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| RESEARCH ARTICLE

Decreased SAIDI and SAIFI the Buruan Feeder Distribution Line with Insulator Cover

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| ABSTRACT
The Buruan feeder is one of the electrical energy distribution systems operated by PLN South Bali. The Buruan feeders are an overhead distribution system with A3CS conductors. This feeder has several components that are open, so it is easy to get external disturbances from animals and trees. To overcome this problem, exposed components need to be isolated, one of which is with an insulator. This research found that in 2021, the value of SAIDI was 3.33 hours/year/customer, and the value of SAIFI was 7 times/year/customer. After maintenance, reconductor, and installed animal barrier, in 2022, the value of SAIDI is 0.65 hours/year/customer, and the value of SAIFI is 4 times/year/customer. This value of SAIFI is not enough for PLN UID Bali to become a world-class company. To support the PLN UID Bali to go to a world-class company, need some act to install an insulator cover. If the insulator cover was installed, the prediction of the value of SAIDI would be 0.019 hours/year/customer, and the value of SAIFI is 0.94 times/year/customer, according to the company's world-class target.

| KEYWORDS

Disturbances, Feeders, Cover, Animal, Tree

| ARTICLE INFORMATION

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1. Introduction

Electrical energy is one of the most important needs and the most important economic support needed in every activity; also, industrial processes' economic growth needs electricity growth (Eric et al., 2018). The bigger the population, the higher the economic growth and more electrical energy is needed (CHENWen, 2009). Electrical energy is very important because the majority of the equipment needs electrical energy. Electrical energy is one of the most consumed energies in a country. So, if it can be managed properly, electrical energy can increase economic growth. PT. PLN (Persero), as the state electricity company in Indonesia, especially in the distribution sector, is required to improve the quality of electrical energy supplied. So that it can provide services continuously and evenly, with quality and reliability, that can meet the needs of society (CHENWen, 2009); in order to achieve this, a reliable and qualified electric power system is needed.

The reliability of electricity affects the business profit. Like in the City of Johannesburg, electricity outages greatly affect economic profits; small entrepreneurs who do not have captive power will decrease in profits compared to entrepreneurs who have captive power (Schoeman T. and M. Saunders, 2018). The same thing is also true in Africa; the profit of business actors who do not have captive power will be greatly affected (Matthew et al., 2018). Especially in this digital era, all processes are carried out online, and the online process needs reliable electricity. The news updating and broadcasting process of an electronic newspaper will be very disturbed by electricity outages (Toyin, 2014).

All of the strategies and experiments are carried out by electricity experts to increase the reliability of the electric power distribution system (Dezaki et al., 2015). The electricity experts conduct research and development to upgrade their knowledge about electricity disturbance. The outage of the electricity system is greatly influenced by the surrounding environment, weather, animals, trees

and so on (Radomis et al., 2011). Thus, it is necessary to find a system or equipment that is feasible to protect the electricity distribution from weather, animals and trees. Errors in operation and the improper implementation of maintenance greatly affect the increase of disturbance at the overhead distribution system (Radomis et al., 2011).

A reliable index to determine the reliability of an electrical distribution system, namely the comparison of an electricity distribution system performance to the number of consumers served in a feeder line. The reliability of an electricity distribution system is measured by SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index) (Ganiyu et al., 2019), (Aleksander et al., 2018), (Ashraf et al., 2014). The operation of an electric power distribution system cannot have zero disturbances that can decrease system reliability, the presence of wind, weather, animals, trees, installation failure, equipment out of service, and others. (Ashraf et al., 2014). Power outages have various reasons, such as Trees, Nothing Found, Birdcage, Wires Joined Together, Jumper Changed, Disc Problem, Transformer Fault, Kite Struck in Line, Wind and Rain, Fuse Problem, Accident, Break Down (Ishpreet et al., 2018).

Poor maintenance culture and inadequate utilization of equipment exacerbate the disturbance of the overhead medium voltage distribution system (Hachimenum et al., 2015). Thus, it is necessary to carry out routine maintenance management to decrease equipment out-of-service and external disturbance. Without maintenance management, like in Nigeria, the electricity power was outage for important institutions and events. When the electricity power outage occurred at the presidential palace, the presidential palace had to prepare its own generator to ensure the reliability and safety of the electricity system (Arobieke et al., 2012).

There have been many problems with the electricity distribution power system in Denpasar, which is in the area of PT. PLN (Persero) ULP Sanur. There are so many feeder lines in the PLN ULP Sanur area. According to data from PT PLN (PERSERO) ULP Sanur in 2021, which had the poorest SAIDI SAIFI in the feeder line, with 7 times outages, that is feeder line to the Buruan. The feeder line to Buruan is located in the coastal area of East Denpasar. The wind in the coastal area contains a lot of salt, which can cause the existing construction in the feeder line to corrode and lose contact quickly; it can cause disturbance in the feeder line. This has an impact on decreasing customer satisfaction with the electricity supply service, which results in frequent complaints to PLN. This research is very important for ideas contributing to PLN in solving the problems of the high disturbance of the Buruan feeders' line.

2. Literature Review

Based on real outage data obtained from a major utility company in the U.S., it was discovered that various types of animals had caused the outage of electric distribution lines(Doostan et al., 2019). What are 562 opportunistic utility outage frequency records of bird electrocutions from 2018 to 2019 in Iran, with 59 electrocuted birds based on where the carcasses were discovered? Thus, it is necessary to install an isolation cover on the bushing and arrester, although sometimes, animal disturbances still occur in other exposed parts. (Mahmood and Richard, 2020). Knowledge of the reliability parameters in power distribution lines is necessary for reliability analyses and also for maintenance upgrading to optimization systems. The accuracy of the calculation of component reliability parameters will only be done by real distribution system operators' databases (Radomis et al., 2011). Such a database includes records of outages and interruptions in electrical systems that must be recorded with high accuracy and detail.

Based on detailed and accurate data, the reliability of the distribution system can be calculated using SAIDI and SAIFI calculations. There are several studies that can be used as references in this research to calculate SAIDI and SAIFI. The formulation that will be used is the formula to find SAIDI and SAIFI values. The formula used is as follows (Ganiyu et al., 2019):

$$\text{SAIDI} = \frac{\sum_{i=1}^{m} C_i .\ t_i}{N} \quad (1)$$

Remark:

m = number of outages in a year
Ci = number of consumers was outage
ti = duration of outage
N = number of consumers was connected to the feeder's line

$$\text{SAIFI} = \frac{\sum_{i=1}^{m} C_i}{N} \quad (2)$$

Remark:

m = number of outages in a year
C*i* = number of consumers was outage
N = number of consumers connected to the feeder's line

Customers connected to distribution feeders with high SAIDI SAIFI led to a complete period of darkness(Ganiyu et al., 2019). The higher the SAIDI SAIFI value, the more value and the longer time consumers experience outages when an outage occurs. Conditions like this are very undesirable in the electric power distribution process. Many efforts must be made to overcome blackouts due to equipment damage or external disturbances.

It is necessary to carry out inspections, maintenance and improvements to the primary and secondary distribution networks(Aleksander et al., 2018). Improving the quality of the distribution network can be done by reducing the use of exposed equipment so that it does not easily experience external interference. Change open equipment to closed equipment, and cover open equipment with adequate insulation.

3. Methodology

This research is a quantitative study to discuss the problems of decreasing SAIDI and SAIFI of Buruan feeders' lines by installing insulator covers. The data processed in this study are primary data and secondary data. Primary data is data from direct observations in the field of electricity power distribution systems to observe the number and types of parts of overhead medium voltage distribution systems. Secondary data is data obtained from the records of the state electricity company (PLN). This data is related to the type and number of disturbances that occur, as well as the number of customers. Based on the results of field observations, the parts of overhead medium voltage distribution that are without insulation to be solved by installing the isolator cover are in accordance with the conditions in the field and the type of isolator cover. After all the problems of the parts of the medium voltage overhead line are resolved, recalculation is done to get the prediction value of SAIDI and SAIFI if the isolator cover is installed.

3.1 Samples

The sample to be examined in this study was 100 percent of all components/equipment of the overhead distribution system as long as the Buruan feeder line. The length of this feeder is 19.55 kilometers. All sections of the medium voltage overhead distribution system are examined one by one, starting from the outgoing of the 20 KV substation to the end of the Distribution circuit.

3.2 Variable operational and definition

This research focuses on calculating the reliability index of overhead medium voltage distribution for the Buruan-Sanur feeders' line. Reliability calculations include the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). To calculate this, data is needed on the number of blackouts in a year, the number of consumers who blackouts, the duration of each blackout, and the number of consumers connected. To find out the cause of the high SAIDI and SAIFI value, it is necessary to observe the amount of SAIDI and SAIFI, which is caused by external interference because there are parts or components without insulation on overhead voltage medium distribution.

3.3 Data collection

The data of the type and number of parts or components without insulation on overhead medium voltage distribution is carried out by visual observations. Visual observations are made using the naked eye. Sometimes, visual observations are done with binoculars to clarify the object. Observed was done by observing the main material and supporting material. Main materials such as distribution transformers, insulators, fuse cut outs and arresters. Supporting materials that become the object of observation consist of cable ties, joints, branching connectors, cable shoes, and insulation. Secondary data was collected at the PLN office to determine single-line feeders, causes of disturbance, the length of the circuit, number of customers in the outage, number of customers connected to the feeder line, duration of the outage, frequency of outage, and so on.

3.4 Data analysis

The data obtained were processed mathematically and statistically. This data processing aims to find out how much the existing SAIDI and SAIFI values, as well as the prediction of SAIDI and SAIFI values if the problem of the parts or components without insulation on overhead medium voltage distribution for the Buruan-Sanur feeder line is solved with an insulator cover.
In this study, statistical data analysis techniques were used.

4. Results and Discussion

Based on secondary data obtained at PLN UP3 South Bali, the total number of customers of the Buruan feeders' line is 3,350 customers, and the outage data is obtained as outlined in the table below.

TABLE 1. Buruan feeders line outage in 2021

No	Date	Duration (hour)	Customer outage (unit)	Disturbance remark
1	5 Jan 2021	0.20	3,350	Transformer failure and connector failure between LBS Pole 1 and Recloser Batur sari
2	16 Jan 2021	1.15	3,124	Line 20 kV short circuit by a cat at substation DS 1251
3	20 Jan 2021	0.05	3,260	arrester short circuit at substation DS0404
4	29 May 2021	0.09	3,350	Line 20 kV short circuit by a squirrel
5	2 Jun 2021	0.4	3,086	Connector failure at substationDS 0592
6	13 Nov 2021	0.70	2,960	Tree short circuit at Line 20 kV of substation DS 0917
7	1 Dec 2021	0.94	3,188	Line 20 kV short circuit by a squirrel at substation DS 143

TABLE 2. Buruan feeders line outage in 2022

No	Date	Duration (hour)	Customer outage (unit)	Disturbance remark
1	3 Feb 2022	0.51	3,278	Line 20 kV short circuit by a bird at substation DS 1019
2	5 May 2022	0.02	3,146	Terminating 20 kV failure at substation DS0019
3	7 Oct 2022	0.11	3,350	Short circuit by a squirrel at line 20 kV between LBS Pole 1-LBS JCO
4	25 Nov 2022	0.03	3,212	Line 20 kV short circuit by a squirrel at the front of Central Telephone Automation Sanur

Based on the outage data that has been obtained, as shown in Table 1 and Table 2, the SAIDI value can be calculated according to the calculation in formula (1) and SAIFI according to the calculation in formula (2) in Buruan feeders' line in 2021 and 2022, namely, as stated in the table this below.

TABLE 3. SAIDI and SAIFI.

Year	SAIDI (hours/year/costumer)	SAIFI (times/year/customer)
2021	3.33	7
2022	0.65	4

The outage caused by external disturbances of the distribution system, such as squirrels, cats, birds, and trees, is also affected by the high SAIDI and SAIFI feeders line in Buruan-Sanur. Based on data from Table 1 numbers 2, 4, 6, and 7, as well as from Table 2 numbers 1, 3, and 4, it can be calculated that the value of SAIDI and SAIFI by external disturbance of distribution system. Thus, the cause of the disturbance can be calculated as a percentage, as shown in Table 4 and Table 5 below.

TABLE 4. Disturbance category in 2021

Disturbance Category	Outage Frequency (times/consumer/year)	Outage (%)
Animal	3	43
Tree	1	14
Part failure	3	43
TOTAL	7	100

TABLE 5. Disturbance category in 2022

Disturbance Category	Outage Frequency (times/consumer/year)	Outage (%)
Animal	3	75
Part failure	1	25
TOTAL	4	100

Based on the results obtained through field observation. There are several parts of the overhead medium voltage distribution without insulation. These parts with a voltage of 20 kV without isolation have the potential to cause external disturbance. The part without insulation is shown in the image below.

FIGURE 1. Strain clamp without insulation.

FIGURE 2. Connector without insulation.

If the exposed parts, as shown in Figures 1 and 2, are without insulation, it will be difficult to increase the value of SAIDI and SAIFI because of the high potential for external disturbance. The accumulation of potential disturbance from the external system in the Buruan feeders' line can be shown in Table 6 below.

TABLE 6. Component without insulation

No	Component Condition	Potency of disturbance	Total
1	Strain Clamp without insulation	Animal and tree short circuit	84
2	Connector CCO without insulation	Animal and tree short circuit	21
3	Connector LLC without insulation	Animal and tree short circuit	75
4	A line without insulation limited to a tree	Tree short circuit	1
5	Fuse cut-out terminal without insulation	Animal and tree short circuit	9
6	Jointing A3C without insulation	Animal and tree short circuit	3
7	jointing A3CS and MVTIC without insulation	Animal and tree short circuit	3
8	Animal protector open at Arrester	Animal and tree short circuit	2
9	Animal protector is broken at arrester	Animal and tree short circuit	1
10	Smart arrester without insulation	Animal and tree short circuit	11
11	Pin post insulator with A3C conductor	Animal and tree short circuit	18

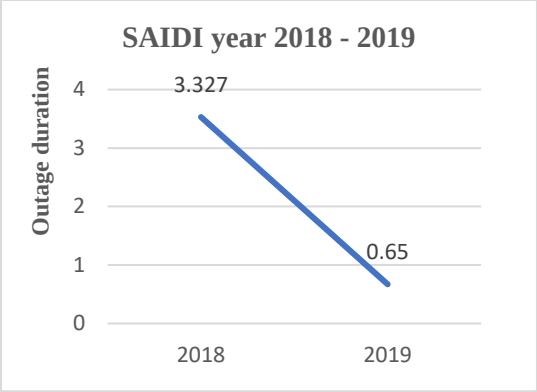

FIGURE 3. SAIDI decreased but was still high

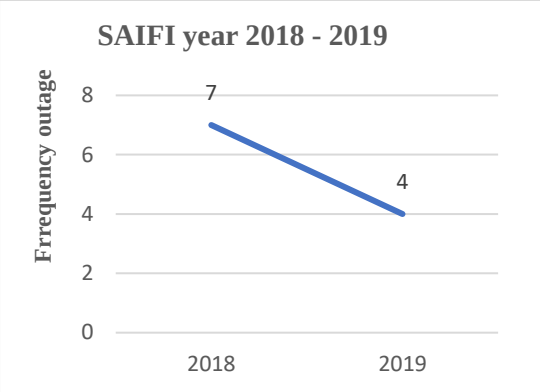

FIGURE 4. SAIFI decreased but is still high

Based on the picture above, it is known that the SAIDI value from 2021 to 2022 has decreased by 2,677 hours to reach 0.65 per year, while the SAIFI value from 2021 to 2022 also decreased by 3 times per year to become 4 times.

To become an international standard company, PLN UID Bali must set the target of SAIDI and SAIFI, benchmark to WCS (World Customer Services) standards. According to the decision of the Board of Directors of PLN No: 119. K / 010 / DIS / 2004, to realize PLN UID Bali as a world-class company, PLN declared a target of SAIDI to 1.023 hours/customer/year and SAIFI to 1.65 times/customer/year. Based on this target, the SAIDI achievements of the Buruan feeders' line have met the target, but the value of SAIFI, the achievements of the Buruan feeders' line, have not met the target. These efforts need some action to improve the reliability where the component without insulation must be protected immediately so that it can protect the construction from animal or tree disturbance.

Protecting the part of the overhead medium voltage distribution line that is not insulated can be done by installing an insulator cover. One of the insulator covers that can be used is the insulator cover with the brand Tekep Insulator. Tekep Isolator has a fairly complete model and is in accordance with the existing construction, as shown in the figure below.

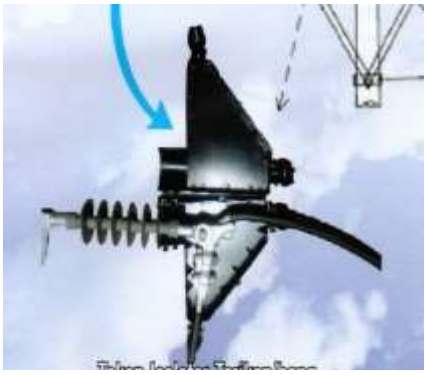

FIGURE 5. Tekep Isolator YS-Strainclamp-70-240 AP, available for strain clamp and connector CCO type

FIGURE 6. Tekep Isolator YS-Connector-70-240AP, available for live line connector

Based on data on potential disturbances in the component of overhead medium voltage distribution without insulation, it can be solved by installing an insulator cover according to the available models, as shown in the table below.

Table 7. Alternative solution for external disturbance.

No	Component Condition	Alternative
1	Strain Clamp without insulation	Install cover for strain clamp/insulator cover (Brand: Tekep Isolator, Type: YS-Strainclamp-70-240 AP) or others.
2	Connector CCO without insulation	Install cover for connector/insulator cover (Brand: Tekep Isolator, Type: YS-Strainclamp-70-240 AP) or others.
3	Connector LLC without insulation	Install cover for live line connector /insulator cover (Brand: Tekep Isolator, Type: YS-Connector-70-240 AP) or other.
4	A line without insulation limited to a tree.	Reconductor with A3CS or install tree guard, or install insulator cover (brand: Tekep Isolator, Type YS-L orYS-B combined with Type YS-EXT-150 AP) or other
5	Fuse cut-out terminal without insulation.	Install fuse cut-out cover/insulator cover (Brand: Tekep Isolator, Type: YS-CO-70-240 AP) or other.
6	Jointing A3C without insulation	Install heat shrinkable, or cover for strain clamp/insulator cover (Brand: Tekep Isolator, Type: YS-Strainclamp-70-240 AP) or others.
7	jointing A3CS and MVTIC without insulation	Install heat shrinkable or cover for strain clamp/insulator cover (Brand: Tekep Isolator, Type: YS-Strainclamp-70-240 AP) or others.
8	Animal protector open at Arrester.	Repair or install insulator cover (Brand: Tekep Isolator, Type: YS-BUS-ARR-70-240 AP) or other
9	The animal protector is broken at Arrester.	Repair or install insulator cover (Brand: Tekep Isolator, Type: YS-BUS-ARR-70-240 AP) or other
10	Smart arrester without insulation	Change with conventional arrester 20 kV
11	Pin post insulator with A3C conductor	Install insulator cover (Brand: Tekep Isolator, Type: YS-L for straight line or YS-B for bent line, combine with Type YS-EXT-150 AP) or other.

If the above efforts, as described in Table 7, are made, it is likely that disturbances caused by animals and trees can be avoided because all components or constructions that allow external disturbances caused by animals or trees are well protected. So that it can increase the reliability index of the feeder line with no disturbance by animals or trees, the SAIDI and SAIFI values are based on equations (1) and (2), as described in the table below.

TABLE 8. Prediction disturbance

Outage Frequency (times/consumer/year)	Outage (%)
0	0
1	100
1	100

TABLE 9. Outage prediction post-install insulator cover.

No	Date	Duration (hour)	Customer outage (unit)	Disturbance remark
1	~~3 Feb 2022~~	~~0.51~~	~~3,278~~	Line 20 kV short circuit by a bird at substation DS 1019
2	5 May 2022	0.02	3,146	Terminating 20 kV failure at substation DS0019
3	~~7 Oct 2022~~	~~0.11~~	~~3,350~~	Short circuit by a squirrel at line 20 kV between LBS Pole 1- LBS JCO
4	~~25 Nov 2022~~	~~0.03~~	~~3,212~~	Line 20 kV short circuit by a squirrel at the front of Central Telephone Automation Sanur

The predictive SADI and SAIFI can be calculated below.

$$\text{SAIDI} = \frac{\sum_{i=1}^{m} C_i . \ t_i}{N}$$

$$= \frac{0.02 \ x \ 3{,}146}{3{,}350}$$

= 0.019 hour/year/costumer

$$\text{SAIFI} = \frac{3{,}146}{3{,}350}$$

= 0.94 times/year/costumer

5. Conclusion

This research aims to answer how isolator covers installed affect the reduction of SAIDI and SAIFI. The use of sections to divide the text of the paper is optional and left to the author as a decision. Where the author wishes to divide the paper into sections, the formatting shown in Table 2 should be used. Buruan feeders' line is under the operation of PLN UP3 Bali Selatan. In 2021, the value of SAIDI is 3.33 hours/year/customer and the value of SAIFI is 7 times/year/customer. After maintenance, reconductor, and installed animal barrier, in the year 2022, the value of SAIDI is 0.65 hours/year/customer, and the value of SAIFI is 4 times/year/customer. This value of SAIFI is not enough for PLN UID Bali to be a world-class company. To support the PLN UID Bali to go to a world-class company, we need some act to install an insulator cover. If an insulator cover was installed, the prediction of the value of SAIDI is 0.019 hours/year/customer, and the value of SAIFI is 0.94 times/year/customer, according to the world-class company target.

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