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Evaluation of PDKB Performance's Impact on SAIDI SAIFI at PT. PLN UP3 Langsa

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Abstract

The reliability of the electricity distribution system is essential to ensure continuous service to consumers. Maintenance is necessary to uphold this reliability. However, on the SUTM (Medium Voltage Overhead Line) network, maintenance often requires power outages, causing losses for both consumers and the company due to undelivered electrical energy (kWh). This study aims to analyze the SAIDI and SAIFI values, as well as the amount of kWh before and after implementing PDKB (Live Line Maintenance) at PT PLN (Persero) UP3 Langsa. The research uses a quantitative descriptive method with data collected through observation and analysis of kWh, SAIDI, and SAIFI metrics. The results show that PDKB-based maintenance saved 1,457,823.97 kWh with a financial gain of Rp. 1,135,391,541.48. The SAIDI and SAIFI values were 819.456 minutes/customer and 9.29 times/customer, respectively. In contrast, maintenance without PDKB resulted in a loss of 3,921,103.2 kWh or Rp. 3,136,882,560, with higher SAIDI and SAIFI values of 1533.84 minutes/customer and 10.04 times/customer. These findings indicate that lower SAIDI and SAIFI values reflect improved service quality, enhancing the company's image and reducing losses from power distribution interruptions.

Keywords*: PDKB, SAIDI, SAIFI*

Abstrak

Keandalan sistem distribusi listrik merupakan faktor utama dalam menjamin kontinuitas layanan kepada konsumen. Pemeliharaan jaringan listrik diperlukan untuk menjaga keandalan penyaluran daya kepada pelanggan. Namun, pada jaringan SUTM, kegiatan ini sering memerlukan pemadaman, yang menyebabkan kerugian bagi konsumen dan perusahaan karena energi listrik (kWh) tidak tersalurkan. Penelitian ini bertujuan untuk mengetahui jumlah nilai SAIDI dan SAIFI, jumlah kWh sebelum dan sesudah adanya PDKB pada PT. PLN (Persero) UP3 Langsa. Metode penelitian yang digunakan adalah metode deskriptif kuantitatif dengan teknik pengumpulan data menggunakan teknik observasi dan analisis nilai kWh, SAIDI dan SAIFI. Hasil penelitian menunjukkan bahwa pemeliharaan dengan PDKB dapat menyelamatkan 1.457.823,97 kWh kepada pelanggan dengan perolehan Rp. 1.135.391.541,48. Nilai SAIDI 819,456 Menit/Pelanggan dan nilai SAIFI 9,29 kali/pelanggan. Sedangkan pemeliharaan tanpa PDKB diperoleh nilai kWh 3,921,103.2 dan nilai rupiah Rp. 3,136,882,560. Nilai SAIDI 1533,84 Menit/pelanggan dan nilai SAIFI 10,04 kali/pelanggan. Hal ini menunjukkan bahwa semakin kecil nilai SAIFI dan SAIDI maka semakin baik pelayanan PLN kepada pelanggan sehingga dapat meningkatkan citra perusahaan dan tidak akan menimbulkan kerugian yang ditimbulkan karena diskontinuitasnya pelayanan penyaluran tenaga listrik.

Kata Kunci: PDKB, SAIDI, SAIFI

Introduction

Reliability in electricity distribution to the community can be maintained through proper maintenance of Medium Voltage Air Insulated Cable (MVAC) networks. However, in practice, this maintenance often requires power outages. The reliability of the electricity distribution system is largely determined by the frequency of feeder interruptions. Maintenance activities carried out during outages can have a significant impact, leading to considerable losses for both consumers and the company, as electrical energy (kWh) cannot be distributed optimally [1].

Various methods of conducting maintenance include electrical maintenance that can be performed without power outages. This maintenance can be carried out by Live Line Maintenance "*Pemeliharaan Dalam Keadaan Bertegangan*" (PDKB) teams. Setiawan research stated that the primary role of PDKB generally involves conducting repairs, maintenance, or network expansions without power shutdowns or under live conditions [2]. This approach ensures a continuous and reliable supply of electricity, minimizing power outages for customers. PT PLN (Persero) UP3 Langsa formed its own Live Line Maintenance (PDKB) Team at the end of August 2021. Prior to the establishment of this team, maintenance work was typically carried out by third-party vendors and required power outages, which often led to less effective results. The effectiveness of maintenance activities can be evaluated based on whether the program or action achieves its intended outcomes and objectives [3].

The PDKB team must understand their role in supporting PLN's program to optimize kWh sales through effective maintenance. Their performance can be measured by how well they apply PDKB techniques to minimize energy loss and maintain network continuity. According to Hendri and Supriyono, PDKB work improves service quality by enabling uninterrupted power distribution during maintenance [4]. Research by Setiawan (2016) showed that PT PLN (Persero) South Surabaya saved 4,245,090.38 kWh, equivalent to Rp4.88 billion, through PDKB from January to March. This emphasizes the PDKB Team's role in reducing outages and maintaining revenue. Similarly, Dian Eka Putra (2015) found that PDKB reduced SAIDI to 61.6 minutes/customer and SAIFI to 0.28 outages/customer, while increasing energy sales by 308,629 kWh and revenue by Rp238.7 million [5]. Rohadi, Nugroho, and Widihastuti (2020) reported that 20 kV PDKB work at PT PLN (Persero) UP3 Kudus successfully saved 1,764,970.5 kWh, equivalent to Rp1.47 billion. This maintenance prevented power outages in the service area, thereby increasing customer satisfaction with PLN Kudus's performance [6]. Roza et al. reported that Work Under Voltage at PT PLN (Persero) Medan Transmission Service Unit saved approximately 2025.85 MWh in one year, indicating strong performance. Similarly, Fajri and Nurwijayanti found that maintaining 20 kV distribution substations with minimal outages significantly improves network reliability [8].

The implementation of Live Line Maintenance (PDKB) has consistently demonstrated significant benefits in improving the reliability and efficiency of electricity distribution**.** Studies show that PDKB effectively reduces power outages (as reflected in lower SAIDI and SAIFI values), increases customer satisfaction, and helps preserve or even boost company revenue through the efficient delivery of electrical energy (kWh).

Minimizing blackouts helps reduce SAIDI and SAIFI ratios, maintain kWh distribution, sustain revenue, and improve customer service. Frequent power flow increases company revenue, while reducing losses can be achieved by controlling SAIDI and SAIFI through PDKB analysis on the Medium Voltage Network [11]. Therefore, this study aims to evaluate the impact of the performance of the Under Voltage Maintenance Team (PDKB) on the reliability indicators of the electricity distribution system, namely SAIDI and SAIFI in the working area of PT. PLN (Persero) UP3 Langsa. This study aims to determine the extent to which the application of the PDKB method can reduce the number of disturbances, minimize blackouts, and improve the quality of electricity services to customers.

To support this objective, PDKB is maintenance work carried out without power outage, involving review of modification, rehabilitation, and maintenance tasks performed under live conditions. PDKB is maintenance work carried out without power outage, involving review of modification, rehabilitation, and maintenance tasks performed under live conditions [2]. According to PDKB Guidelines, PDKB teams use two approaches while doing maintenance: the Hot Stick technique (Insulated Stick) and the Barehand method (Direct Contact) [12]. PDKB implementation is supervised to ensure work results meet quality standards, overseen by two supervisors: the Work Supervisor and the Occupational Health and Safety Supervisor (K3 Supervisor). PDKB implementers must work carefully and follow the Minimum Safe Distance (Safety Zone/EP) to ensure personal safety when operating near live electrical components [13]. Protective elements are detailed in Table 1.

Table 1. Protective Elements

Voltage	**U<20 Kv**	**20 kV<U<26 kV**
Safe distance	6 EP	8 EP

*1 EP=10 cm

Table 1 shows the minimum safe distance that PDKB personnel must observe when working on medium-voltage power networks, based on the voltage level involved. The safe distance is expressed in EP (Element of Protection) units, where 1 EP equals 10 cm. For voltage below 20 kV (U < 20 kV), the minimum safe distance is 6 EP, or 60 cm. For voltage between 20 kV and less than 26 kV (20 kV < U < 26 kV), the minimum safe distance is 8 EP, or 80 cm. Applying these safe distances is essential to prevent the risk of electric shock when performing live-line maintenance (PDKB) [14].

Figure 1. Occupational Health and Safety Equipment

Method

a. Research Flow

This study was carried out by collecting and analyzing data on energy distribution (kWh), System Average Interruption Duration Index (SAIDI), and System Average Interruption Frequency Index (SAIFI) before and after the implementation of Live Line Maintenance (PDKB). Post-PDKB implementation data were obtained from maintenance activities conducted between August 2021 and August 2022, as recorded in the SIMPDKB application. Meanwhile, pre-PDKB data from the period August 2020 to August 2021 were calculated and analyzed for comparison purpose. The stages of the research flow are shown in Figure 1.

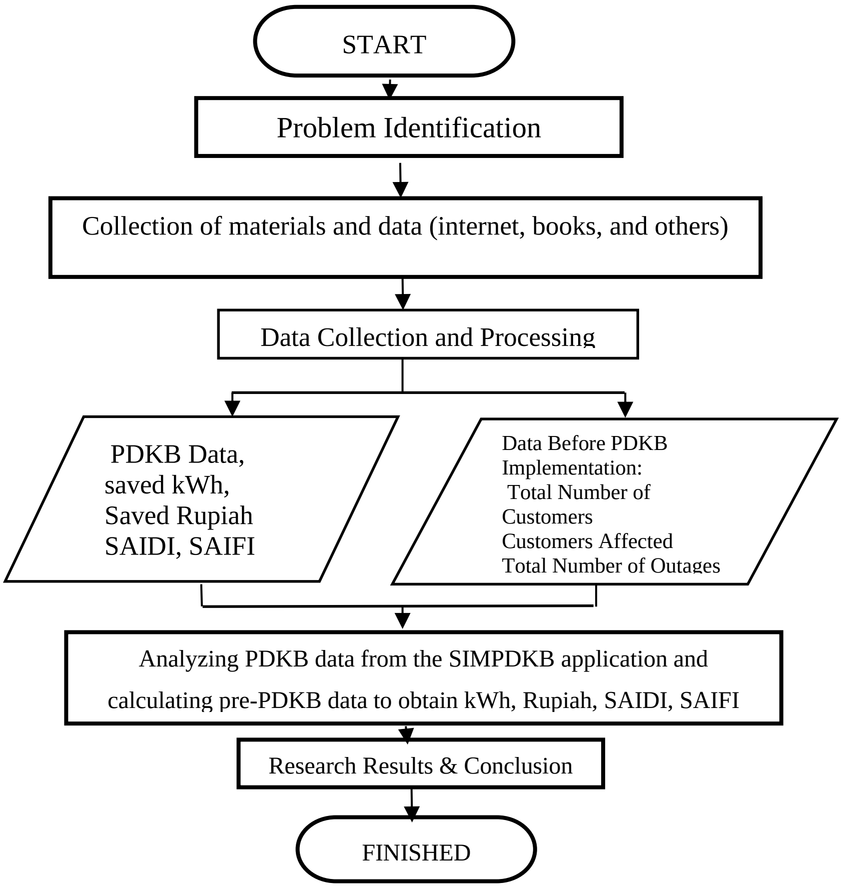

Figure 2. Research Flow Diagram

b. KWh

Sold kWh is the term used to describe the electrical energy that PLN distributes to customers. The saved kWh or kWh saved by PDKB is represented in this study by sold kWh. In other terms, saved energy (kWh) is electrical energy that can still be supplied while working without a power loss [15]. kWh and Rupiah (currency) that are not delivered can be calculated by assessing the load on the feeder first.

The calculation of load on the feeder can be computed using the equation [10]:

$$I = \frac{Customers\ x\ P\ average}{U\ x\ \sqrt{3}\ x\ cos\ \varphi} \quad \text{.....................} (1)$$

Explanation:

I	: Load on the network (Ampere)
Customers	: Number of customers on that network (Customers)
P rata-rata	: Average power usage per customer (VA)
U	: Voltage on the network (V)
$\sqrt{3}$	: 1,73
$cos\ \varphi$	: 0,85

Therefore, to calculate kWh, it is formulated as follows:

$$kWh = Ix\ U\ x\ \sqrt{3}\ x\ cos\ \varphi\ x\ t \quad \text{.................................... (2)}$$

Explanation:

I	: Load on the network (Ampere)
U	: Voltage on the network (V)
$\sqrt{3}$	: 1,73
$cos\ \varphi$	: 0,85
T	: Standard Offline Work Time (Hours)

From the results obtained, the Rupiah can be formulated as follows:

$$Rp = kWh\ x\ (Rp/kWh) \quad \text{.................. (3)}$$

Explanation:

Rp/kWh	: Total Rupiah Sold per Unit / Total kWh Sold per Unit

c. SAIDI

System Average Interruption Duration Index (SAIDI) is the average value of the duration of failures for each consumer over the course of one year [16]. The equation to calculate SAIDI influenced by PDKB performance is as follows:

$$SAIDI = \frac{Number\ of\ customer\ outagr\ duration}{Total\ Number\ of\ customers} \quad \text{............... (4)}$$

d. SAIFI

System Average Interruption Frequency Index (SAIFI) is the average number of failures that occur per customer served by the system over a typical time period, usually per year [16]. The equation to calculate SAIFI influenced by PDKB performance is as follows:

$$SAIFI = \frac{\text{Number of Times Customers Experienced Outages}}{Total\ Number\ of\ Customers} \text{.............. (5)}$$

Results and Discussion

To expand the coverage and improve the reliability of power distribution in the Aceh region, PLN established additional PDKB teams in new operational areas. PDKB Langsa was inaugurated for the first time on Wednesday (8/9/2021), previously PDKB in Aceh only existed in the cities of Banda Aceh and Lhoksemawe. There are numerous benefits to the PDKB Team's formation, particularly for the community, as electrical maintenance may be carried out without causing power outages, hence reducing the negative effects of power outages.

Live Line Maintenance (PDKB) UP3 Langsa is formed as a team consisting of 10 members, including 1 supervisor, team leader, preparator, K3 supervisor, and 6 technician members. The performance of PDKB is analyzed through saved kWh, saved Rupiah, SAIDI, and SAIFI values. In this study, researchers reviewed these values before and after the implementation of PDKB as a performance comparison. The comparison aims to evaluate the effectiveness of PDKB in improving service reliability and reducing power interruptions.

a. The saved kWh and Rupiah values

Based on data from SIMPDKB, the cumulative data since the establishment of PDKB in UP3 Langsa from August 2021 to 2022, with a total weight of 1655, results in data as shown in Table 2.

Table 2. Accumulated Report of PDKB Implementation at UP3 Langsa

ACTUAL				VARIABLE		
Worksite	Saved kWh	Average Rp/kWh	Projected Saved Rp	Work Duration	Number of Customers Affected	Total Number of UP3 Customers
616	1.457.823,97	778.83	1.135.391.541,48	908	3245279	349321

Maintenance of the network conducted by PDKB teams yielded results as per Table 2. The work carried out at 616 worksites saved 1,457,823.97 kWh for customers, resulting in Rp. 1,135,391,541.48 in revenue. If this work had been done offline over 1 year, approximately 1.4 million kWh would not have been delivered to customers, and PLN UP3 Langsa would have lost electricity sales revenue amounting to 1.1 billion Rupiah.

b. The Reliability of Electrical Maintenance is Assessed Through Saidi and Saifi.

Based on the data in SIMPDKB, the ratio values of SAIDI and SAIFI can be seen in Table 3.

Table 3. Report of SAIDI and SAIFI Values

CONTRIBUTION		VARIABLE		
SAIDI (MNT/PLG)	SAIFI (KALI/PLG)	Work Duration	Number of Customers Affected	Total Number of UP3 Customers
819,456	9,29	908	6.670.773	349.321

Table 3 presents key reliability indicators—SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index)—along with supporting variables used to evaluate the performance of the electricity distribution system in the UP3 Langsa area. From the accumulated data, it is found that the SAIDI is 819.456 minutes/customer and SAIFI is 9.29 times/customer.

b. The Value of kWh Before the Existence of PDKB

Before the existence of PDKB, maintenance was carried out offline by third-party vendors. PLN incurred additional costs to pay these vendors. Furthermore, some vendors faced limitations in terms of personnel, equipment, or work tools, resulting in reduced effectiveness in the maintenance process. The kWh figure that was determined was derived from calculations that began with the feeder's load calculation, which identified the quantity of kWh that was not supplied. Data collected from August 2020-2021 before the introduction of PDKB at PLN UP3 Langsa showed that 27,990 customers were affected on the feeder. The maintenance required 311.29 hours, as extracted from Table 4 data involving 121 feeders.

Table 4. Maintenance Time at UP3 Langsa

NO	DATE	FEEDER	HOURS (TIME)		
			OUTAGE	NORMAL	OUTAGE DURATION
1	8/28/2021	TC 08 / SERUWAY	8:37	9:25	0:48
2	8/28/2021	TC 07 / SUNGAI YU	9:43	10:58	1:15
3	8/28/2021	TC 06 / LANGSA	9:43	12:24	2:41
4	8/28/2021	AT 03 / KEUDE GEROBAK	9:52	13:09	3:17
5	8/28/2021	BK 07 / PUTRI BETUNG	10:15	15:44	5:29
6	8/28/2021	TC 11 / GH PULO TIGA	9:00	9:05	0:05
7	8/28/2021	TB 02 / KARANG BARU	14:41	14:54	0:13
8	8/28/2021	KN 03 / KUNING	9:24	12:01	2:37
9	8/28/2021	AT 07 / IDI CUT	10:32	13:20	2:48
10	8/4/2021	AT 07 / IDI CUT	10:40	13:54	3:14
11	8/3/2021	AT 03 / KEUDE GEROBAK	10:29	13:00	2:31
12	8/1/2021	TC 08 / SERUWAY	10:40	11:32	0:52
13	7/31/2021	BK 02 / PINDING	11:00	18:10	7:10
14	7/31/2021	BK 06 / KOTA 1	11:38	14:10	2:32
15	7/31/2021	IDI 06	8:56	12:18	3:22
16	7/31/2021	IDI 09	8:56	12:18	3:22
17	7/31/2021	KB 07 / BAGOK	11:54	11:57	0:03
18	7/30/2021	KB 02 / KUTA BINJE 2	10:15	11:34	1:19
19	7/29/2021	PK 05 / PAYA MEULIGOE	9:14	15:10	5:56
20	7/29/2021	PL 06 / MADAT	8:40	12:25	3:45
21	7/28/2021	AT 08 / TITI BAROE	9:00	10:48	1:48
22	7/27/2021	AT 08 / TITI BAROE	9:30	11:37	2:07
23	7/31/2021	AT 06 / KOTA IDI	9:00	11:24	2:24
24	7/24/2021	KN 08 / KETAMBE	10:48	12:36	1:48
25	7/24/2021	TC 07 / SUNGAI YU	11:04	14:55	3:51
26	7/24/2021	LA 08 / SEULALAH	9:46	9:58	0:12
27	7/17/2021	AT 07 / IDI CUT	13:55	15:18	1:23
28	7/17/2021	RE 03 / TRANGON	10:00	16:30	6:30
29	7/17/2021	LA 08 / SEULALAH	13:55	15:05	1:10
30	7/16/2021	LS 04	14:45	17:30	2:45
31	7/17/2021	AT 07 / IDI CUT	15:20	15:54	0:34
32	7/17/2021	AT 07 / IDI CUT	9:22	12:56	3:34
33	7/15/2021	KB 05 / ALUE IE MIRAH	10:00	15:50	5:50
34	7/15/2021	AT 03 / KEUDE GEROBAK	9:30	11:08	1:38
35	7/17/2021	LA 02 / POLRES	9:26	12:45	3:19
36	7/17/2021	LS 08	9:15	9:20	0:05
37	7/13/2021	AT 07 / IDI CUT	9:35	11:47	2:12
38	7/13/2021	AT 07 / IDI CUT	11:50	13:49	1:59
39	7/13/2021	KB 02 / KUTA BINJE 2	13:44	16:24	2:40
40	7/10/2021	TC 11 / GH PULO TIGA	9:45	16:25	6:40
41	7/10/2021	PK 03 / PEUREULAK	8:54	13:05	4:11
42	7/10/2021	PK 06 / SUNGAI RAYA	8:54	13:05	4:11
43	7/10/2021	AT 03 / KEUDE GEROBAK	10:00	11:37	1:37
44	7/8/2021	PK 06 / SUNGAI RAYA	9:20	12:23	3:03
45	7/10/2021	KB 03 / ARAKUNDO	9:59	11:05	1:06
46	7/7/2021	CN 04 / LAWE PAKAM	10:27	15:35	5:08
47	7/7/2021	KB 07 / BAGOK	9:15	16:20	7:05
48	7/6/2021	RE 03 / TRANGON	14:51	18:45	3:54
49	7/6/2021	PG 05 / TENGGULUN	9:22	12:14	2:52
50	7/5/2021	BK 06 / KOTA 1	13:38	16:03	2:25
51	7/5/2021	PK 06 / SUNGAI RAYA	10:02	12:16	2:14
52	7/4/2021	AT 03 / KEUDE GEROBAK	10:05	11:43	1:38
53	7/3/2021	AT 03 / KEUDE GEROBAK	9:25	14:43	5:18
54	7/3/2021	SJ 02 / SEI LIPUT	10:22	13:20	2:58
55	7/3/2021	BK 06 / KOTA 1	14:30	16:22	1:52
56	7/2/2021	LS 04	14:54	16:24	1:30
57	7/2/2021	AT 03 / KEUDE GEROBAK	9:24	11:02	1:38
58	7/3/2021	LS 09	9:22	12:12	2:50
59	7/3/2021	LS 02	10:00	12:42	2:42
60	7/3/2021	LA 03 / A. YANI	9:28	12:41	3:13

61	7/1/2021	AT 03 / KEUDE GEROBAK	9:13	15:30	6:17
62	7/1/2021	AT 03 / KEUDE GEROBAK	9:00	14:38	5:38
63	7/1/2021	KB 05 / ALUE IE MIRAH	10:00	14:38	4:38
64	3/27/2021	LS 05	9:40	10:50	1:10
65	3/27/2021	LL 02 / ALUR CANANG	9:00	10:48	1:48
66	3/17/2021	TC 06 / LANGSA	9:55	11:16	1:21
67	3/13/2021	KN 02 / LAWE ALAS	9:35	11:29	1:54
68	3/4/2021	TC 08 / SERUWAY	9:40	11:45	2:05
69	3/5/2021	BK 04 / RIKIT GAIB	14:46	16:59	2:13
70	2/27/2021	IDI 02	9:45	16:48	7:03
71	2/27/2021	IDI 01	9:45	16:48	7:03
72	2/27/2021	PK 03 / PEUREULAK	9:30	13:26	3:56
73	2/27/2021	SJ 02 / SEI LIPUT	9:29	12:34	3:05
74	2/27/2021	TC 11 / GH PULO TIGA	9:43	12:38	2:55
75	2/27/2021	LS 05	9:37	10:14	0:37
76	2/27/2021	LA 09 / WIRYO	9:16	11:19	2:03
77	2/28/2021	SU 06 / INC PL04	10:20	15:35	5:15
78	2/25/2021	BK 05 / KOTA 2	16:32	17:22	0:50
79	2/23/2021	KB 09 / BLANG JAMBE	15:00	17:12	2:12
80	2/23/2021	KB 07 / BAGOK	15:00	17:13	2:13
81	2/23/2021	KB 06 / KUTA BINJE 1	15:00	17:13	2:13
82	2/23/2021	KB 02 / KUTA BINJE 2	15:00	17:12	2:12
83	2/18/2021	PL 04 / EXP SU 06	9:32	9:37	0:05
84	2/15/2021	IDI 02	9:00	9:00	0:00
85	2/14/2021	IDI 09	13:30	18:15	4:45
86	2/14/2021	IDI 06	9:07	9:08	0:01
87	2/13/2021	CN 05	9:39	10:56	1:17
88	2/11/2021	BE 01 / SEI RAYA	9:35	12:50	3:15
89	2/9/2021	IDI 11	9:03	13:09	4:06
90	2/6/2021	TC 03 / BATALYON	9:43	12:42	2:59
91	12/24/2020	LS 05	9:57	12:30	2:33
92	12/5/2020	TC 11 / GH PULO TIGA	10:00	13:52	3:52
93	11/8/2020	IDI 01	10:00	11:00	1:00
94	11/8/2020	LS 06	9:00	12:00	3:00
95	11/30/2020	IDI 11	13:00	16:00	3:00
96	11/30/2020	CN 04 / LAWE PAKAM	15:01	17:02	2:01
97	11/28/2020	AT 07 / IDI CUT	9:16	11:04	1:48
98	11/28/2020	AT 02 / INDUSTRI	9:16	11:46	2:30
99	11/21/2020	TC 11 / GH PULO TIGA	11:59	12:30	0:31
100	11/21/2020	TC 04 / GH SRIWIJAYA	11:58	12:30	0:32
101	11/14/2020	LS 03	9:40	14:06	4:26
102	11/14/2020	RE 02 / KUTA PANJANG	10:02	12:05	2:03
103	11/7/2020	SJ 05 / KUALA SIMPANG	9:00	15:02	6:02
104	10/24/2020	SJ 05 / KUALA SIMPANG	9:20	14:21	5:01
105	10/17/2020	LS 05	9:45	11:20	1:35
106	10/10/2020	BK 07 / PUTRI BETUNG	9:00	11:57	2:57
107	10/10/2020	BK 06 / KOTA 1	9:00	12:55	3:55
108	10/10/2020	SJ 04 / RANTAU	9:00	9:05	0:05
109	10/8/2020	LL 01 / ALUR PINANG	9:36	12:50	3:14
110	10/3/2020	AT 04 / PEUDAWA PNTG	9:53	13:50	3:57
111	10/3/2020	AT 08 / TITI BAROE	9:53	15:13	5:20
112	9/19/2020	KN 08 / KETAMBE	10:12	13:04	2:52
113	9/12/2020	AT 07 / IDI CUT	9:45	10:56	1:11
114	9/12/2020	AT 02 / INDUSTRI	9:45	10:56	1:11
115	9/10/2020	SU 05 / SIMPANG ULIM	10:40	13:35	2:55
116	9/3/2020	CN 04 / LAWE PAKAM	9:30	11:16	1:46
117	8/22/2020	AT 07 / IDI CUT	9:08	12:33	3:25
118	8/22/2020	AT 02 / INDUSTRI	9:08	12:33	3:25
119	8/20/2020	LL 01 / ALUR PINANG	11:34	14:36	3:02
120	8/12/2020	LS 05	10:15	10:48	0:33
121	8/8/2020	TC 08 / SERUWAY	9:58	10:43	0:45
		Total Outage Duration			311,29

The calculation value of the load on the feeder:

$$I = \frac{Customers\ x\ P\ average}{U\ x\ \sqrt{3}\ x\ cos\ \varphi}$$

$$I = \frac{27.990 \ x\ 450\ VA}{20.000\ V\ x\ 1{,}73\ x\ 0{,}85}$$
$$I = \frac{12.595.500\ VA}{29.410V}$$
$$I = 428{,}3\ A$$

Therefore, to calculate kWh:

$$kWh = Ix\ U\ x\ \sqrt{3}\ x\ cos\ \varphi\ x\ t$$
$$kWh = 428{,}3\ A\ x\ 20\ kV\ x\ 1{,}73\ x\ 0{,}85\ x\ 311{,}29$$
$$kWh = 3.921.103{,}2$$

From the results obtained, the Rupiah can be calculated as follows:

Rp = kWh x (Rp/kWh)
$$Rp = 3.921.103{,}2\ x\ 800$$
Rp = 3.136.882.560

The calculation results before the existence of PDKB amounted to 3,921,103.2 kWh and Rp. 3,136,882,560, meaning that over 1 year, 3.9 million kWh were not delivered to customers, and PLN UP3 Langsa lost electricity sales revenue of Rp. 3.1 billion Power outages during maintenance disrupt electricity flow and sales. According to Sugiarto, outages are often needed for worker safety, but PDKB allows safer maintenance without cutting power [17]. It can state that PDKB a more efficient and customer-friendly method, as it maintains service continuity while ensuring operational safety. The comparison of saved kWh and Rupiah values between maintenance with PDKB and without PDKB shows a significant difference. This can be seen in Graphs 3 and 4.

Figure 3. Graph of kWh Values

Figure 4. Graph of Rupiah Values

It can be seen from the graphs that without PDKB, the kWh value is 3,921,103.2 kWh and Rp. 3,136,882,560, which is higher compared to PDKB where the kWh value is 1,457,823.97 and Rp. 1,135,391,541.48. This indicates that in one year, the amount of kWh not delivered is 3.9 million when regular maintenance is conducted, whereas with PDKB, maintenance can save 1.4 million kWh in one year. Regarding the financial calculations, before the existence of PDKB, the revenue loss was Rp. 3.1 billion, while with PDKB, it was Rp. 1.1 billion. Therefore, maintenance without PDKB results in more kWh not delivered to customers, and PLN UP3 Langsa loses more electricity sales revenue compared to maintenance with PDKB.

c. SAIDI and SAIFI Values before PDKB

Based on the maintenance data, SAIDI and SAIFI values can be analyzed and calculated. During the period from August 2020 to 2021, according to Table 4.3, there were 121 feeders with a total outage duration of 27,790 customers experiencing an outage for 311.29 hours, out of a total of 338,403 customers.

$$SAIDI = \frac{Number\ of\ customer\ outagr\ duration}{Total\ Number\ of\ customers}$$

$$= \frac{27.790x\ 311{,}29}{338.403}$$

$$= 25{,}564$$

$$= 25{,}564\ x\ 60\ minute$$

$$= 1533{,}84 \text{ Minute/Customers}$$

$$SAIDI = \frac{Number\ of\ customer\ outagr\ duration}{Total\ Number\ of\ customers}$$

$$= \frac{27.790}{338{,}403}$$

$$= 0{,}083$$

$$= 0{,}083x\ 121\ \ times\ the\ job$$

$$= 10{,}04 \text{ time/customers}$$

Based on the calculations before the implementation of PDKB, the outage duration per customer (SAIDI) was 1533.84 minutes/customer and the System Average Interruption Frequency Index (SAIFI) was 10.04 times/customer. In comparison, after implementing PDKB, SAIDI significantly decreased to 819.456 minutes/customer and SAIFI reduced to 9.29 times/customer. From these calculations, we can observe the impact of PDKB on SAIDI and SAIFI in the graphs, as shown in Graphs 5 and 6.

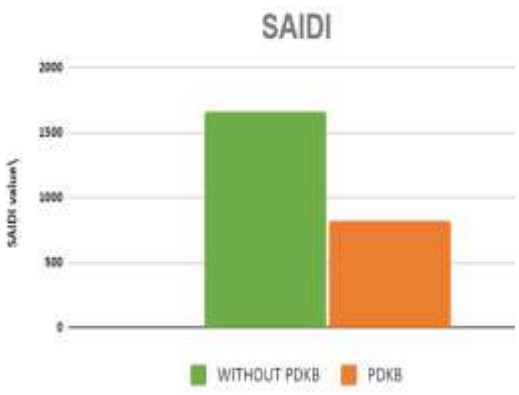

Figure 5. Graph of SAIDI value

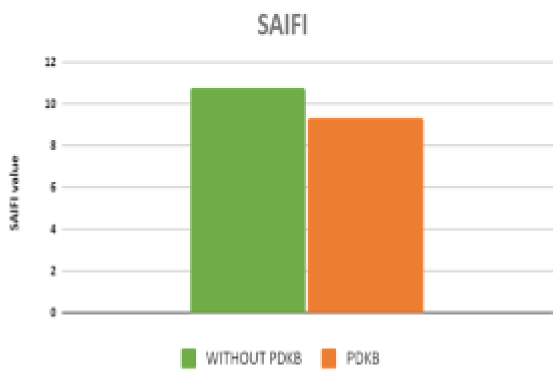

Figure 6. Graph of SAIFI value

Based on the graph, during electrical network maintenance without PDKB, both SAIDI and SAIFI values are higher compared to maintenance with PDKB. This is also consistent with the research by Aprilianto and Budiono, which indicates that the smaller the SAIFI and SAIDI values, the better the service provided by PLN to its customers [18]. This result proved that the implementation of PDKB significantly contributes to improving service reliability and minimizing the impact of maintenance activities on customers.

Conclusion

The research findings on maintenance with PDKB at PT. PLN (Persero) UP3 Langsa, conducted with 616 work points, resulted in saving 1,457,823.97 kWh for customers, amounting to Rp. 1,135,391,541.48 in financial savings. The reliability of live electrical maintenance, as seen from SAIDI and SAIFI values, showed that the number of customer outage minutes (SAIDI) was 819.456 minutes per customer, with SAIFI at 9.29 interruptions per customer. Before implementing PDKB at PT. PLN (Persero) UP3 Langsa, the kWh saved amounted to 3,921,103.2 and Rp. 3,136,882,560 in financial terms. SAIDI was recorded at 1533.84 minutes per customer, with SAIFI at 10.04 interruptions per customer. These results demonstrate a significant improvement in service reliability after the implementation of PDKB. The decrease in both SAIDI and SAIFI values indicates fewer and shorter power interruptions experienced by customers [19][20]. Additionally, the reduction in financial losses highlights the effectiveness of PDKB in maintaining energy distribution without outages.

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