the LT distribution system. The 11 KV power delivery to consumer premises is referred to as HVDS. HVDS is the most efficient method for reducing technical losses and improving supply quality in the power distribution system. High voltage lines are brought as close to the loads as possible in this system, and small-sized transformers are built [20-24].

For the substation, load point indices are calculated using the parallel system

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approach. The basic load point indices of load point ‘i are: average failure rate λi (f/yr), average outage time r_i (hr), and average annual outage time Ui (hr/yr) [5].

$$\lambda_T = \lambda_1\lambda_2(r_1 + r_2) \quad (1)$$

$$r_{T=} \ r_1 * r_2 \quad (2)$$

$$U_T = \lambda_T * r_T \quad (3)$$

$$Total\ Availability = 1 - U_T \quad (4)$$

The series system is used to calculate the feeder fundamental(basic) load point indices. $Average\ failure$ rate λ_i The load point ‘i is given in equation (5)

$$\lambda_i = \sum \lambda_c \quad {}^{f}/_{yr} \quad (5)$$

$Average\ Outage\ Time\ r_i$ Is for load ‘i is given in equation (6)

$$r_i = \frac{U_i}{\lambda_i}\ hr \quad (6)$$

$Average\ Annual\ outage\ time\ U_i$ The load I is given in equation (7)

$$U_i = \sum \lambda_c r_c \quad {}^{hr}/_{yr} \quad (7)$$

where, λ_c Is the annual failure rate on average (f/yr), fundamental cut set ('c' is the system component that suffers from persistent errors), used in equation (5), and rc The average restoration time (in hours) resulting from component 'c' failing is used in equation (7). The switching procedure or the repair and replacement process could both be the cause of the typical restoration time. Fundamentally, there are three leading load point indices. The system behaviour and response, however, are not always fully represented by them. System performance indices are additional reliability indices that are used to reflect the degree of importance of a system outage caused by persistent problems [3-6].

Performance or reliability Indices of the System

(i) System Average Interruption Frequency Index, SAIFI

$$SAIFI = \frac{Total\ number\ of\ customer\ interruptions}{total\ number\ of\ customer\ sserved} = \frac{\frac{\sum \lambda_i N_i}{\sum N_i} f}{customer.yr} \quad (8)$$

(ii) System Average Interruption Duration Index, SAIDI

$$SAIDI = \frac{sum\ of\ customer\ interruption\ durations}{total\ number\ of\ customers\ served} \frac{\sum U_i N_i}{\sum N_i}\ hr \quad (9)$$

(iii) Customer Average Interruption Duration Index, CAIDI

$$CAIDI = \frac{Sum of customer\ interruption\ durations}{total number of customer\ interruptions} = \frac{\sum U_i N_i}{\sum \lambda_i N_i} \frac{hr}{failure} \quad (10)$$

(iv) Average Service Availability Index, ASAI

$$ASAI = \frac{Customerhoursavailableforservice}{customerhoursdemanded} = \frac{\sum N_i \times 8760 - \sum U_i N_i}{\sum N_i \times 8760} \quad (11)$$

$$(v)\ Energy\ Not\ Supplied, ENS = \sum L_{a(i)} U_i \frac{kWh}{yr} \quad (12)$$

where La(i) represents the average load connected to load point i and N is the number of customers at load point i. The significant reliability indices that show the level of dependability of an electrical distribution system are SAIDI, ENS, and %ASAI. An electrical distribution grid with low SAIDI and ENS and with a high %ASAI is said to be a more reliable system [6]. For the total distribution system, i.e., the combination of substation and feeder, the failure rates of the substation and feeder will be added.

III. CASE STUDY

A. Urban Case

An existing distribution system consists of subsystems, including a substation and a feeder, which is a ring-type substation at 33 kV/11 kV connected to an 11 kV feeder. The DTR capacity of this 11 kV feeder is 1.32 MVA. The low-voltage distribution system (LVDS), which supplies commercial and residential loads, as shown in Fig. 1, is considered for the case study. The details of the LVDS feeder are: length of 11kV (HT) feeder is 4.2kM, length of 0.433 kV (LT) distributor is 6.12 kM, number of 11/0.433 kV, 63 kVA, 100 kVA & S250kVA DTRs are 4,7 & 4 respectively, number of disconnecting switches is 6, no. of fuses (placed before each DTR) is 15. Table I shows the average failure rates and average repair times of feeder sections and different capacity distribution transformers and substation components [2,3]. Table 2 shows the load and customer data of an existing radial LVDS feeder [16,17].

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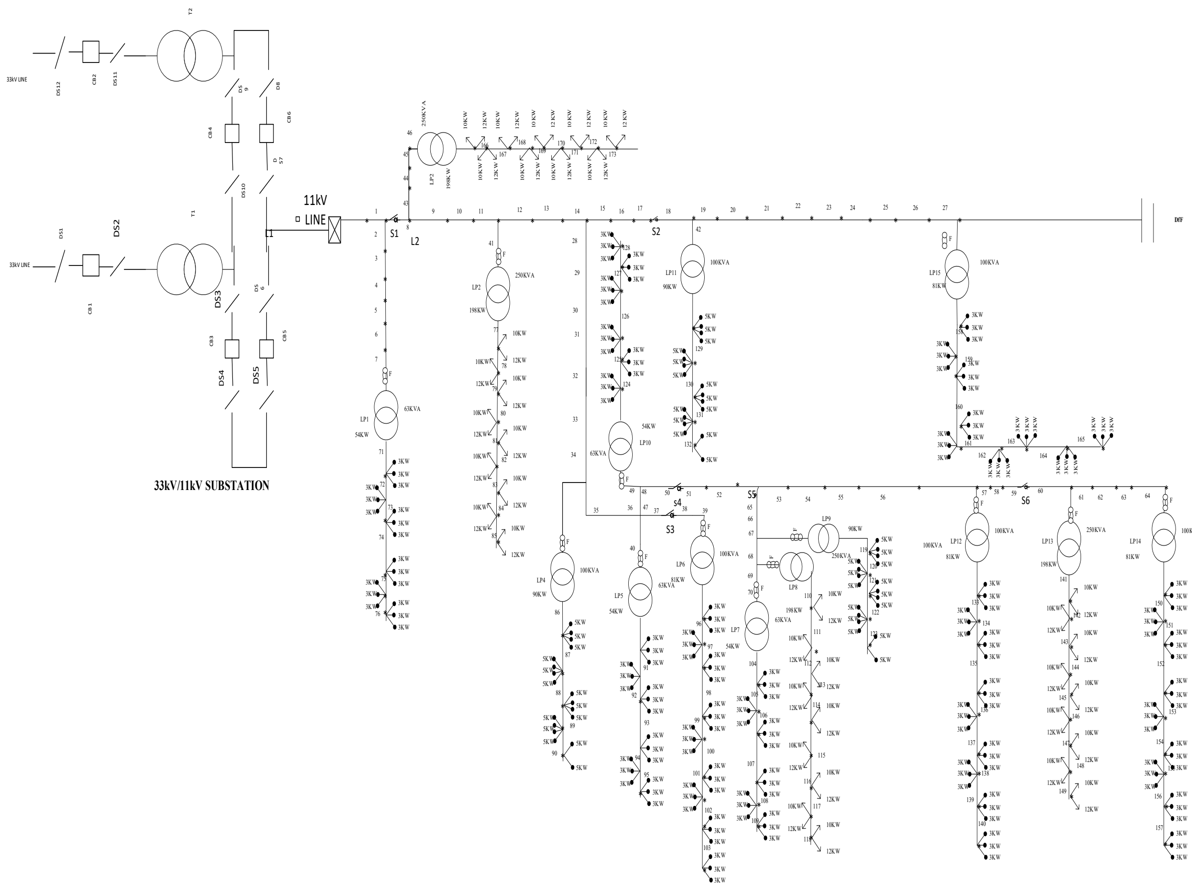

Fig 1. Single Line Diagram of the Combination of Substation and Feeder of Urban Area Network

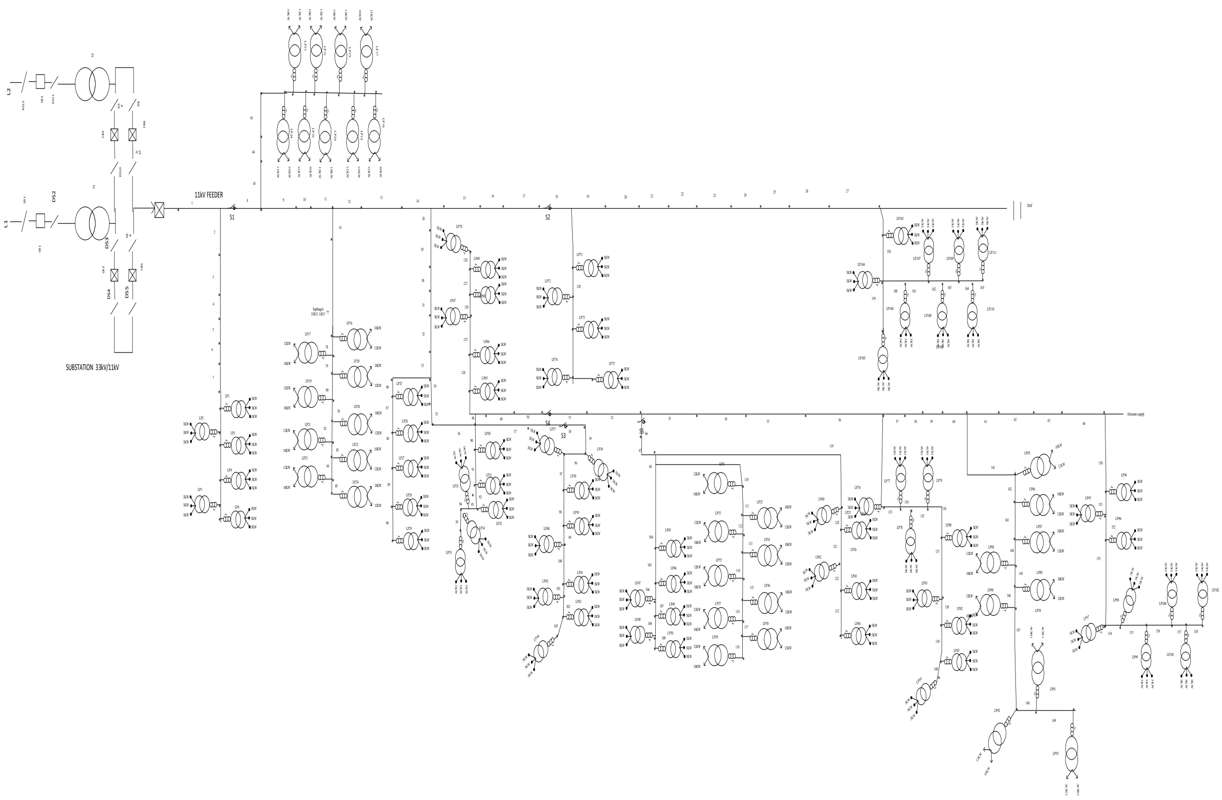

Fig 2. Single Line Diagram of the Combination of Substation and HVDS Feeder of Urban Area Network

Table I: Shows the Average Failure Rates and Average Repair Times of Feeder and Substation

Description	λ(f/yr)	r(hr)
SUBSTATION Component name		
33kV HV Lines	0.092	8
33kV CB	0.0035	4
33/11kV T/F	0.030	15
11kV CB	0.010	4
33kVBusbar	0.002	2
11kVBusbar	0.002	2
Disconnectors	0.010	4
FEEDER Component name		
HT Line (11kV)	0.0124(f/yr/km)	2
Secondary (LT) line &service drop lines	0.0124(f/yr/km	1.5
High capacity DTR (63 kVA & Above	0.0150(f/yr)	20
Low–capacity pole-mounted DTR(25kVA and below)	0.0100(f/yr)	36

Table II: Load and Customer Data of an Existing LVDS Radial Feeder

Load point	DTR (kVA)	Number of customers	Connected load(kW)	Total average load(kW)
1	63	18	18x3	54
2	250	18	9x12+9x 10	198
3	250	18	9x12+9x 10	198
4	100	18	16 x 5+2x 5	90
5	63	18	18 x 3	54
6	100	27	27 x 3	81
7	63	18	18 x 3	54
8	250	18	9x12+9x 10	198
9	100	18	16 x5+2 x 5	90
10	63	18	18 x 3	54
11	100	18	16x+2 x 5	90
12	100	27	27x 3	81
13	250	18	9x12+9x 10	198
14	100	27	27 x 3	81
15	100	27	27 x 3	81

By using the above Table I & Table II, with Failure mode and effects analysis (FMEA) techniques, CYME software is used to confirm the reliability indices [8,16]. The basic load point indices of all 15 load points of an existing LVDS feeder are calculated. The results of the basic load point indices (Table III) and the customer and load data are used to obtain the system performance indices, which are tabulated in Table IV.

Table III: Results of Basic Load Point Indices of the COMBINATION OF SUBSTATION &LVDS FEEDER

λ(f/yr)	r(hr)	U(hr)
2.14	4.3	9.24

Table IV: System Performance Indices of the COMBINATION of SUBSTATION & LVDS FEEDER

Reliability indices	COMBINATION OF SUBSTATION & LVDS FEEDERS
SAIDI	0.616552867
CAIDI	0.287373338
ENS	987.9154226
%ASAI	0.999929617

After converting the LVDS Feeder into an HVDS feeder, the same network of small-rated DTRs and customers is grouped into a large number of groups, as shown in Fig. 2. For example, the load point 1 of an existing LVDS consists of one DTR (1*63kVA) and six residential loads(18*3kW). In contrast, the corresponding HVDS network consists of six small-rated DTRS (6 × 10 kVA) DTRs, six load points (3 × 3 kW, 3 × 3 kW, 3 × 3 kW, 3 × 3 kW, 3 × 3 kW, 3 × 3 kW), as shown in Table V. Similarly, small-rated DTRs are replacing all high-rated DTRs. Since the number of small-rated DTRs is high, only a subset of the load points, customers, and load data for the corresponding HVDS network are shown in Table V.

Table V: Load and Customer Data of Some Load Points of HVDS radial feeder

Load point	DTR (kVA)	Number of customers	Connected load(kW)	Total average load(kW)	Length of LT line (km)
1	10	3	3x3	9	0
2	10	3	3 x 3	9	0
3	10	3	3 x 3	9	0
4	10	3	3 x 3	9	0
5	10	3	3 x 3	9	0
6	10	3	3 x 3	9	0
20	25	3	1x12+ 1x10	22	0
38	10	3	3 x 3	9	0
56	10	2	3 x 3	9	0
83	25	4	4 x 5	20	0
100	25	3	1x12+ 1x10	22	0
111	25	3	3 x 3	9	0

The basic load point indices of all 111 load points of the corresponding HVDS radial feeder are calculated. By using Table-V & Table-I. The results of the basic load point indices are presented in Table VI, and the customer and load data are utilised to derive the system performance indices, which are tabulated in Table VII.

Table-VI: Results of Basic Load Point Indices of SUBSTATION & HVDS FEEDER

λ(f/yr)	r(hr)	U(hr)
15.3215293	19.00587	291.198

Table-VII System Performance Indices of an Existing SUBSTATION & HVDS FEEDER

Reliability indices	SUBSTATION & HVDS FEEDER
SAIDI	0.362643508
CAIDI	0.023668885
ENS	581.1384494
%ASAI	0.999958192

The improvement in reliability is demonstrated by comparing the values of reliability indices, such as SAIDI, CAIDI, and ENS, as shown in Table VII. When it is converted from LVDS to HVDS, the percentage reduction in the values of SAIDI, CAIDI, and ENS is considerable, at 41.182%, 91.7%, and 41.175%, respectively, as shown in Fig. 3.

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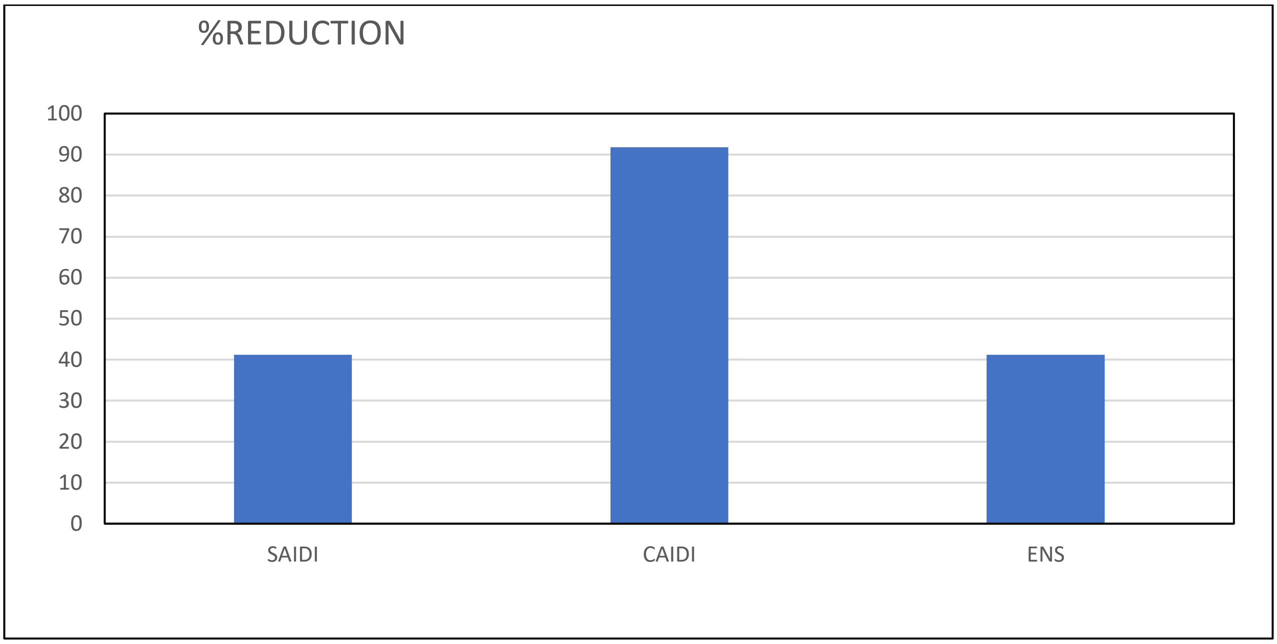

Fig 3. Percentage Reduction in System Performance Indices (ENS, CAIDI, SAIDI) of the Combination of SUBSTATION & HVDS FEEDER Network, Corresponding Substation & LVDS Feeder Network

B. Rural Case:

An existing 33kV/11kV distribution system consists of subsystems, including a substation and feeder, which is a single-bus type 33/11kV substation connected to an 11kV feeder, as shown in Fig. 4. The DTR capacity of this system is 2.086 MVA and is considered for the case study. The information on LVDS feeders is: length of 11kV (HT) feeder is 12.9 kM, length of 0.433 kV (LT) distributor is 6.36 kM, number of 11/0.433 kV, 63 kVA & 100 kVA DTRs are 23 & 9 respectively, number of disconnecting switches is 6, no. of fuses (placed before each DTR) is 30. Table VIII presents the average failure rates and average repair times of feeder sections, as well as the distribution of capacities among different capacity distribution transformers and substation components. Table IX shows the load and customer data of an existing radial LVDS feeder.

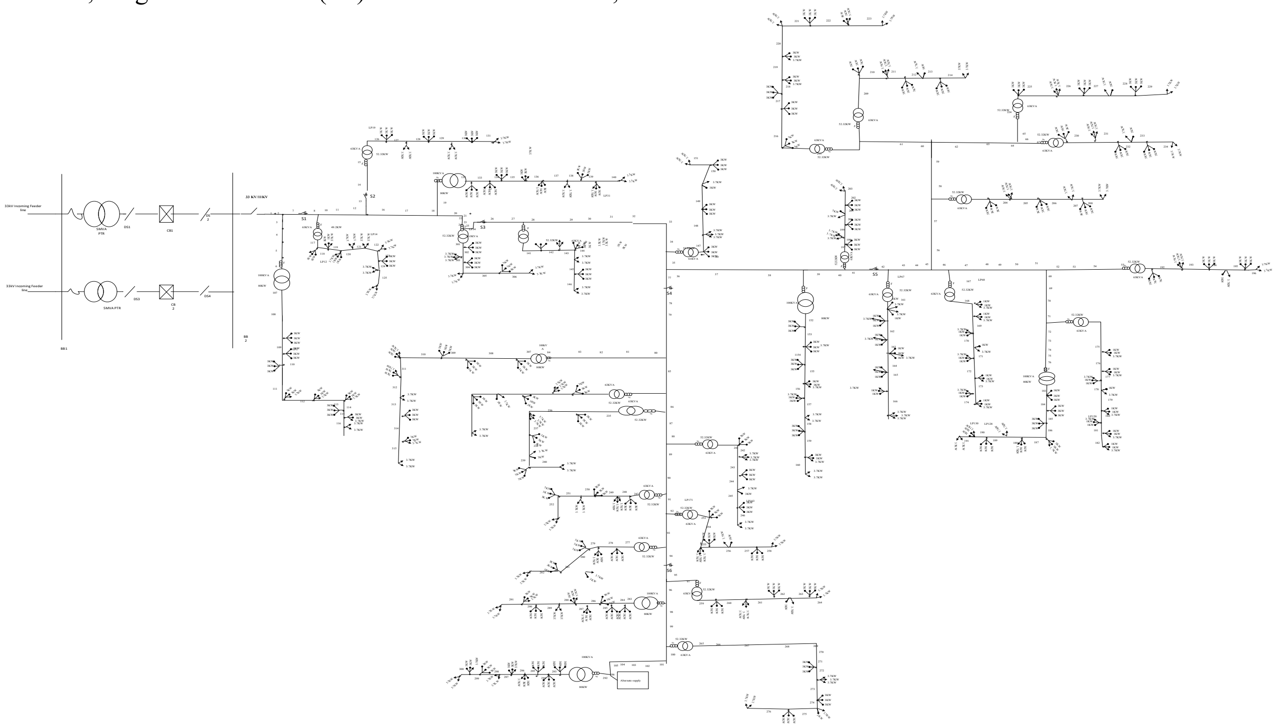

Fig 4. Single Line Diagram of the Combination of Substation and LVDS Feeder of Rural Network

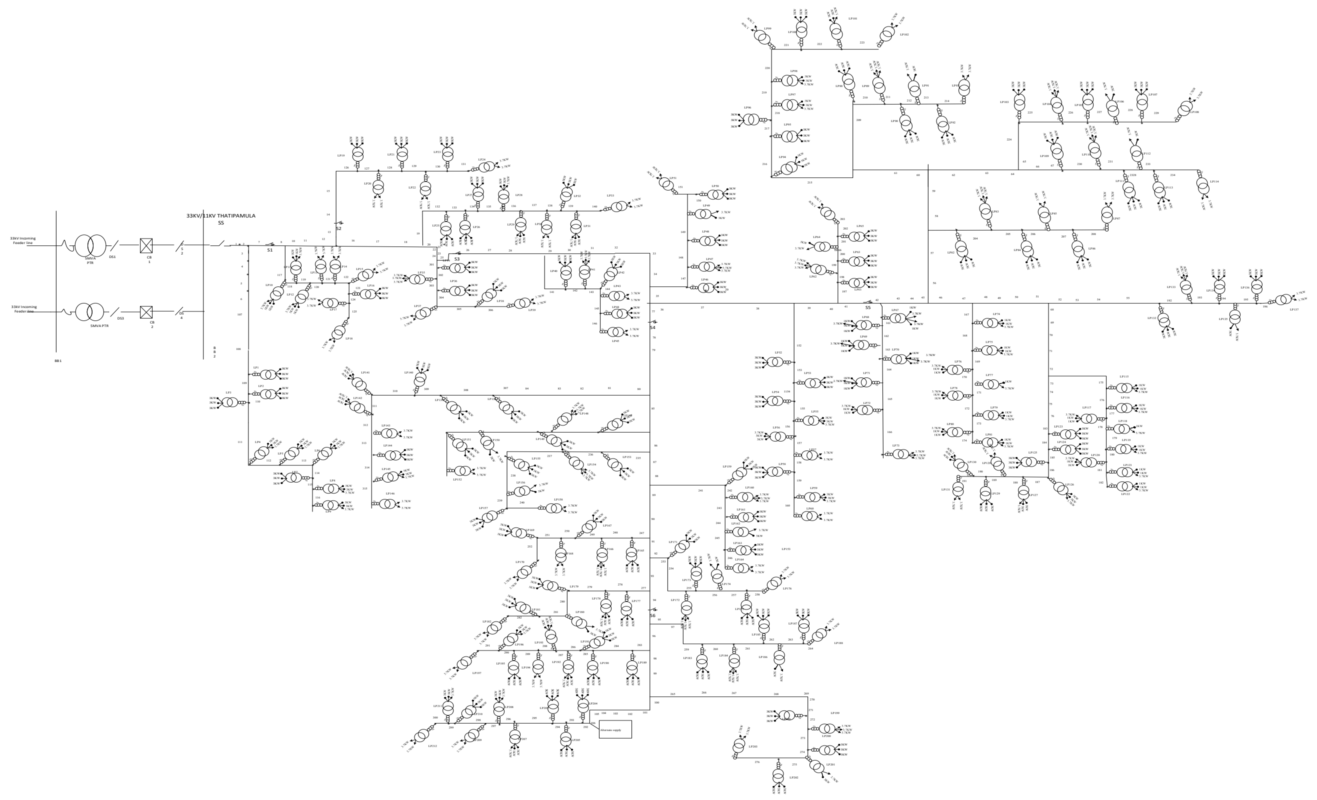

Fig 5. Single Line Diagram of the Combination of Substation and HVDS Feeder of Rural Network

Table VIII: Shows the Average Failure Rates and Average Repair Times of an Existing Feeder and Substation

Description	λ(f/yr)	r(hr)
SUBSTATION Component name		
Lines	0.046	8
T/F	0.015	15
CB	0.006	4
Busbar	0.002	2
Disconnectors	0.010	4
FEEDER Component name		
HT Line (11kV)	0.0124(f/yr/km)	2
Secondary (LT) line &service drop lines	0.0124(f/yr/km	1.5
High capacity DTR (63 kVA &Above	0.0150(f/yr)	20
Low–capacity pole-mounted DTR(25kVA and below)	0.0100(f/yr)	36

Table IX: Load and Customer Data of an Existing LVDS Radial Feeder

Load point	DTR (kVA)	No. of Customers with			Total average load(kW)
		3 kW	3.72 kW	1kw	
1	100	18	7	-	80.04
2	63	-	10	-	49.2
3	63	10	6	-	52.32
4	100	18	7	-	80.04
5	63	10	6	-	52.32
6	63	10	6	-	52.32
7	63	10	6	-	52.32
8	100	18	7	-	80.04
9	63	10	6	-	52.32
10	63	-	8	20	49.76
11	63	-	8	15	44.76
12	63	10	6	-	52.32
13	63	10	6	-	52.32
14	100	18	7	-	80.04
15	63	10	6	-	52.32
16	63	10	6	-	52.32
17	63	15	8	15	44.76
18	100	18	7	-	80.04
19	63	10	6	-	52.32
20	100	18	7	-	80.04
21	63	10	6	-	52.32
22	63	10	6	-	52.32
23	63	10	6	-	52.32
24	63	10	6	-	52.32
25	63	10	6	-	52.32
26	63	10	6	-	52.32
27	63	10	6	-	52.32
28	100	18	7	-	80.04
29	63	10	6	-	52.32
30	100	18	7	-	80.04

By using Tables-VIII & Table-IX, with Failure mode and effects analysis (FMEA) techniques, CYME software is used to confirm the reliability indices [8,16]. The Fundamental load point indices of all 30 load points of an existing combination of substation and LVDS feeder are calculated.

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The results of basic load point indices shown in Table X of an existing LVDS Feeder & Substation and the customer & load data are used to obtain the system performance indices and tabulated in Table XI

Table-X: Results of Basic Load Point Indices of Combination of Substation and LVDS Feeder

λ(f/yr)	r(hr)	U(hr)
7.74	12.2	94.76

Table-XI: System Performance Indices of Combination of SUBSTATION & LVDS FEEDER

Reliability indices	COMBINATION OF SUBSTATION AND LVDS FEEDER
SAIDI	3.160917
CAIDI	0.407922
ENS	5592.376
%ASAI	0.999639

The same network of low-rated DTRs and even consumers are grouped together in a significant number of groups after conversion to HVDS. For example, the load point 1 of an existing LVDS consists of one DTR (1*100kVA) and seven agricultural pump sets(7*5HP) and four residential loads(4*9kw), whereas the corresponding HVDS network consists of nine small rated DTRS (3*15KVA & 6*10KVA) DTRs, nine load points as shown in Table 12. Similarly, all high-rated DTRs are being replaced by low-rated DTRs. Since the number of small rated DTRs is high, only some of the load points, customer and load data of the corresponding HVDS network are shown in Table-XII

Table-XII: Load and Customer Data o.f Some Load Points of HVDS Radial Feeder

Load point	DTR (kVA)	Number of customers	Connected load kW)	Total average load(kW)	Length of LT line(km)
1	10	3	3*3	9	0
2	10	3	3*3	9	0
3	10	3	3*3	9	0
20	15	3	3*3.72	11.16	0
38	10	3	3*3	9	0
156	10	2	1*3+1*3.72	6.72	0
183	10	3	3*3	9	0
200	10	3	3*3	9	0
212	10	2	2*3.72	7.44	0

The basic load point indices of all 212 load points of the Combination of Substation and LVDS Feeder and the corresponding Combination of Substation and HVDS radial feeder are calculated. The results of basic load point indices and customer and load data are used to obtain the system performance indices, which are tabulated in Table XIII.

Table-XIII: System Performance Indices of HVDS Feeder

Performance Indices	Combination of Substation and HVDS feeder
SAIDI	1.846634
CAIDI	0.034389
ENS	3258.93
%ASAI	0.999789

The improvement in reliability is demonstrated by comparing the values of reliability indices, such as SAIDI, CAIDI, and ENS, as shown in Table XIII. When it is converted from a combination of LVDS feeders to a combination of substation and HVDS feeders, the percentage reduction in the values of SAIDI, CAIDI, and ENS is considerable, at 41.57%, 91.56%, and 41.72%, respectively, as shown in Fig. 6.

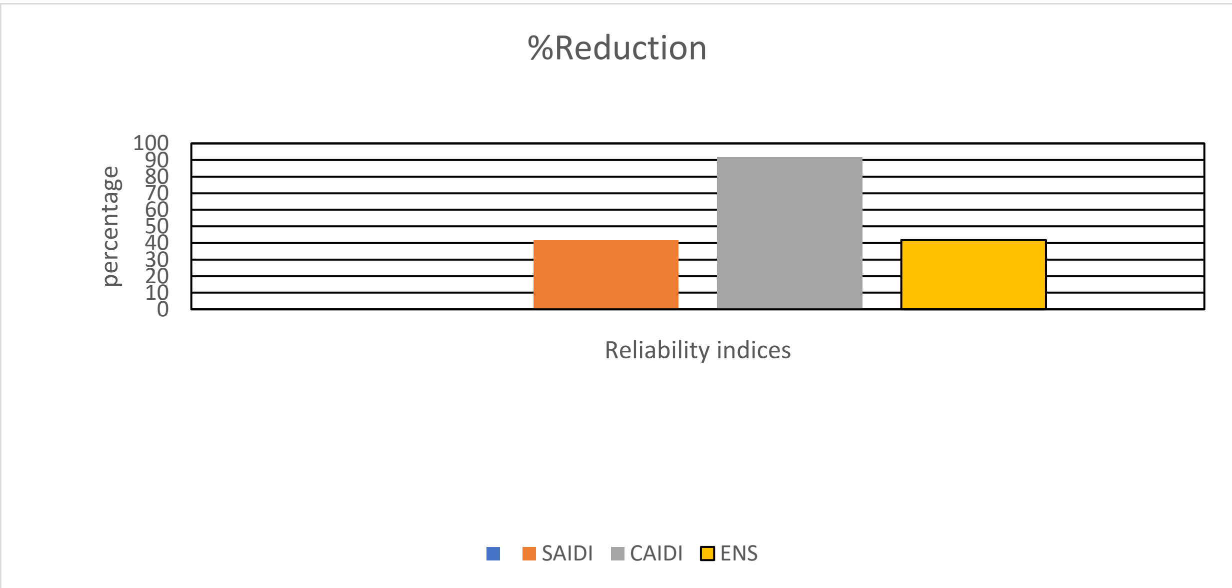

Fig. 6. Percentage Reduction in SAIDI, CAIDI, and ENS of HVDS Network with Respect to The Corresponding LVDS Network

The following Table-XIV represents the comparison between rural and urban areas, including the combination of substation and LVDS feeder, as well as the corresponding combination of substation and HVDS feeder. Finally, it shows the ENS having a greater impact on the Rural case compared to the Urban area.

Table-XIV: Reliability Comparison of Urban and Rural Distribution Systems

Reliability indices	URBAN		RURAL	
	SUBSTATION &LVDS FEEDER	SUBSTATION &HVDS FEEDER	SUBSTATION &LVDS FEEDER	SUBSTATION &HVDS FEEDER
SAIDI	0.616	0.3626	3.22	1.846
CAIDI	0.287	0.0236	0.4166	0.034
ENS	987.91	581.13	5714.96	3258.92

IV. CONCLUSION

When the combination of a substation and an LVDS feeder is transformed into a combination of a substation and an HVDS feeder, the SAIDI value in urban areas is significantly reduced (41.18%), indicating an improvement in reliability. When LVDS is transformed into HVDS, the SAIDI value in rural areas is significantly reduced (41.57%). This enhancement shows that each customer experiences shorter interruption times. After converting from LVDS to HVDS in urban areas, the value of ENS decreases by 41.17%. In rural areas, the decrease is 41.72%. This improvement is the result of fewer customers experiencing issues with the HVDS system than the LVDS system. It is observed that the HVDS concept has a greater impact on rural areas compared to LVDS areas, and both customers and utilities are satisfied with the implementation of the HVDS system from a reliability perspective.

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